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2006 Annual Summary Report for the Area 3 and Area 5 Radioactive Waste Management Sites at the Nevada Test Site Nye County, Nevada

Review of the Performance Assessments and Composite Analyses

Prepared for

National Nuclear Security Administration
Nevada Site Office

National Nuclear Security Administration

Prepared by

National Security Technologies LLC

Under Contract Number
DE-AC52-06NA25946

March 2007

DISCLAIMER

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EXECUTIVE SUMMARY

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* (National Security Technologies, LLC, 2006) requires an annual review to assess the adequacy of the performance assessments (PAs) and composite analyses (CAs) for each of the facilities, with the results submitted as an annual summary report to the U.S. Department of Energy (DOE) Headquarters. The Disposal Authorization Statements for the Area 3 and Area 5 Radioactive Waste Management Sites (RWMSs) also require that such reviews be made and that secondary or minor unresolved issues be tracked and addressed as part of the maintenance plan (DOE, 2000; 2002).

The DOE, National Nuclear Security Administration Nevada Site Office performed annual reviews in fiscal year (FY) 2006 by evaluating operational factors and research results that impact the continuing validity of the PAs and CAs results. This annual summary report presents data and conclusions from the FY 2006 review, and determines the adequacy of the PAs and CAs. Operational factors, such as the waste form and containers, facility design, waste receipts, and closure plans, as well as monitoring results and research and development (R&D) activities, were reviewed in FY 2006 for determination of the adequacy of the PAs. Likewise, the environmental restoration activities at the Nevada Test Site relevant to the sources of residual radioactive material that are considered in the CAs, the land-use planning, and the results of the environmental monitoring and R&D activities were reviewed for determination of the adequacy of the CAs.

Waste operations, R&D, and monitoring results for FY 2006 were reviewed and compared with the assumptions and conceptual models of the PAs and CAs of the Area 3 and Area 5 RWMSs. Important developments include the following:

- Development of version 4.001 of the Area 5 RWMS GoldSim® PA model, which includes the CA component and the Title 40 Code of Federal Regulations (CFR) 191 evaluation of the transuranic (TRU) waste in classified trench 4 (T04C)
- Development of version 2.0 of the Area 3 RWMS GoldSim PA model, with a CA component
- Development of new closure inventory estimates based on disposals through FY 2006
- Evaluation of new or revised waste streams by special analysis

The Area 3 RWMS was placed on inactive status beginning July 1, 2006, with the last shipment received in April 2006. The facility is scheduled to close in FY 2008. In FY 2006, there were no operational changes, monitoring results, or R&D results for the Area 3 RWMS that would impact PA validity. Despite the increase in waste volume and inventory at the Area 3 RWMS since 1996 when the PA was approved, the facility performance evaluated with the new version 2.0 GoldSim Area 3 RWMS model (with the final closure inventory) remains well below the DOE Order 435.1 performance objectives. The conclusions of the Area 3 PA remain valid. A revision to the combined PA/CA document will be developed in FY 2008.

Addendum 2 to the Area 5 RWMS PA document was issued for public release in June 2006 (Bechtel Nevada, 2006a). With the update of the closure inventory for the 2006 disposals, version 4.001 of the Area 5 RWMS GoldSim model shows that the facility continues to comply with all performance objectives.

The continuing adequacy of the CAs was evaluated with the new models, and no significant changes that would alter CA results or conclusions were found. Inclusion of the Frenchman Flat Underground Test Area (UGTA) results in the Area 5 RWMS CA is scheduled for FY 2009, pending completion of the Corrective Action Decision Document (CADD) for the Frenchman Flat UGTA Corrective Action Unit (CAU), scheduled for FY 2008. Therefore, a revision of the Area 5 RWMS CA is scheduled for FY 2009. The revision of the Area 3 RWMS CA, which will include the UGTA source terms, is expected in FY 2021, following the completion of the Yucca Flat CAU CADD, scheduled for FY 2020.

Near-term R&D efforts will focus on continuing development of the Area 3 and Area 5 RWMS GoldSim PA/CA and inventory models. The consequences of potential subsidence of the disposal units that may impact the Area 3 RWMS will be incorporated into the Area 3 RWMS GoldSim model in FY 2007. A special analysis (an evaluation of compliance with Title 40 CFR 191 performance objectives) will be performed for the TRU waste in T04C in FY 2007 to identify the preferred remediation option. To support this analysis, the Area 5 RWMS GoldSim model will be further revised to incorporate climate change for a 10,000-year compliance period.

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ACRONYMS and ABBREVIATIONS

BN	Bechtel Nevada
Bq	Becquerel
$Bq/m^2/s$	Becquerel per square meter per second
CA	Composite Analysis
CADD	Corrective Action Decision Document
CAU	Corrective Action Unit
CFR	Code of Federal Regulations
cm	centimeter
DAS	Disposal Authorization Statement
DOE	U.S. Department of Energy
ER	environmental restoration
ET	evapotranspiration
ft	foot
ft^3	cubic feet
FY	fiscal year
GCD	Greater Confinement Disposal
IC	institutional control
ICMP	Integrated Closure and Monitoring Plan
in	inch
ISC	Industrial Source Complex
L	liter
LFRG	Low-Level Waste Disposal Facility Federal Review Group
m	meter
m^3	cubic meters
mSv	milliSievert
NNSA/NSO	U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office
NTS	Nevada Test Site
NSTec	National Security Technologies, LLC
PA	performance assessment

ACRONYMS and ABBREVIATIONS
(continued)

R&D	research and development
RaDU	radium disposal unit
RTG	radioisotope thermoelectric generator
RWMS	Radioactive Waste Management Site
SLB	shallow land burial
TBq	TeraBecquerel
TDR	time-domain reflectometry
TEDE	total effective dose equivalent
TLD	thermoluminescent dosimeter
TRU	transuranic
UGTA	Underground Test Area
yr	year

1.0 INTRODUCTION

This report summarizes the results of an annual review of conditions affecting the operation of the Area 3 and Area 5 Radioactive Waste Management Sites (RWMSs) and a determination of the continuing adequacy of the performance assessments (PAs) and composite analyses (CAs). The Area 5 RWMS PA documentation consists of the original PA (Shott et al., 1998), referred to as the 1998 Area 5 RWMS PA; and a supporting addendum (Bechtel Nevada [BN], 2001b), including an update of PA results (BN, 2006a), referred to as the 2006 Area 5 RWMS PA update. The Area 5 RWMS CA was issued as a single document (BN, 2001a) and has a single addendum (BN, 2001c). The Area 3 PA and CA were issued in a single document (Shott et al., 2000). 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* (National Security Technologies, LLC [NSTec], 2006) and the Disposal Authorization Statements (DASs) for the Area 3 and 5 RWMSs (U.S. Department of Energy [DOE], 2000; 2002) require preparation of an annual summary and a determination of the continuing adequacy of the PAs and CAs. The annual summary report is submitted to DOE Headquarters.

Following the annual report format in the DOE PA/CA Maintenance Guide (DOE, 1999), this report presents the annual summary for the PAs in Section 2.0 and the CAs in Section 3.0. The annual summary for the PAs includes the following:

- Section 2.1 summarizes changes in waste disposal operations
- Section 2.1.5 provides an evaluation of the new estimates of the closure inventories derived from the actual disposals through fiscal year (FY) 2006
- Section 2.2 summarizes the results of the monitoring conducted under the DOE, National Nuclear Security Administration Nevada Site Office's (NNSA/NSO's) *Integrated Closure and Monitoring Plan for the Area 3 and Area 5 Radioactive Waste Management Sites at the Nevada Test Site* (ICMP) (BN, 2005), and the research and development (R&D) activities
- Section 2.4 is a summary of changes in facility design, operation, or expected future conditions; monitoring and R&D activities; and the maintenance program
- Section 2.5 discusses the recommended changes in disposal facility design and operations, monitoring and R&D activities, and the maintenance program

Similarly, the annual summary for the CAs (presented in Section 3.0) includes the following:

- Section 3.1 presents the assessment of the adequacy of the CAs, with a summary of the relevant factors reviewed in FY 2006
- Section 3.2 presents an assessment of the relevant site activities at the Nevada Test Site (NTS) that would impact the sources of residual radioactive material considered in the CAs

- Section 3.3 summarizes the monitoring and R&D results that were reviewed in FY 2006
- Section 3.4 presents a summary of changes in relevant site programs (including monitoring, R&D, and the maintenance program) that occurred since the CAs were prepared
- Section 3.5 summarizes the recommended changes to these programs

1.1 Tracking of Minor Issues

Tracking and resolution of all minor or secondary issues identified in the Low-Level Waste Disposal Facility Federal Review Group (LFRG) review reports for the Area 3 and Area 5 RWMS PAs and CAs continued in FY 2006. Table 1 lists the minor issues that are being tracked and resolved through the maintenance program. The resolution pathway for each issue is included in the third column of Table 1.

Table 1
Minor Issues Identified in the LFRG Review Reports for the Area 3 and Area 5 RWMS PAs and CAs

Identified Issue	Source Document for Issue	Resolution Pathway
Engineered barrier will be added and the assurance requirements of U.S. Environmental Protection Agency Title 40 Code of Federal Regulations (CFR) 191 must be met for the Greater Confinement Disposal (GCD) boreholes.	GCD PA	Engineered barrier will be added and the assurance requirements will be met at the time of closure of the Area 5 RWMS, as stated in the ICMP (BN, 2005).
Inconsistencies between conceptual models for the Area 5 RWMS PA and CA, the Area 3 RWMS PA and CA, and the GCD PA.	Area 5 RWMS PA; Area 5 RWMS CA; Area 3 RWMS PA/CA; GCD PA	Continuous development of probabilistic PA models using the GoldSim® software system is eliminating inconsistencies; this work will continue to be described in annual summary reports (e.g., BN, 2006b).
Conduct site monitoring and site characterization studies, as required, to increase confidence in the results of the PAs.	Area 3 RWMS PA/CA	Monitoring programs at both Area 5 and Area 3 RWMSs are ongoing; data are being incorporated in the GoldSim models to increase confidence in the PA results.
Maintenance program must include periodic assessment of changes in potentially inter-acting sources (underground test areas [UGTA], industrial sites) and impacts on the CAs	Area 5 RWMS CA; Area 3 RWMS PA/CA	Changes in potentially interacting sources will be evaluated through the maintenance program and results will be presented in the annual summary reports.

Table 1
Minor Issues Identified in the LFRG Review Reports for the Area 3 and Area 5 RWMS PAs and CAs (continued)

Identified Issue	Source Document for Issue	Resolution Pathway
Maintenance program must include periodic assessment of changes in land-use restrictions and impacts on the CAs.	Area 5 RWMS CA; Area 3 RWMS PA/CA	Changes in land-use restrictions will be reviewed through the maintenance program and results will be presented in the annual summary reports.
Monitoring systems need to be deployed and data gathered and evaluated to distinguish between interacting sources at the Area 3 RWMS.	Area 3 RWMS PA/CA	Monitoring systems deployed at the disposal facilities are described in the ICMP (BN, 2005); monitoring results will be evaluated and presented in the annual summary reports.

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2.0 PERFORMANCE ASSESSMENT

2.1 Waste Disposal Operations

PA maintenance requires an annual review of waste operations including waste forms and waste containers disposed, facility design, waste acceptance criteria, closure design, and waste inventory. Current operations are compared with the assumptions and conceptual models of the PAs to assess the continuing validity of the PA and compliance with DAS conditions. Differences in waste inventory, facility design, and closure design between the PAs and current conditions are noted and described below. The impacts of these changes are summarized in Section 2.1.5.

2.1.1 Waste Form and Containers

The Area 3 and Area 5 RWMS PAs do not explicitly model the performance of waste forms and containers. Radionuclides are assumed to be fully available for release and transport at closure. These assumptions remain valid for waste disposed through FY 2006.

2.1.2 Facility Design and Operations

The PAs use assumptions about disposal unit volume, area, and depth of burial that may affect performance. Historical information and associated uncertainty of these parameters remains unchanged.

The Area 3 RWMS was placed in inactive status in July 2006, with the last waste disposed in April 2006. No new disposal units were opened in FY 2006. The two post-1988 disposal units, U-3ah/at and U-3bh, are currently operationally closed.

No new cells were opened at the Area 5 RWMS. In FY 2006, the mixed low-level disposal unit, Pit 3 (P03U), began receiving mixed low-level waste from off-site generators.

2.1.3 Waste Receipts

The Area 3 and Area 5 RWMS PAs analyze waste inventories that were estimated as the sum of past disposals and estimated future disposals. The estimate of closure inventory may change over time as estimates or records of past disposals are revised or when forecasts of future waste change. Estimates of past disposals may change as disposal records are reviewed, database records are revised, and assumptions used to revise historical records change. However, closure inventory uncertainty is dominated by uncertainty in future disposals. Experience has shown that future inventory estimates will change, perhaps significantly, over time as new generators or new waste streams are approved, or wastes are sent to other alternative disposal sites.

2.1.3.1 *New or Revised Waste Streams*

Each new or revised waste stream is evaluated by the Radiological Waste Acceptance Program for its potential impacts on the PA and conformance with waste acceptance criteria. Some waste streams, because of their potential to alter PA assumptions or conceptual models, require a special analysis for acceptance. Waste streams exceeding screening criteria are evaluated by adding the inventory to the Area 5 RWMS PA model and determining if all performance objectives can be met. If all performance objectives can be met, the waste stream is recommended for approval.

In FY 2006, eight waste streams were evaluated by special analyses using the Area 5 RWMS PA GoldSim model (Table 2). Six waste streams were accepted without conditions. The Los Alamos National Laboratory Radioisotope Thermoelectric Generators (RTGs) waste stream, consisting of six RTGs, was accepted with conditions placed on the spacing of the RTGs in the disposal unit to control heat generation. The Sandia National Laboratories RTG waste stream is still under review.

Table 2
Waste Streams Evaluated by Special Analysis in FY 2006

Waste Stream	Description	Issue	Result
WVDP000000003, Rev. 6	West Valley Fuel, Recovery and Storage Debris and Filters	Inventory	Accepted
LANL000000001, Rev. 0	Los Alamos Radioisotope Thermoelectric Generators	Heat Generation, ^{90}Sr Inventory	Accepted with Conditions
ONLO000000140, Rev. 0	Fernald Treated T-Hoppers	^{222}Rn Flux Density	Accepted
ASLA000000020, Rev. 0	Sandia Molten Pool Waste	Inventory	Accepted
ORNLEUSOURCES, Rev. 0	Oak Ridge Eu-152/154 Sealed Sources	^{152}Eu Inventory	Accepted
WVDP000000013, Rev. 2	West Valley Contaminated Concrete and General Debris	^{222}Rn Flux Density	Accepted
ASLA000000015, Rev. 1	Sandia Radioisotope Thermoelectric Generators	Heat Generation, ^{90}Sr Inventory	In Review
PORTLPP000011, Rev. 0	Portsmouth Alumina Trap Material	^{99}Tc Inventory	Accepted

2.1.3.2 *FY 2006 Closure Inventory Estimate for the Area 3 RWMS*

The Area 3 RWMS was placed in inactive status at the end of June 2006. The site may be used in the future for disposal of large-volume bulk waste streams, but there are currently no waste streams designated for disposal in Area 3. The FY 2006 inventory includes waste disposed through June 30, 2006, and assumes no future inventory.

The FY 2006 Area 3 RWMS inventory was prepared using the Area 3 Inventory v2.010 GoldSim model. Most model input parameters, including annual disposal rates and revision scaling factors, are stochastic parameters. The stochastic inputs are sampled repeatedly and an inventory is calculated for each realization. The resulting inventory is a lognormal distribution described by a geometric mean and standard deviation. The model calculates radioactive decay and ingrowth during disposal operations and assumes that final closure will occur on

September 30, 2008. Revisions estimate the activity of individual nuclides assumed to be present in radionuclide mixtures such as mixed fission products, depleted uranium, enriched uranium, and weapons-grade plutonium.

The model estimates the inventory of wastes disposed before and after September 26, 1988. Pre-1988 waste was disposed mostly in U-3ax/bl and a small amount was disposed in U-3ah/at (Table 3). The total pre-1988 inventory consists of approximately 326 TeraBecquerel (TBq) in 2.3×10^5 cubic meters (m^3) (8.1×10^6 cubic feet [ft^3]) of waste.

Table 3
FY 2006 Estimate of Area 3 RWMS Inventory Disposed Before September 26, 1998
(Estimates are calculated from 500 Monte Carlo realizations and decayed to October 1, 2008.)

Nuclide	U-3ax/bl		U-3ah/at	
	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation
H-3	3.0E+14	2.95	1.8E+12	2.19
C-14	9.3E+10	3.08	9.3E+07	2.89
Al-26	3.4E+06	3.14	3.4E+03	3.06
Cl-36	2.0E+10	3.13	2.0E+07	2.98
Ar-39	9.6E+10	3.15	1.0E+08	2.85
K-40	5.2E+09	3.03	5.6E+06	2.73
Ca-41	1.4E+11	3.11	1.4E+08	2.88
Co-60	1.1E+11	2.85	*Negligible*	
Ni-59	3.7E+09	3.10	3.7E+06	2.96
Ni-63	3.3E+11	3.15	3.7E+08	2.99
Kr-85	1.7E+11	3.05	3.2E+08	2.76
Sr-90	7.0E+12	3.05	1.0E+10	2.60
Zr-93	4.8E+08	3.02	5.2E+05	2.72
Nb-93m	1.4E+11	3.24	2.1E+08	3.04
Nb-94	1.2E+11	3.13	1.1E+08	3.02
Tc-99	1.2E+10	2.22	1.1E+10	3.87
Pd-107	2.2E+07	3.05	2.3E+04	2.74
Cd-113m	1.3E+11	3.17	2.2E+08	2.98
Sn-121m	1.4E+12	3.09	1.7E+09	3.00
Sn-126	2.1E+08	3.03	2.3E+05	2.74
I-129	1.1E+07	3.05	1.2E+04	2.73
Cs-135	4.1E+08	3.03	4.1E+05	2.74
Cs-137	9.3E+12	3.00	1.2E+10	2.68
Sm-151	5.6E+11	3.04	6.3E+08	2.75
Eu-150	2.4E+11	3.35	3.0E+08	3.37
Eu-152	1.1E+12	3.24	1.7E+09	2.91
Eu-154	3.1E+11	3.18	6.7E+08	3.04

Table 3
FY 2006 Estimate of Area 3 RWMS Inventory Disposed September 26, 1998
(continued)

Nuclide	U-3ax/bl		U-3ah/at	
	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation
Gd-152	1.3E-01	3.20	1.1E-04	2.91
Ho-166m	4.4E+09	3.16	4.8E+06	2.88
Ra-226	5.6E+11	3.71	1.1E+05	2.15
Ra-228	1.3E+09	2.52	3.7E+05	2.73
Ac-227	4.4E+05	2.07	6.3E+05	2.19
Th-228	8.1E+09	2.79	7.4E+06	2.88
Th-229	8.5E+06	2.99	6.3E+03	2.71
Th-230	2.0E+07	1.84	2.5E+07	2.15
Th-232	1.4E+09	2.53	4.1E+05	2.73
Pa-231	1.6E+06	2.10	2.4E+06	2.19
U-232	6.3E+09	3.14	6.7E+06	2.90
U-233	3.0E+09	3.02	3.2E+06	2.70
U-234	8.9E+10	1.99	1.3E+11	2.15
U-235	3.4E+09	2.14	5.6E+09	2.19
U-236	2.4E+09	2.85	2.6E+09	2.89
U-238	4.4E+10	2.07	1.1E+11	2.46
Np-237	4.8E+08	2.35	2.4E+08	2.33
Pu-238	2.0E+11	3.03	2.0E+10	2.53
Pu-239	1.0E+12	2.99	2.0E+09	2.22
Pu-240	2.8E+11	3.01	5.2E+08	2.16
Pu-241	9.3E+11	3.04	3.3E+09	2.05
Pu-242	1.0E+08	3.02	1.4E+05	2.36
Am-241	3.3E+11	2.98	5.6E+08	2.12
Am-243	4.4E+07	3.00	4.8E+04	2.74
Cm-244	1.6E+10	3.06	2.3E+07	2.75
Total	3.3E+14		2.1E+12	

Negligible – No disposal recorded; inventory assumed to be negligible.
Bq – Becquerel

The post-1988 waste is disposed in U-3ah/at and U-3bh (Table 4). The post-1988 inventory is estimated to consist of approximately 3.2×10^4 TBq in 3.3×10^5 m^3 (1.2×10^7 ft^3) of waste. On an activity basis, the inventory is predominantly ^3H. The FY 2006 inventory and volume estimates are reduced from previous years due to the suspension of operations before the U-3ah/at and U-3bh disposal units were filled.

Table 4
FY 2006 Estimate of Area 3 RWMS Inventory Disposed After September 26, 1988
(Estimates are calculated from 500 Monte Carlo realizations and decayed to October 1, 2008.)

Nuclide	U-3ah/at		U-3bh	
	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation
H-3	1.8E+16	2.05	1.2E+16	2.24
C-14	1.0E+11	1.76	3.0E+07	2
Al-26	7.8E+04	3	*Negligible*	
Cl-36	5.2E+08	2.67	*Negligible*	
Ar-39	2.3E+09	2.86	*Negligible*	
Ar-42	6.3E+08	2.03	3.3E+08	2.68
K-40	2.6E+09	1.89	7.0E+08	2.45
Ca-41	3.3E+09	2.88	*Negligible*	
Ti-44	1.4E+10	2.04	7.0E+09	2.5
Co-60	3.3E+10	1.75	2.0E+10	2.15
Ni-59	9.6E+08	2.24	1.8E+08	2.18
Ni-63	2.3E+11	1.77	8.5E+09	2.12
Se-79	2.1E+07	2.47	*Negligible*	
Kr-85	9.3E+09	2.36	*Negligible*	
Sr-90	4.4E+14	2.58	6.7E+10	2
Zr-93	1.2E+07	2.66	*Negligible*	
Nb-93m	4.8E+09	2.93	*Negligible*	
Nb-94	2.7E+09	2.97	1.7E+08	2.17
Tc-99	2.1E+12	1.89	8.1E+10	2.06
Pd-107	5.2E+05	2.65	*Negligible*	
Cd-113m	5.2E+09	2.85	*Negligible*	
Sn-126	5.2E+08	2.38	8.9E+05	2.68
I-129	4.8E+08	1.93	2.4E+08	2.53
Ba-133	1.4E+10	1.98	4.4E+09	2.58
Cs-135	9.3E+06	2.63	*Negligible*	
Cs-137	2.6E+14	1.81	7.0E+10	1.77
Sm-151	1.4E+10	2.64	1.1E+06	2.64
Eu-150	6.3E+09	3.5	*Negligible*	
Eu-152	8.5E+10	1.93	3.0E+09	2.32
Eu-154	3.0E+10	2.18	6.3E+08	2.15
Gd-152	2.9E-03	2.44	3.7E-05	2.39
Ho-166m	1.1E+08	2.86	*Negligible*	
Bi-207	4.8E+05	2.69	2.1E+07	2.75
Pb-210	8.1E+10	2.18	7.4E+07	1.74

Table 4
FY 2006 Estimate of Area 3 RWMS Inventory Disposed After September 26, 1988
(continued)

Nuclide	U-3ah/at		U-3bh	
	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation
Ra-226	1.0E+11	2.03	3.7E+08	1.85
Ra-228	8.1E+09	1.56	1.1E+11	2.64
Ac-227	3.6E+09	2.33	8.5E+04	1.96
Th-228	6.7E+10	2.18	6.7E+10	2.63
Th-229	1.4E+07	2.21	1.1E+07	2.51
Th-230	4.4E+10	2.03	7.4E+10	2.65
Th-232	1.3E+10	1.63	2.2E+11	2.65
Pa-231	2.4E+08	2.03	1.1E+06	2.06
U-232	6.7E+10	2.38	*Negligible*	
U-233	1.6E+10	2.11	2.2E+10	2.5
U-234	7.4E+12	1.93	1.3E+11	2
U-235	3.4E+11	1.83	1.1E+10	2.14
U-236	3.6E+11	2.5	1.1E+08	2.63
U-238	1.2E+13	1.65	5.9E+11	2.4
Np-237	2.4E+11	2.03	1.5E+08	1.89
Pu-238	5.9E+11	2.05	1.7E+11	2.53
Pu-239	2.7E+12	1.64	5.2E+11	1.9
Pu-240	5.6E+11	1.69	8.9E+10	1.96
Pu-241	3.0E+12	1.69	3.7E+11	1.93
Pu-242	1.1E+08	1.66	4.1E+07	2.19
Pu-244	7.0E-01	2.71	2.5E-06	2.64
Am-241	4.4E+11	1.65	8.1E+10	1.81
Am-242m	2.4E+08	2.18	3.7E+06	2.63
Am-243	5.6E+08	1.89	4.8E+07	2.7
Cm-243	4.8E+06	1.9	1.4E+06	2.67
Cm-244	1.5E+10	1.72	2.2E+08	2.17
Cm-245	5.2E+08	2.12	8.5E+06	2.76
Cm-246	8.5E+07	2.21	*Negligible*	
Cm-247	6.7E+05	2.6	*Negligible*	
Cm-248	5.9E-12	2.83	*Negligible*	
Cf-249	3.5E+03	2.2	*Negligible*	
Cf-250	2.7E+03	2.58	*Negligible*	
Cf-251	1.7E+08	2.56	*Negligible*	
Total	1.9E+16		1.2E+16	

Negligible – No disposal recorded; inventory assumed to be negligible.
Bq – Becquerel

The volume of waste disposed at the Area 3 RWMS is divided equally (approximately) between the pre- and post-1988 period (Figure 1). Since 2000, the inventory has been disposed predominately in the post-1988 period (Figure 2).

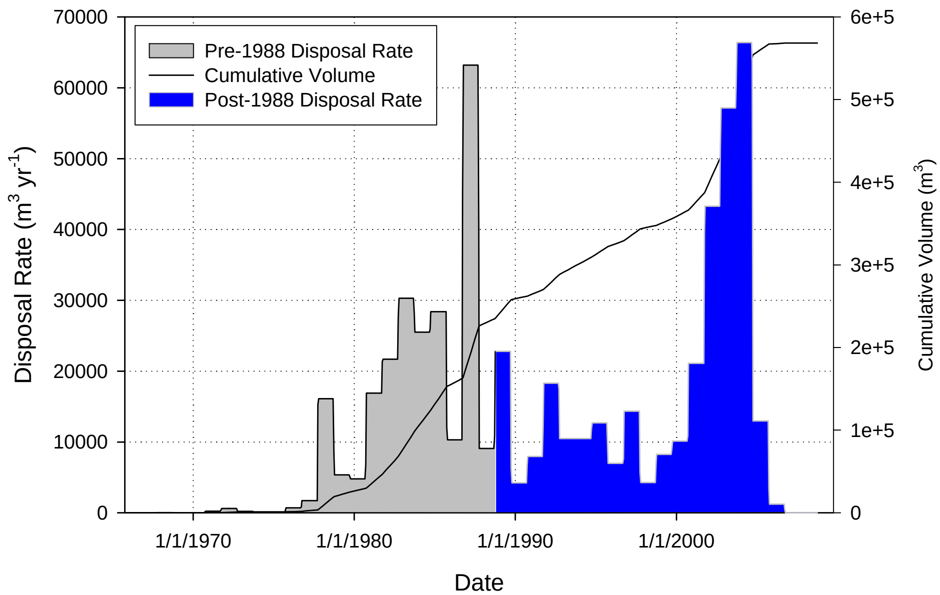

Figure 1
Volume Disposed per Year and the Arithmetic Mean of Cumulative Volume for the Area 3 RWMS

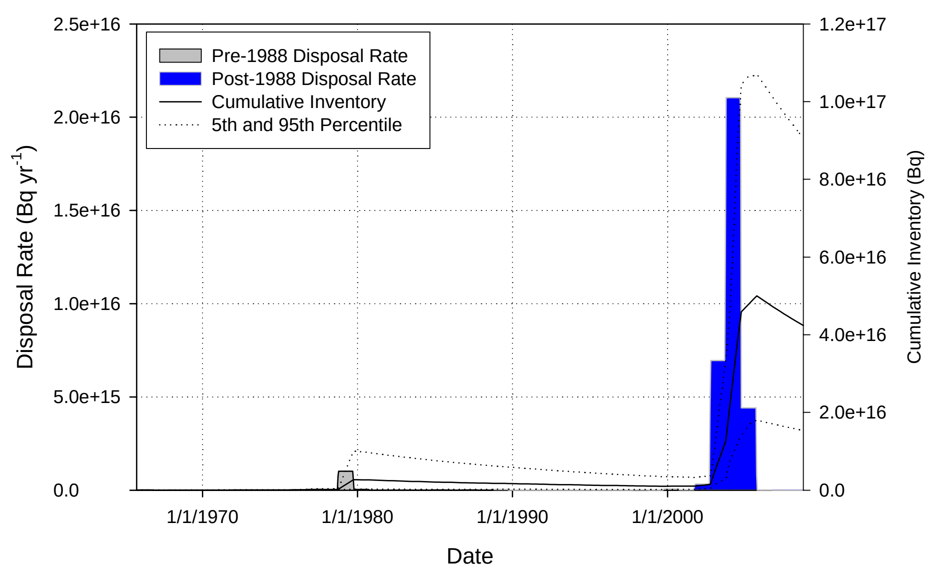

Figure 2
Activity Annual Disposal and Inventory for the Area 3 RWMS

2.1.3.3 *FY 2006 Closure Inventory Estimate for the Area 5 RWMS*

The Area 5 RWMS PA GoldSim model divides the site inventory into three virtual disposal units based on the depth of burial. Most wastes are disposed in the shallow land burial (SLB) disposal unit below a 4-meter (m) (13-foot [ft]) cover. Wastes capable of producing significant ^{222}Rn flux densities are disposed below thicker covers in two radium disposal units (RaDUs), the lower cell of Pit 6 (P06U) and Pit 13 (P013U). High-specific-activities wastes have been disposed in GCD boreholes. The inventory of the three virtual disposal units is further divided into pre- and post-1988 portions.

The FY 2006 estimate of the Area 5 RWMS closure inventory was prepared using the Area 5 Inventory v2.021 GoldSim model. The model sums past disposals, revisions, and future inventory estimates probabilistically. Stochastic distributions are sampled each FY during operations. Radioactive decay and ingrowth during the operational period are explicitly included in the model. The estimated inventories are decayed until the assumed date of closure on September 30, 2028.

The SLB inventory is divided into pre-1988, post-1988, and future inventories (Table 5). Closure of the Area 3 RWMS has had the effect of increasing the Area 5 RWMS future SLB inventory and reducing the uncertainty in the future inventory. Previously, the division of future waste between the Area 3 and Area 5 RWMSs was a source of future inventory uncertainty.

Two long-lived radionuclides, selenium-79 and rubidium-87 (not previously disposed), were added to the inventory in FY 2005 and FY 2006. The closure inventory of these nuclides are approximately 37 GigaBecquerel or less, and are unlikely to have any significant impact on performance.

The arithmetic mean SLB volume estimate has increased from 5.5×10^5 to 6.3×10^5 m^3 (1.9×10^7 to 2.2×10^7 ft^3) between FY 2005 and FY 2006 (Figure 3). The arithmetic mean post-1988 SLB volume has increased from 3.7×10^5 to 4.6×10^5 m^3 (1.3×10^7 to 1.6×10^7 ft^3).

The geometric mean closure inventory estimate has increased slightly from 1.1×10^5 TBq last year to 1.2×10^5 TBq (Figure 4). The geometric mean post-1988 closure inventory estimate has increased slightly from last year from 7.0×10^4 to 7.8×10^4 TBq.

RaDU Inventory

The lower cell of Pit 6 (P06U) and Pit 13 (P013U) were excavated to greater depth to contain thorium wastes that have the potential to generate ^{222}Rn in the future as ^{226}Ra is produced by the decay of ^{230}Th. The inventory of both disposal units is dominated by ^{232}Th. The lower cell of Pit 6 was operational from FY 1992 until FY 2002. The Pit 6 inventory remains unchanged from previous years. Pit 13 began operations in FY 2004 with disposal of the Defense National Stockpile Center thorium nitrate waste stream. The entire thorium nitrate waste stream was disposed in FY 2004 and FY 2005. Pit 13 remains open for disposal of additional radium-bearing waste streams and other low-level wastes. The inventory of wastes disposed in Pit 6 and Pit 13 through FY 2006 are summarized in Table 6.

Table 5
FY 2006 Estimate of the Area 5 RWMS SLB Inventory
(Estimates are calculated from 500 Monte Carlo realizations and decayed to October 1, 2028.)

Nuclide	Pre-1988 SLB		Post-1988 SLB		Future SLB	
	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation
H-3	3.1E+16	1.56	3.1E+16	1.56	3.4E+16	1.96
C-14	2.6E+11	1.56	1.6E+11	1.77	3.4E+10	1.9
Al-26	8.1E+06	1.7	3.7E+04	2.29	*Negligible*	
Cl-36	4.4E+10	1.64	2.3E+08	2.15	3.6E+06	4.73
Ar-39	2.0E+11	1.67	9.6E+08	2.29	*Negligible*	
K-40	1.2E+10	1.6	1.2E+10	1.58	2.8E+09	2.79
Ca-41	3.3E+11	1.65	1.5E+09	2.23	3.7E+05	137.09
Co-60	2.0E+12	2.26	2.0E+14	2.01	6.3E+12	8.86
Ni-59	8.5E+09	1.65	2.3E+11	2.09	2.3E+08	5.08
Ni-63	6.3E+11	1.66	2.4E+13	2.13	6.7E+10	2.27
Se-79	*Negligible*		4.4E+10	2.22	*Negligible*	
Kr-85	4.1E+11	2.24	5.2E+09	1.85	7.4E+08	4.73
Sr-90	1.5E+15	3.55	3.0E+13	2.25	4.4E+12	4.16
Zr-93	1.1E+09	1.6	1.8E+07	1.82	5.2E+03	22.71
Nb-93m	1.1E+11	1.66	9.6E+08	2.31	2.4E+03	17.58
Nb-94	2.8E+11	1.65	1.6E+09	2.04	2.1E+06	9.48
Tc-99	1.2E+13	2.39	1.3E+14	2.39	1.4E+13	4.43
Pd-107	4.8E+07	1.61	3.4E+05	1.85	*Negligible*	
Ag-108m	*Negligible*		4.4E+06	2.34	3.5E+05	13.37
Cd-113m	8.9E+10	1.67	8.9E+08	2.27	*Negligible*	
Sn-121m	2.4E+12	1.64	1.4E+10	2.34	*Negligible*	
Sn-126	4.8E+08	1.6	4.8E+08	2.08	6.3E+03	24.49
I-129	3.6E+07	1.56	1.3E+09	1.76	2.0E+08	4.55
Ba-133	1.8E+08	2.54	1.2E+09	1.93	1.5E+09	6.17
Cs-135	8.5E+08	1.61	9.6E+06	1.81	2.5E+03	14.07
Cs-137	3.7E+15	2.84	5.9E+14	2.48	6.7E+13	7.86
Pm-145	*Negligible*		8.1E+04	2.23	1.7E+04	45.62
Pm-146	*Negligible*		5.6E+04	2.07	4.1E+03	21.61
Sm-146	*Negligible*		1.9E-02	2.1	2.6E-02	133.55
Sm-151	1.0E+12	1.6	7.8E+09	1.89	3.7E+06	3.06
Eu-150	3.5E+11	1.76	2.1E+09	2.55	*Negligible*	
Eu-152	2.5E+12	2.05	4.8E+13	2.05	1.1E+12	84.6
Eu-154	3.0E+11	1.93	3.4E+13	2.03	3.7E+11	103.45

Table 5
FY 2006 Estimate of the Area 5 RWMS SLB inventory
(continued)

Nuclide	Pre-1988 SLB		Post-1988 SLB		Future SLB	
	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation
Gd-148	*Negligible*		1.5E+04	1.72	5.2E+03	2.75
Gd-152	1.6E+00	2.11	3.7E+00	2.05	3.0E-02	90.5
Ho-166m	1.1E+10	1.64	4.8E+07	2.32	*Negligible*	
Bi-207	5.9E+05	3.03	1.3E+07	1.97	5.9E+05	12.54
Pb-210	1.1E+12	2.52	4.4E+10	1.54	2.7E+10	2.01
Ra-226	1.4E+12	2.53	5.6E+10	1.6	3.6E+10	2.14
Ra-228	4.1E+10	2.08	5.2E+11	1.53	2.6E+11	2.04
Ac-227	1.1E+10	1.59	2.8E+09	1.4	8.1E+08	1.56
Th-228	5.6E+10	1.77	6.7E+11	1.49	2.6E+11	1.94
Th-229	1.6E+08	1.83	8.9E+08	1.78	1.4E+08	2.02
Th-230	3.7E+10	1.59	2.2E+11	1.59	1.7E+11	2.6
Th-232	4.1E+10	2.08	Negligible		3.0E+11	2.05
Pa-231	7.0E+09	1.62	3.7E+09	1.46	8.9E+08	1.49
U-232	1.1E+10	1.66	1.2E+11	2.07	1.3E+10	3.64
U-233	3.4E+10	1.89	3.0E+11	1.96	6.3E+10	2.37
U-234	7.8E+13	1.73	7.8E+13	1.44	2.5E+13	1.53
U-235	3.1E+12	1.75	3.3E+12	1.38	1.3E+12	1.41
U-236	1.0E+12	2.36	2.3E+12	1.55	4.8E+11	2.19
U-238	8.9E+13	1.9	1.3E+14	1.44	5.9E+13	1.49
Np-237	2.1E+11	1.74	4.8E+10	1.45	7.4E+09	1.94
Pu-238	5.9E+12	1.65	2.5E+12	1.53	1.3E+12	1.56
Pu-239	1.2E+13	1.65	4.8E+12	1.47	1.6E+12	1.41
Pu-240	2.9E+12	1.64	1.1E+12	1.47	3.6E+11	1.42
Pu-241	3.4E+12	1.64	2.5E+12	1.41	1.7E+12	1.34
Pu-242	6.7E+08	1.48	4.8E+11	2.2	3.6E+10	26.42
Pu-244	4.8E+09	3.92	4.4E+04	2.26	1.4E+03	114.76
Am-241	3.7E+12	1.47	1.2E+12	1.39	3.1E+11	1.36
Am-242m	*Negligible*		1.6E+09	1.75	3.7E+06	3.26
Am-243	4.8E+08	2.13	1.1E+09	1.81	6.7E+07	2.18

Table 5
FY 2006 Estimate of the Area 5 RWMS SLB inventory (continued)

Nuclide	Pre-1988 SLB		Post-1988 SLB		Future SLB	
	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation
Cm-243	5.9E+09	2.13	8.1E+07	1.72	1.0E+07	2.41
Cm-244	7.0E+10	2.64	2.1E+11	2.32	4.1E+10	4.05
Cm-245	1.4E+05	2.86	3.1E+09	1.99	2.2E+07	10.69
Cm-246	8.1E+04	2.5	5.2E+08	1.98	4.1E+06	6.77
Cm-247	*Negligible*		6.7E+00	1.89	1.6E-01	261.13
Cm-248	6.7E+04	2.93	1.7E+03	1.82	5.2E+02	5.39
Cf-249	*Negligible*		1.8E+07	1.95	6.3E+05	2.78
Cf-250	2.5E+05	2.12	1.3E+05	2.35	7.0E+03	27.59
Cf-251	*Negligible*		5.9E+06	1.9	6.7E+05	12.3
Total	3.7E+16		3.3E+16		3.4E+16	

Negligible – No disposal recorded; inventory assumed to be negligible.
Bq – Becquerel

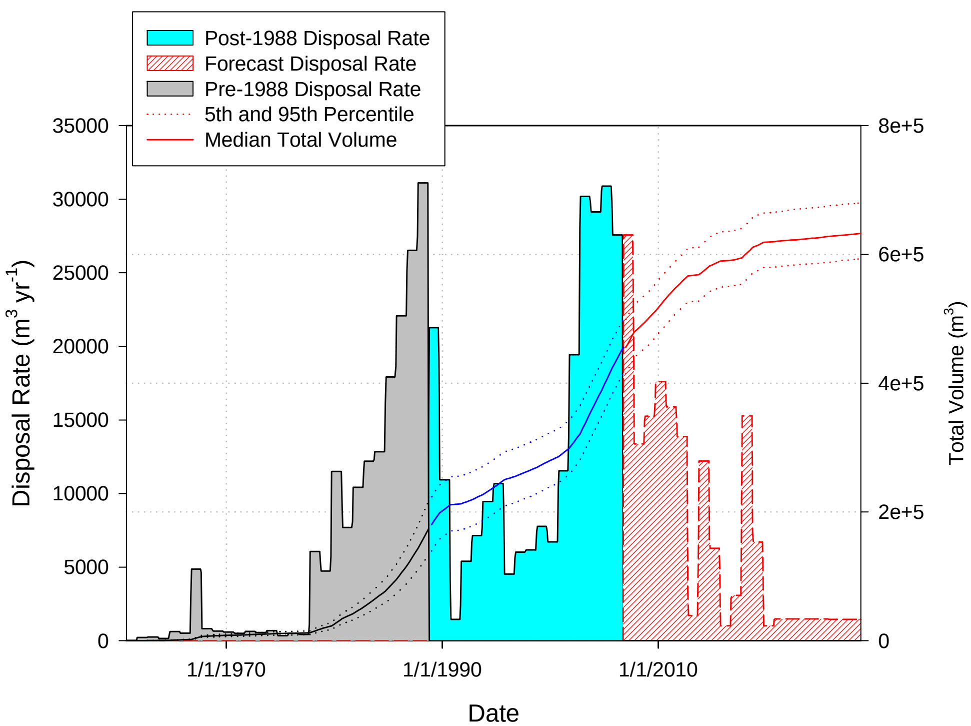

Figure 3
Volume Disposed per Year and Median of Cumulative Volume for the Area 5 RWMS Shallow Land Burial Disposal Units

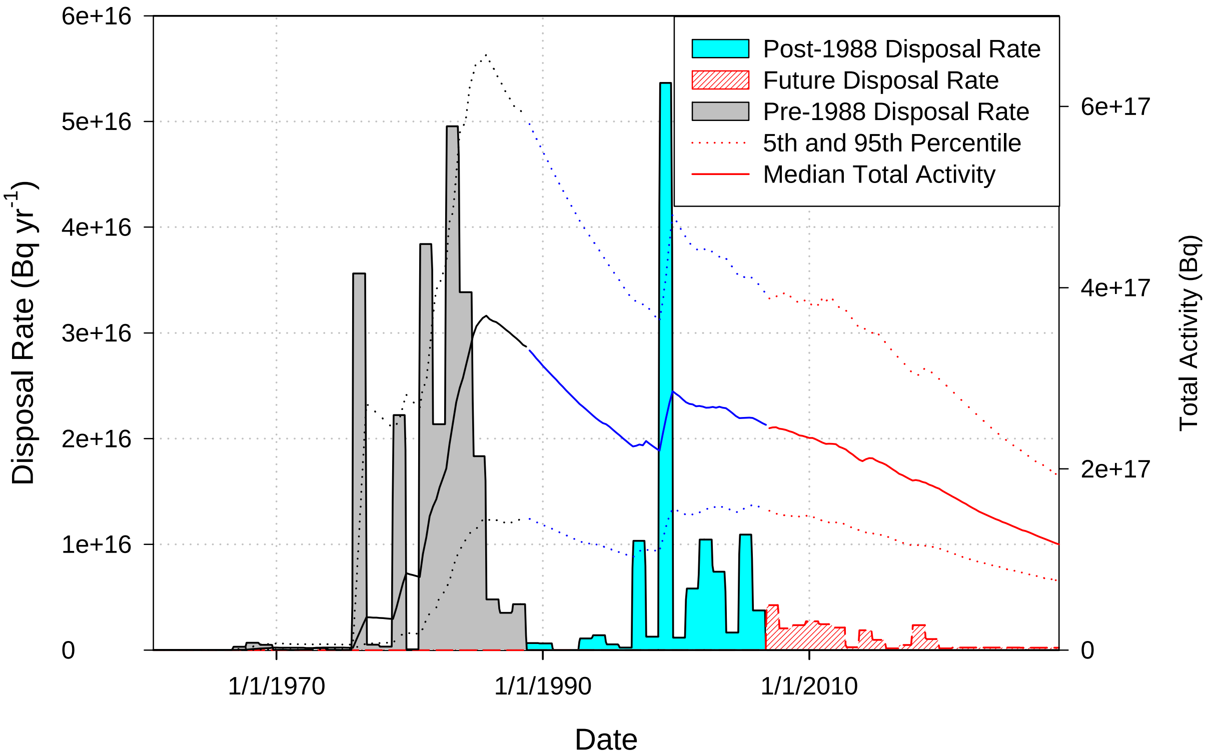

Figure 4
Activity Annual Disposal Rate and Median Inventory for the Area 5 RWMS Shallow Land Burial Disposal Units

Table 6
Estimate of the Area 5 RWMS RaDU Inventory Disposed through FY 2006
(Estimates are calculated from 500 Monte Carlo realizations and decayed to October 1, 2028.)

Nuclide	P06U		P013U	
	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation
H-3	*Negligible*		4.4E+07	2.21
Co-60	*Negligible*		7.4E+06	2.27
Ni-63	*Negligible*		4.8E+07	2.16
Sr-90	2.0E+07	2.8	5.9E+09	2.29
Tc-99	8.9E+08	2.7	1.3E+10	2.09
Sn-126	*Negligible*		1.5E+07	2.25
Cs-137	*Negligible*		8.5E+09	2.18
Eu-152	*Negligible*		1.1E+07	2.16
Eu-154	*Negligible*		1.6E+07	2.14
Gd-152	*Negligible*		8.9E-07	2.15
Pb-210	7.0E+09	1.67	7.0E+10	1.5
Ra-226	2.0E+10	1.68	1.4E+11	1.49
Ra-228	5.6E+12	1.63	5.6E+12	1.04
Ac-227	2.3E+06	1.9	1.6E+05	2.15
Th-228	5.6E+12	1.63	5.6E+12	1.04
Th-229	4.8E+09	2.21	2.1E+02	2.03
Th-230	1.5E+12	1.7	1.9E+12	2.05
Th-232	5.9E+12	1.64	5.9E+12	1.04
Pa-231	6.3E+06	1.9	5.2E+05	2.15
U-232	*Negligible*		2.0E+08	2.15
U-233	1.8E+12	2.2	1.9E+05	2.03
U-234	1.7E+11	1.8	6.3E+09	2.18
U-235	9.3E+09	1.91	1.1E+09	2.16
U-236	1.9E+08	2.12	3.0E+01	2.07
U-238	2.1E+11	1.84	1.1E+11	2.07
Np-237	8.1E+05	2.6	1.9E+09	2.03
Pu-238	1.3E+10	1.93	4.1E+08	2.03
Pu-239	3.3E+06	2.16	8.9E+09	1.92
Pu-240	*Negligible*		4.4E+07	2.08
Pu-241	1.1E+10	2.18	6.3E+09	2.21
Am-241	1.0E+09	2.19	1.4E+09	1.85
Total	2.1E+13		2.1E+13	

Negligible – No disposal recorded; inventory assumed to be negligible.
Bq – Becquerel

<u>GCD Inventories</u>

The GCD boreholes have received high-specific-activity wastes, including transuranic (TRU) waste regulated under Title 40 CFR 191. The GCD boreholes were active from FY 1984 through FY 1991. The PA divides the GCD inventory into pre- and post-1998 portions. The majority of the waste on an activity and volume basis was disposed in the pre-1988 period. The GCD inventories are unchanged from previous years (Table 7).

2.1.4 Closure

The Area 3 RWMS PA/CA assumes that the disposal units will be closed with a vegetated monolayer cover of native alluvium. The cover is assumed to be 3 m (10 ft) thick after subsidence. This was a conservative assumption consistent with closure the plan for U-3ax/bl.

The 1998 Area 5 RWMS PA assumes that the site will be closed with a 2.4-m (8-ft) vegetated monolayer cover. This was a conservative assumption consistent with the operational covers that were installed when the PA was prepared. After 100 years of active institutional control (IC), the integrity of the cover is assumed to degrade by erosion and subsidence. The 2006 Area 5 RWMS PA update and the Area 5 RWMS v4.001 GoldSim model assume that a 4-m- (13-ft)-thick closure cover, consistent with the Area 5 RWMS DAS requirements, will be installed.

No significant changes are seen in closure planning since the revised ICMP (BN, 2005). The PA and CA assumptions continue to be consistent with or are more conservative than the closure plans. The current closure plan is to use monolayer evapotranspiration (ET) closure covers. Closure cover thickness will be specified in specific closure plans for each disposal unit.

2.1.5 Updated PA Results for FY 2006

Revised PA models and inventories were issued in FY 2006. The new models and inventories were used to update the PA results for the Area 3 and Area 5 RWMSs.

2.1.5.1 *PA Results for the Area 3 RWMS*

Updated PA results for the Area 3 RWMS were estimated using the FY 2006 inventory and the Area 3 RWMS v2.0 GoldSim model. The model was run with cover maintenance disabled, effectively eliminating subsidence. The results should be considered preliminary until the consequences of subsidence are incorporated. The model was run in GoldSim v9.21 with 2,000 Latin hypercube realizations of 1,000 years' duration.

The updated PA results for U-3ah/at and U-3bh show increases for all performance objectives, except the air pathway (Tables 8 and 9). These increases reflect changes in model assumptions, model parameters, and the closure inventory. The mean and 95th percentile of all results are less than the performance objective for both disposal units. The Area 3 RWMS PA results are considered valid, but the PA should be revised when the final closure configuration is determined.

2.1.5.2 *PA Results for the Area 5 RWMS*

The FY 2006 Area 5 RWMS inventory was analyzed using the Area 5 RWMS v4.001 GoldSim model to assess the continuing validity of PA conclusions. The geometric mean inventory and standard deviation data listed in Tables 3 through 7 were entered into the inventory elements for

Table 7
FY 2006 Estimate of the Area 5 RWMS GCD Borehole Inventory
(Estimates are calculated from 500 Monte Carlo realizations and decayed to October 1, 2028.)

Nuclide	Pre-1988 GCD		Post-1988 GCD	
	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation
H-3	2.00E+16	1.97	1.85E+14	2.15
C-14	6.66E+04	2.59	*Negligible*	
Al-26	2.63E+00	2.62	*Negligible*	
Cl-36	1.52E+04	2.58	*Negligible*	
Ar-39	7.03E+04	2.67	*Negligible*	
K-40	4.07E+03	2.48	*Negligible*	
Ca-41	1.07E+05	2.61	*Negligible*	
Co-60	9.62E+11	2.26	*Negligible*	
Ni-59	2.78E+03	2.57	*Negligible*	
Ni-63	2.26E+05	2.62	*Negligible*	
Kr-85	6.29E+04	2.49	*Negligible*	
Sr-90	5.18E+15	3.81	1.18E+08	3.74
Zr-93	3.66E+02	2.48	*Negligible*	
Nb-93m	6.29E+04	2.63	*Negligible*	
Nb-94	8.51E+04	2.69	*Negligible*	
Tc-99	7.77E+09	3.07	7.03E+09	3.63
Pd-107	1.67E+01	2.48	*Negligible*	
Cd-113m	5.92E+04	2.65	*Negligible*	
Sn-121m	9.62E+05	2.64	*Negligible*	
Sn-126	1.59E+02	2.48	*Negligible*	
I-129	8.51E+00	2.48	*Negligible*	
Cs-135	2.92E+02	2.48	*Negligible*	
Cs-137	2.55E+14	3.61	*Negligible*	
Sm-151	3.70E+05	2.49	*Negligible*	
Eu-150	1.48E+05	2.86	*Negligible*	
Eu-152	4.44E+05	2.61	*Negligible*	
Eu-154	9.25E+04	2.63	*Negligible*	
Gd-152	1.07E-07	2.6	*Negligible*	
Ho-166m	3.40E+03	2.63	*Negligible*	
Pb-210	2.66E+12	3.78	4.44E+04	2.2
Ra-226	3.55E+12	3.78	1.41E+05	2.2
Ra-228	9.62E+08	2.94	3.66E-08	3.62
Ac-227	7.03E+10	3.82	6.29E+05	2.3

Table 7
FY 2006 Estimate of the Area 5 RWMS GCD Borehole Inventory
(continued)

Nuclide	Pre-1988 GCD		Post-1988 GCD	
	Geometric Mean (Bq)	Geometric Standard Deviation	Geometric Mean (Bq)	Geometric Standard Deviation
Th-228	9.62E+08	2.94	3.11E-08	3.61
Th-229	8.14E+01	1.67	5.18E+01	2.12
Th-230	5.92E+07	2.87	1.63E+07	2.2
Th-232	9.62E+08	2.94	5.55E-08	3.62
Pa-231	4.81E+06	2.85	1.44E+06	2.3
U-232	4.07E+03	2.58	*Negligible*	
U-233	4.07E+04	1.66	2.85E+04	2.12
U-234	1.44E+11	2.85	4.44E+10	2.2
U-235	5.18E+09	2.83	1.70E+09	2.3
U-236	3.70E+08	3.63	5.55E+01	3.62
U-238	3.63E+10	2.35	8.14E+10	2.12
Np-237	2.44E+08	1.65	1.67E+08	2.12
Pu-238	3.00E+11	2.75	4.07E+06	3.61
Pu-239	1.63E+13	2.78	2.26E+08	3.63
Pu-240	3.70E+12	2.74	4.81E+07	3.62
Pu-241	4.07E+12	3.01	6.66E+07	3.75
Pu-242	3.55E+08	2.75	*Negligible*	
Am-241	5.92E+12	2.12	4.07E+07	3.63
Am-243	3.37E+01	2.52	*Negligible*	
Cm-244	7.40E+03	2.48	*Negligible*	
Total	2.55E+16		1.85E+14	

Negligible – No disposal recorded; inventory assumed to be negligible.
Bq – Becquerel

Table 8
PA Results for the U-3ah/at Disposal Unit

Performance Objective/Scenario	Limit	2000 Area 3 RWMS PA		FY 2006 Summary	
		Mean	95th Percentile	Mean	95th Percentile
Air Pathway (mSv/yr)	0.1	2E-5	6E-5	5E-6	1.6E-4
All Pathways (mSv/yr)	0.25	4E-5	1E-4	9E-4	0.18
Radon Flux Density (Bq/m^2/s)	0.74	3.7E-4	1.5E-3	1.1E-2	3.5E-2
Intruder/Agriculture (mSv)	1	5E-4	NA	3.6E-2	0.12
Intruder/Postdrilling (mSv)	1	3E-5	NA	1.3E-2	4.9E-2

mSv/yr -- milliSievert per year.
Bq/m^2/s -- Becquerel per square meter per second.
NA – Monte Carlo simulation results are not available.

Table 9
PA Results for the U-3bh Disposal Unit

Performance Objective/Scenario	Limit	Area 3 RWMS PA		FY 2006 Summary	
		Mean	95th Percentile	Mean	95th Percentile
Air Pathway (mSv/yr)	0.1	4E-5	9E-5	5E-6	1.6E-4
All Pathways (mSv/yr)	0.25	4E-5	1E-4	9E-4	0.18
Radon Flux Density (Bq/m^2/s)	0.74	2E-4	7E-4	7.9E-2	0.28
Intruder/Agriculture (mSv)	1	3E-4	NA	0.26	NA
Intruder/Postdrilling (mSv)	1	5E-4	NA	9.6E-3	3E-2

mSv/yr -- milliSievert per year.
Bq/m^2/s -- Becquerel per square meter per second.
NA – Monte Carlo simulation results are not available.

the SLB units, Pit 6, Pit 13, and GCD, respectively. The disposal unit area, disposal unit volume, and waste volumes were updated with FY 2006 data. All SLB disposal units were assumed to be closed with a 4-m- (13-ft)-thick cover. The model was run assuming a 250-year (approximately) median period of active IC, 100-year period of passive IC, and a 1,000-year compliance period. The model was run in GoldSim v9.21 with 1,000 Latin hypercube samples.

The results for the FY 2006 SLB inventory indicate that there is reasonable expectation of compliance with the performance objectives (Table 10). The mean for the atmospheric pathway for all scenarios is less than the 0.1 mSv/yr limit. The mean for the all-pathways compliance scenarios, the transient occupancy, and open rangeland scenario are less than the 0.25 mSv/yr performance objective. The resident farmer scenario is a low-probability scenario analyzed to evaluate the impact of agricultural pathways. The mean for the resident farmer scenario, 0.003 mSv/yr, indicates that there is a reasonable expectation of compliance, even in the unlikely event that a future resident is engaged in agriculture at the site. The resident farmer total effective dose equivalent (TEDE) is mostly attributable to ingestion of Tc-99 in food produced on site. The mean ^{222}Rn flux density is less than the 0.74 Bq/m^2/s performance objective. The mean of the probability weighted intruder TEDE is less than the 1 mSv performance objective for the postdrilling and intruder-agriculture scenario. The 95th percentile of all scenarios is less than the performance objective, indicating that there is a high probability of compliance.

The results for the FY 2006 Pit 6 inventory indicate that there is a reasonable expectation of compliance with the performance objectives (Table 11). The probability weighted mean intruder TEDEs are less than the 1 mSv performance objective for both intrusion scenarios. The 95th percentiles for both scenarios are less than the performance objective, indicating a high expectation of compliance.

The results for the FY 2006 Pit 13 inventory indicate that there is a reasonable expectation that current inventory meets all performance objectives (Table 12). The mean of the ^{222}Rn flux density (0.52 Bq/m/s) is less than the performance objectives. The 95th percentile (1.6 Bq/m/s) exceeds the performance objective. The 95th percentiles of all other performance objectives are less than the performance objective, indicating that there is a high probability of compliance.

Table 10
Area 5 RWMS v4.001 GoldSim Model PA Results

Pathway/Scenario	Limit	2006 Area 5 RWMS PA Update		FY 2006 Summary	
		Mean	95th Percentile	Mean	95th Percentile
Air Pathway/Transient Occupancy (mSv/yr)	0.10	4.1E-5	3.7E-4	5.3E-6	NA
Air Pathway/Resident Farmer (mSv/yr)	0.10	1.1E-5	9.9E-5	3.8E-6	8.3E-6
Air Pathway/Open Rangeland – Cane Springs (mSv/yr)	0.10	2.5E-8	2.2E-7	2.5E-9	NA
Air Pathway/Open Rangeland – NTS Boundary (mSv/yr)	0.10	2.3E-7	2.0E-6	3.4E-8	NA
All-Pathways/Transient Occupancy (mSv/yr)	0.25	1.5E-3	3.4E-3	1.1E-3	2.5E-3
All-Pathways/Resident Farmer (mSv/yr)	0.25	0.044	0.039	3.3E-3	NA
All-Pathways/Open Rangeland - Cane Spring (mSv/yr)	0.25	0.022	0.018	1.4e-3	NA
All-Pathways/Open Rangeland - NTS Boundary (mSv/yr)	0.25	0.044	0.033	3.6E-3	1E-4
Radon Flux Density ($Bq/m^2/s$)	0.74	0.044	0.096	0.043	0.082
Chronic Intruder/Agriculture (mSv) Shallow Land Burial (SLB)	1	0.12	0.43	0.026†	0.10†
Chronic Intruder/Postdrilling SLB (mSv)	1	4.2E-3	1.2E-3	2.5E-3‡	7.8E-3‡

† – Results weighted with 0.12 scenario probability.
‡ – Results weighted with 0.16 scenario probability.
NA – not available; insufficient non-zero realizations.

Table 11
Area 5 RWMS v4.001 GoldSim Model PA Results for Pit 6

Pathway/Scenario	Limit	2006 Area 5 RWMS PA Update		FY 2006 Summary	
		Mean	95th Percentile	Mean	95th Percentile
Radon Flux Density ($Bq/m^2/s$)	0.74	0.043	0.12	0.041	0.10
Chronic Intruder/Agriculture (mSv)	1	4.1E-3	7.2E-5	8.1E-4†	2.4E-3†
Chronic Intruder/Postdrilling (mSv)	1	2.0E-3	4.8E-3	7.0E-4§	1.8E-3§

† – Results weighted with 0.0047 scenario probability.
§ – Results weighted with 0.0039 scenario probability.

Table 12
Area 5 RWMS v4.001 GoldSim Model PA Results for Pit 13

Pathway/Scenario	Limit	2006 Area 5 RWMS PA Update		FY 2006 Summary	
		Mean	95th Percentile	Mean	95th Percentile
Radon Flux Density (Bq/m^2/s)	0.74	0.33	1.0	0.52	1.6
Chronic Intruder/Agriculture (mSv)	1	1.5E-3	5.1E-1	5.2E-4[†]	1.8E-3[†]
Chronic Intruder/Postdrilling (mSv)	1	1.6E-3	3.0E-3	1.3E-3[‡]	2.6E-3[‡]

† – Results weighted with 0.0065 scenario probability.
§ – Results weighted with 0.0065 scenario probability.

The air pathway results all show a significant decrease for FY 2006. The Area 5 RWMS PA v4.001 model uses an active and passive IC period which is longer than previous versions. In previous model versions, the maximum dose for the air pathway occurred at the end of the IC period. With the use of a longer IC period, the maximum dose shifts to the end of the compliance period. The all-pathway results also show decreases. The decrease is smallest for the transient occupancy scenario, which previously had a maximum dose at 1,000 years. Overall, the current results show small decreases from the 2006 Area 5 RWMS PA update. The Area 5 RWMS PA results are still considered valid and there is no need to revise the PA at this time.

2.2 Monitoring and Research and Development Results

2.2.1 Monitoring

Monitoring activities at the Area 3 and 5 RWMSs and at the NTS provide the data necessary to support PA and CA maintenance. The *Routine Radiological Environmental Monitoring Plan* (BN, 2003) is the basis for all NTS-wide environmental surveillance, site-specific effluent monitoring, and operational monitoring conducted by various missions, programs, and projects on the NTS. The ICMP (BN, 2005) describes the specific monitoring programs for the waste disposal facilities at the NTS. The program for the RWMSs includes the following monitoring elements:

- Vadose zone monitoring
- Groundwater detection monitoring (Area 5 RWMS only)
- Radon monitoring
- Meteorology monitoring
- Direct radiation monitoring
- Biota monitoring
- Subsidence monitoring
- Air monitoring

The following four reports, published annually, contain details regarding the monitoring program and results:

- *Nevada Test Site Environmental Report 2003* (e.g., BN, 2004a)
- *National Emissions Standards for Hazardous Air Pollutants Calendar Year 2003 Report* (e.g., BN, 2004b)
- Annual Waste Management Monitoring Report (e.g., BN, 2004c)
- Annual Area 5 Groundwater Monitoring Report (e.g. BN, 2004d)

Monitoring activities are summarized in Table 13.

Table 13
Summary of Area 3 and Area 5 RWMS Monitoring Programs

Monitoring Element	Area 3 RWMS	Area 5 RWMS
Vadose Zone Monitoring	• Measurements of soil water content in waste disposal unit cover • Eight drainage lysimeters for water balance since 2001	• Measurements of soil water content and water potential in waste disposal unit covers • Measurements of soil water content in waste disposal unit floor • Two weighing lysimeters (vegetated and bare) for water balance since 1994
Groundwater Monitoring	None	Resource Conservation and Recovery Act detection monitoring at three wells
Radon Monitoring	• Radon flux measurements from waste covers (various locations)	• Radon flux measurements from waste covers (various locations)
Meteorology Monitoring	• Air temperature at 3 and 10 m (10 and 33 ft) • Relative humidity at two heights • Wind speed at two heights • Wind direction at two heights • Barometric pressure • Solar radiation • Precipitation	• Air temperature at two heights • Relative humidity at two heights • Wind speed at two heights • Wind direction at two heights • Barometric pressure • Solar radiation • Precipitation
Direct Radiation Monitoring	Nine thermoluminescent dosimeters (TLDs)	Ten TLDs
Biota Monitoring	Sampling vegetation for tritium	Sampling vegetation for tritium
Subsidence Monitoring	Routine inspection of operational covers	Routine inspection of operational covers
Air Monitoring	Air particulates sampled at four locations; atmospheric moisture sampling for tritium at two locations	Air particulates sampled at two locations; atmospheric moisture sampling for tritium at two locations

2.2.1.1 *Vadose Zone Monitoring*

Vadose zone monitoring is conducted at the Area 3 and Area 5 RWMSs to confirm the key assumption of no downward pathway, to detect changes in system performance, to assess and update parameters for the GoldSim models, and to establish baseline data for long-term monitoring. Vadose zone monitoring data continue to confirm the conceptual models used in the Areas 3 and 5 PA/CAs. Recent data are particularly significant, given that annual precipitation totals for Areas 3 and 5 for 2004 and 2005 were approximately 130 to 160 percent of their long-term averages.

Two locations in Area 3 are instrumented with vadose zone monitoring sensors: (1) the closure cover of U-3ax/bl, and (2) a drainage lysimeter facility (Figure 5). U-3ax/bl is instrumented with time-domain reflectometers (TDRs) for volumetric water content measurements. Sensors are located approximately every 30 centimeters (cm) (1 ft) to a depth of 244 cm (8 ft) at four locations within the cover. Readings from these sensors were fit to a statistical distribution. This distribution is included in the Area 3 RWMS PA v2.0 model to describe the near-surface volumetric water content. The U-3ax/bl TDR data from 2005 indicate wetting fronts reached deeper than 152 cm (5 ft) by March 2005. The moisture from this wetting was removed by ET and water contents returned to baseline levels (~10 percent) by September 2005.

The Area 3 drainage lysimeters are instrumented with TDR and heat dissipation sensors to measure matric potential. This facility is used to conduct ET cover research. Currently, research is being conducted to assess the performance of ET covers under enhanced precipitation by applying irrigation to one half of the paired lysimeters to achieve a three-times natural precipitation treatment. Vadose zone model calibration using cover and lysimeter data from Area 3 are planned for 2007.

Three operational covers and two weighing lysimeters are instrumented in Area 5 (Figure 6 and 7). The 10-year vegetated lysimeter data set was used to calibrate a vadose zone flow model. Model simulations are consistent with the conceptual model that there is no downward pathway under vegetated conditions (Desotell et al., 2006). These data were also fit to a statistical distribution and used to describe the near-surface water content in the Area 5 RWMS v4.001 PA model.

2.2.1.2 *Groundwater Monitoring*

Groundwater monitoring has been conducted for a suite of radiological and chemical constituents at the three wells surrounding the Area 5 RWMS since 1993 (Figure 6). All analytical data from these wells continue to support the no groundwater pathway conceptual model used in the Area 5 RWMS PA. Additionally, elevation measurements taken at the three wells surrounding the RWMS, as well as nearby locations, indicate the uppermost aquifer is approximately 235 m (771 ft) below ground surface and is essentially flat, with very low groundwater velocities.

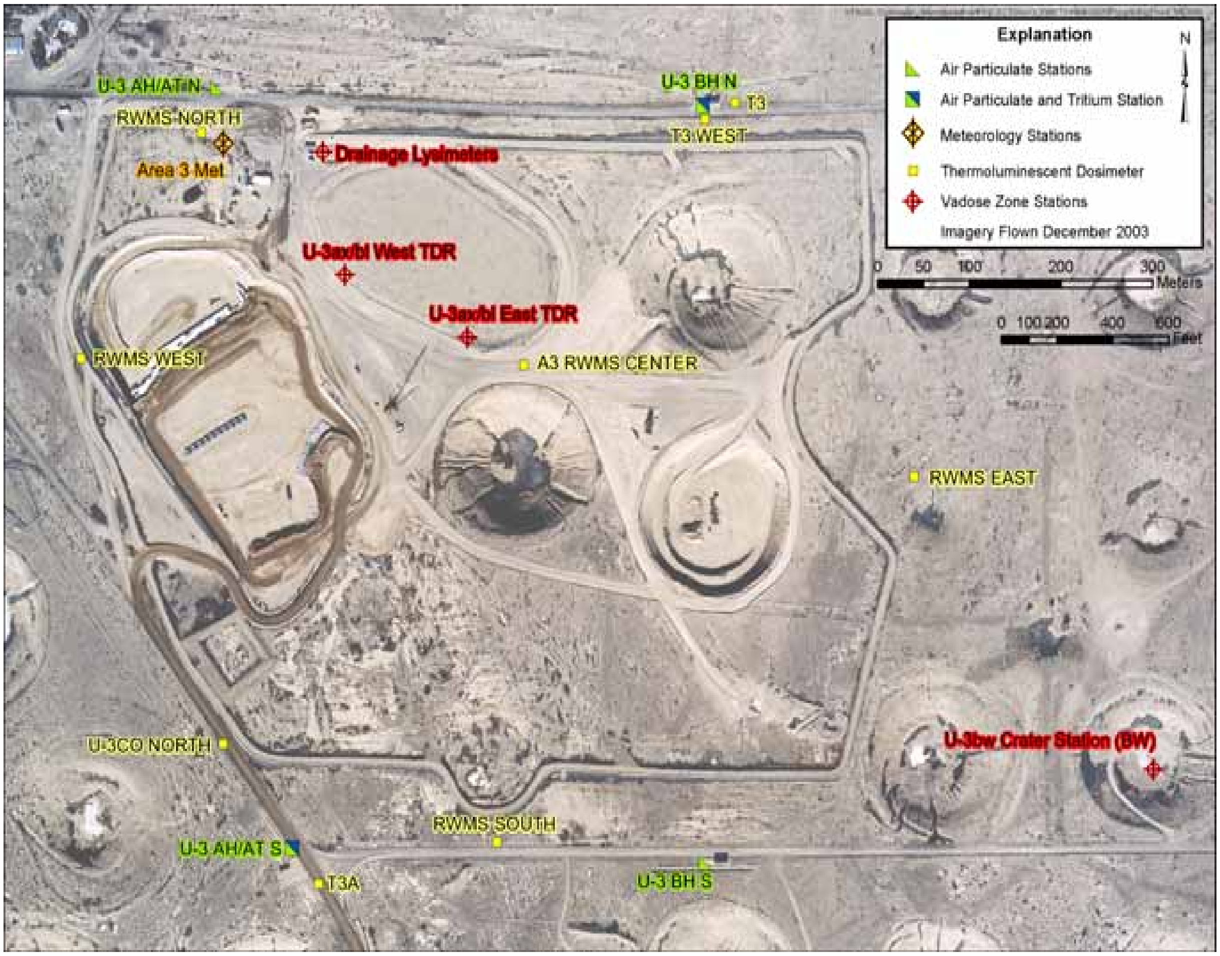

Figure 5
Monitoring Stations at the Area 3 RWMS

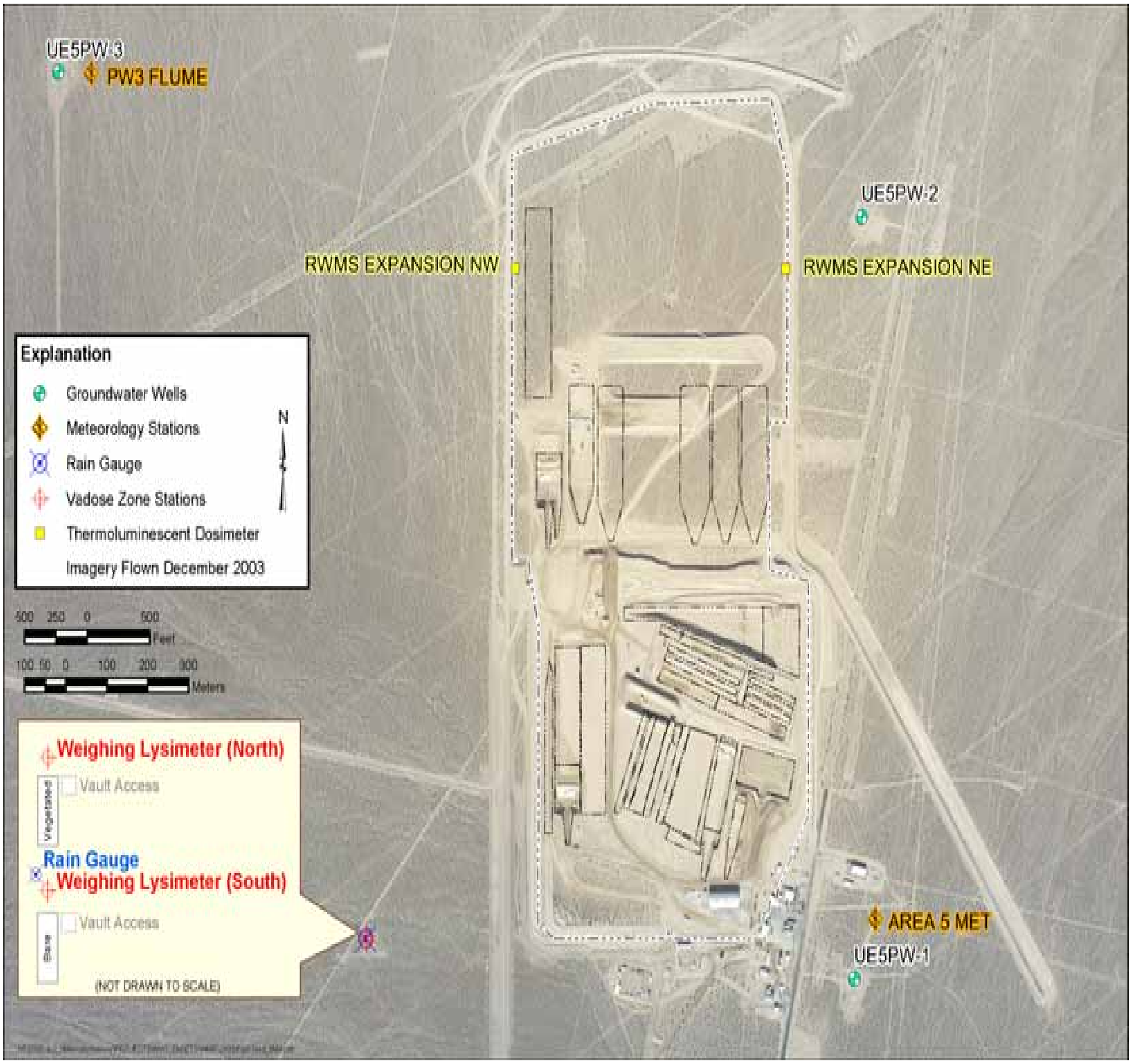

Figure 6
Location of the Area 5 RWMS Pilot Wells and Weighing Lysimeter Facility

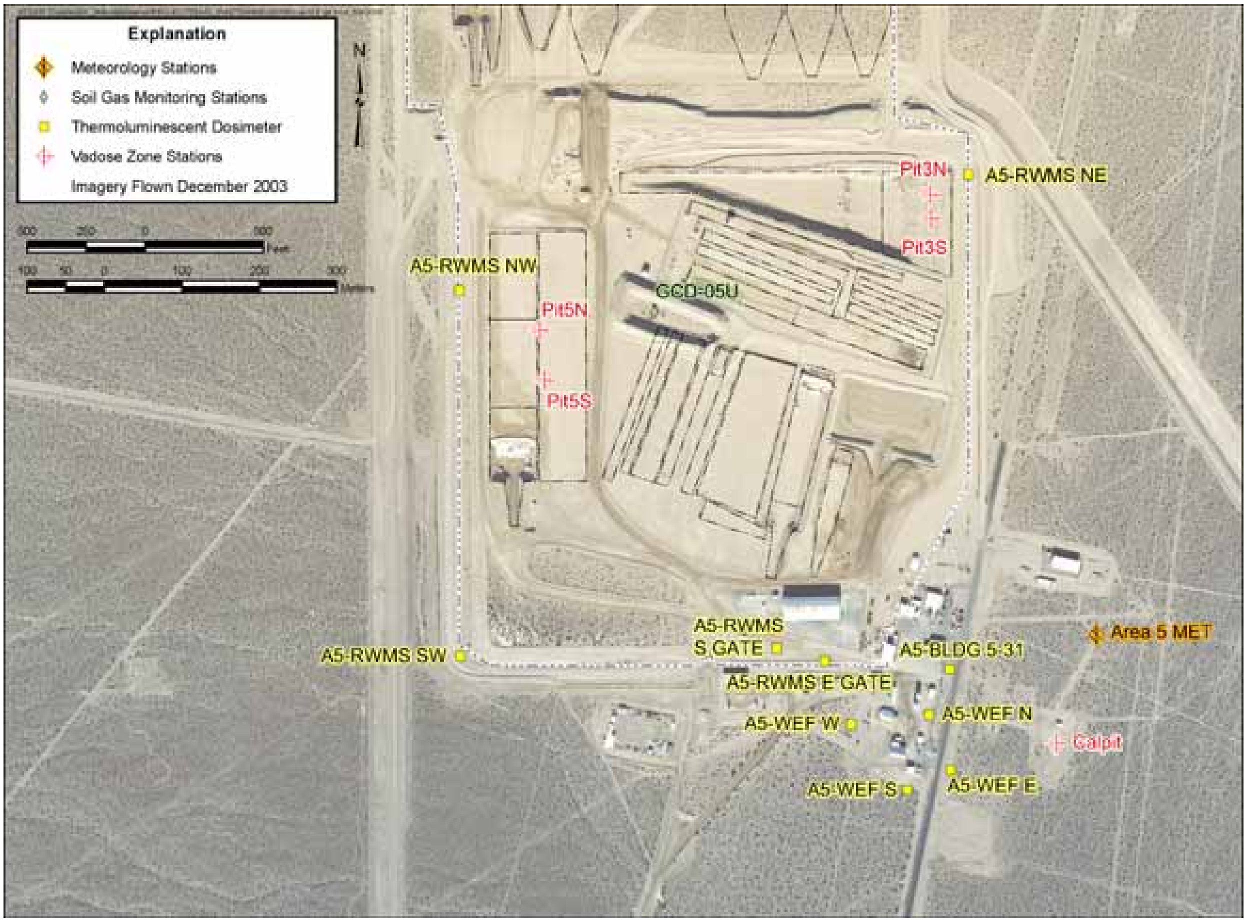

Figure 7
Monitoring Stations at the Area 5 RWMS

Groundwater is not monitored at the Area 3 RWMS. Because of the great depth to the water table (~ 490 m [1,607 ft] below ground surface) and negligible chance of recharge, a groundwater monitoring waiver was granted by the state of Nevada for the mixed waste disposal unit U-3ax/bl, which is located within the Area 3 RWMS.

2.2.1.3 *Radon Monitoring*

Radon flux monitoring has been conducted at various locations within the Area 3 and Area 5 RWMSs since 2000. Results indicate that radon flux from waste covers is similar to undisturbed background locations and well below the 0.74 Bq/m^2/s) performance objective. These results are consistent with radon flux calculations in the PA models. The mean of the 23 radon flux measurements taken in Area 5 during 2005 is 0.048 Bq/m^2/s).

2.2.1.4 *Meteorology Monitoring*

Detailed meteorological data are collected at both the Area 3 and Area 5 RWMSs (Figure 5 and 7). Measurements include precipitation, air temperature, relative humidity, wind speed and direction, barometric pressure, and incoming solar radiation. These are the basic meteorological parameters required to quantify the exchange of water and heat between the soil and atmosphere. Meteorological measurements are taken to (1) confirm that the RWMSs are sited in arid environments, (2) be used as input in process level models, and (3) refine PA/CA parameter distributions. On-site meteorological data were recently used in process level water balance modeling for the Area 5 RWMS (Desotell et al., 2006). Long-term data are being compiled to refine the wind speed distributions used in the PA/CA models. In 2005, precipitation totals were above average, totaling 21.9 cm (8.6 inches [in.]) and 20.1 cm (7.9 in.) in Areas 3 and 5, respectively. Potential evapotranspiration to precipitation ratios for 2005 are 6.9 and 7.7 for Areas 3 and 5, respectively.

2.2.1.5 *Direct Radiation Monitoring*

Exposure rates, as measured with TLDs, indicate that annual exposures at the Area 5 RWMS are within the range of exposures measured at NTS background locations. The Area 3 RWMS is located within 400 m (1,300 ft) of 14 historic atmospheric nuclear weapons tests. These tests left radioactive surface soil contamination and therefore elevated radiation exposures across the area. During disposal operations, waste is covered with clean soil. The use of clean cover material has resulted in lowering TLD readings within the Area 3 RWMS to background levels.

2.2.1.6 *Biota Monitoring*

Vegetation growing on and around waste disposal units is periodically sampled. Analyses of water distilled from these plant samples typically have detectable amounts of tritium. These data could be used in conjunction with disposal unit-specific modified PA models to evaluate the accuracy of tritium migration predictions. In 2005, 45 individual plant samples were taken from Area 5 RWMS operational covers and composited into 11 samples for tritium laboratory analysis. Sample results ranged from 48 to 7.3×10^4 Bq/liter (L), with a median of 2.0×10^3 Bq/L. Seven plant samples were taken from U-3ax/bl and composited into a single sample for tritium analysis. The U-3ax/bl composite sample result is 44 Bq/L.

2.2.1.7 *Subsidence Monitoring*

Subsidence has been formally monitored since 2000. Subsidence occurs most commonly in recently filled disposal units, especially along the edges where soil backfill may not be completely compacted. Subsided areas are repaired and documented. Prediction of the timing and magnitude of subsidence because of container collapse continues to be an area of high uncertainty where more research is needed. Twelve subsidence features were observed at the Area 5 RWMS during 2005, requiring a total of 27 m^3 (949 ft^3) of soil to repair the operational covers.

2.2.1.8 *Air Monitoring*

Air particulate samples are collected at the Area 3 and Area 5 RWMSs. Results indicate that elevated levels of plutonium-239 plus plutonium-240 ($^{239+240}Pu$) are present at the Area 3 RWMS. The source of plutonium is likely to be the nearby soil contamination areas created by atmospheric nuclear weapons tests. The mean concentration for $^{239+240}$Pu in 2005 (~ 5.9×10^{-6} Bq/m^3) is less than any level of public concern. CA model predicted concentrations of plutonium at the Area 3 RWMS from contaminated soils sites in Yucca Flat are consistent with measured concentrations.

Air particulate data collected at the Area 5 RWMS are consistent with the screening analyses conducted for the Area 5 CA, which concluded that the radioactive contamination soil sites in Frenchman Flat and the Area 5 RWMS are not interacting sources. The Frenchman Flat soil sites are therefore not included in the CA.

Tritium in air data are collected at the Area 3 and Area 5 RWMSs. These data could be used in conjunction with modified PA models to evaluate the accuracy of tritium migration predictions.

2.2.2 Research and Development

The PA/CA Maintenance Plan calls for annual reviews of R&D activities relevant to the PA. Results of both on-site and off-site R&D activities (e.g., those performed at other DOE sites, the National Laboratories, the Desert Research Institute, and academic institutions) provide the data necessary to manage uncertainty in conceptual models, mathematical models, model parameters, and evaluation scenarios of the PA, and to assure continuing adequacy of the PA.

The DASs require NNSA/NSO to address all secondary issues (e.g., consistency of models and parameters between the Area 3 and 5 RWMSs) noted during the PA/CA reviews as part of the maintenance program. R&D is the mechanism for NNSA/NSO to address these issues and manage uncertainty.

2.2.2.1 *FY 2006 Research and Development Activities*

The major R&D efforts undertaken in FY 2006 were the continuation of the development of the Area 3 and Area 5 RWMS GoldSim models and the development of GoldSim inventory models for the Area 3 and Area 5 RWMSs. These are summarized below.

<u>Area 5 RWMS GoldSim Model Development</u>

The FY 2006 PA update was performed with the Area 5 RWMS v4.001 PA model. Version 4.001 was developed from the previous v4.0 by addition of the FY 2006 inventory. Version 4.0 was approved by NNSA/NSO for all model applications, including waste stream evaluations and compliance determinations, with the exception of the containment requirement calculations under Title 40 CFR 191 (NNSA/NSO, 2006a). Major developments since v3.11mod of the model used in developing Addendum 2 to the Area 5 RWMS PA, include the following:

- The model has been migrated to GoldSim v9.21.

- New calculations have been added for assessment of compliance with Title 40 CFR 191 TRU waste regulations, primarily for the TRU waste in classified trench T04C. Two quantitative requirements of Title 40 CFR 191, the containment requirements, and the individual protection requirements, were implemented. To show compliance with the containment requirements, cumulated releases from the facility over a 10,000-year period with climate change must be quantified. Because the current version does not include climate change, it will be implemented in a new version of the model in FY 2007.

- New calculations have been added to perform CA.
- All inventories were updated to FY 2006 estimates.
- The model now includes an additional period of passive institutional control (IC) occurring at the end of active IC. The duration of passive IC is based on expert opinion concerning the effectiveness of site knowledge and markers.
- Termites were removed from the model as their effect was deemed to be minimal.
- The ground surface radon flux is now calibrated using laboratory-measured values for the effective diffusivity, D_{eff}, using results from soil samples; alternative calibrations using other approaches such as the Rogers and Neilson (1991) model have been removed from the GoldSim version.
- Seventeen new radionuclides (including nine new chemical elements) have been added to the model: C-14 gas (a gaseous form of carbon), Ar-42, Ti-44, Se-79, Ag-108m, Pm-145, Pm-146, Sm-146, Gd-148, Gd-152, Hf-182, Os-194, Ir-192m, Am-242m, Cm-247, Cf-249, and Cf-251.
- The inventory of C-14 is now randomly split into the solid phase and the gaseous phase (C-14 gas) by using the value of FractionCarbonSolid, which is defined globally. In previous versions of the model, all C-14 was assumed to be in a gaseous form. Now it occurs in both solid and gaseous forms, apportioned randomly.
- Biotic parameters for plants and animals were updated.
- The air dispersion $\frac{\chi}{Q}$ calculation was modified for the resident farmer to be the maximum value at 100 m (328 ft) from the RWMS boundary, and the $\frac{\chi}{Q}$ tables were modified to produce values exactly where needed, eliminating linear interpolation.
- The value for the tritium plant/soil concentration ratio was replaced with a calculation method from Kennedy and Strenge (1992).
- The calculation of contaminant concentrations in the resident farmer soil was modified to exclude noble gases, because these are expected to escape as the soils are relocated via surface transport mechanisms. The ^{222}Rn that occurs from the decay of ^{226}Ra in the soils, however, is retained.

Area 3 Radioactive Waste Management Site GoldSim Model Development

Version 2.0 is the current version of the model approved by NNSA/NSO for all model applications, including waste stream evaluations and compliance determinations, with the condition that the model should be run with subsidence for U-3ah/at disabled (NNSA/NSO, 2006b). Major developments since v1.0 of the model include the following:

- Inventories were updated to include disposals through FY 2006.
- Calculations supporting the CA were added.
- The calculation of subsidence of U-3ah/at was modified. The model allows the remediation of the cover as subsidence occurs with the addition of fill-soil over the cover to maintain the as-built cover elevation through the end of the IC period; however, transport parameters following subsidence are not yet developed.
- The model runs under GoldSim v9.21.
- The model now includes the choice of three IC periods, including active and passive IC periods based on expert elicitation and a 100-year IC period based in regulatory policy. The duration of passive IC is based on expert opinion regarding the effectiveness of site knowledge and markers.

GoldSim Inventory Model Development

The Area 3 and Area 5 RWMS FY 2006 inventory estimates were prepared with the Area 3 Inventory v2.010 and Area 5 Inventory v2.021 models, respectively. The only significant changes to these models from previous versions are the addition of FY 2006 data and the allocation of all future waste to the Area 5 RWMS.

2.2.2.2 *Current Research and Development Activities*

The current R&D activities include the following:

- Continuing development of the Area 5 RWMS GoldSim model: Model development in FY 2006 will include updating the transport parameter distributions to incorporate climate change required by the containment requirements of Title 40 CFR 191. The member of public scenarios will be reviewed for consistency with those in the Area 3 RWMS PA, and a single compliance scenario will be developed and adopted for use for both the Area 5 and Area 3 RWMS PAs as well as the CA.
- Performing cover thickness optimization studies in support of design of the closure cover for the original Area 5 RWMS 92-acre disposal area.
- Continuing development of the Area 3 RWMS GoldSim model: Subsidence will be further evaluated and the consequences of subsidence will be incorporated into the model with the addition of new values for transport and media parameters under subsided conditions when

no cover maintenance takes place. The member of public compliance scenario developed for the Area 5 RWMS model will replace the current scenarios implemented in v2.0 of the model.

- Performing sensitivity analyses for the Area 3 RWMS GoldSim model.

2.2.2.3 *FY 2008 Research and Development Activities*

Activities beyond FY 2007 will focus on:

- Updating the models as more data or information become available.
- Using the model to support future disposal, closure, monitoring and research decisions.
- Using sensitivity analysis to simplify the Area 5 RWMS GoldSim model.
- Evaluating new and revised waste streams as they are proposed.

The GoldSim models will continue to be used to evaluate PA results using revised closure inventories that include current disposals. Based on the results of the sensitivity analyses undertaken in FY 2007, new studies may be undertaken in FY 2008 to reduce the uncertainty of sensitive model parameters, if feasible to do so.

2.2.2.4 *Research and Development Activities Beyond FY 2008*

The long-term goal of the maintenance program is to reduce uncertainty in exposure scenarios (member of public and inadvertent human intrusion), conceptual models, mathematical models, and model parameters. Reduction of uncertainty and associated improvement of the PA model will be accomplished through special studies. In addition, future R&D activities include the development of new waste concentration limits, evaluation of waste forms and containers (both engineering and geochemical properties) for disposal, refinement of closure cover designs, and evaluation of IC and land-use options for optimizing disposal operations.

2.3 Summary of Changes

In FY 2006, changes in site inventories, the Area 3 and Area 5 RWMS disposal facility designs, the PA models, and site characterization data were noted. Development of the Area 3 RWMS and Area 5 RWMS GoldSim models continued in FY 2006 with release of v2.0 and v4.001, respectively. PA model results continue to indicate a high probability of compliance with all performance objectives. Monitoring results continue to support PA assumptions and conceptual models.

2.4 Recommended Changes

Analysis of the current inventory data with the Area 5 RWMS v4.001 GoldSim model indicates that there is a reasonable expectation of compliance with all performance objectives. No significant change occurred since the preparation of the 2006 Area 5 RWMS PA update. Therefore, no revision to the PA is necessary.

The most significant change at the Area 3 RWMS is the increased inventory since the approved PA in 1996. Analysis of the current inventory with the Area 3 RWMS v2.0 GoldSim model indicates that there is still a reasonable expectation of compliance with the performance objectives. A revision of the Area 3 RWMS PA is recommended in FY 2008 to update the PA with GoldSim model results, as well as with the latest estimate of the closure inventory.

3.0 COMPOSITE ANALYSIS

3.1 Assessment of the Adequacy of the Composite Analysis

The reviews of the Area 3 and Area 5 RWMS inventories, environmental restoration (ER) activities at the NTS—those impacting the sources of residual radioactive materials considered in the CAs, the results of the monitoring and R&D activities, and land-use planning—show that the assumptions in the CAs have not changed. Therefore, the results of the CAs remain valid, and revision of the CAs is not necessary at this time.

Of particular importance are the conservative assumptions made in the CAs about IC and future land use. Although NNSA/NSO has been considering controlling the NTS boundaries in perpetuity, the CAs assume that, after an IC period, the public will have access to lands within 100 m (330 ft) of the disposal sites. Therefore, dose scenarios evaluated in the CAs provide conservative bounding estimates of future performance.

In FY 2006, two new versions of the Area 3 and Area 5 RWMS PA models were released that include CA modules. The updated results from these models are not significantly different from the CA results. All results are significantly less than the 0.3 mSv dose constraint.

3.2 Source Terms

In addition to the PA inventories, the CAs evaluated the pre-1988 inventory of the RWMSs and other sources of residual radioactive materials from the ER sites that interact with the RWMSs. The ER sources considered in the CA models remain unchanged for the Area 3 RWMS. The Area 5 RWMS CA showed that there was negligible interaction between the contaminated soil sites in Frenchman Flat and the RWMS. Therefore, the Area 5 RWMS CA model calculates the dose for a future member of public 100 m (330 ft) from the RWMS boundary and does not explicitly include the minor air pathways doses from soil sites. No new sources of contamination have been identified, and there is no new information that would reduce the uncertainty of the current sources. The review results for the RWMSs and ER sources are summarized below.

3.2.1 Radioactive Waste Management Sites

There have been no significant changes to the pre-1988 waste inventories evaluated in the CAs. The Area 3 RWMS CA inventory was estimated with the Area 3 Inventory v2.010 model (see Section 2.0). The Area 5 RWMS CA inventory was estimated with the Area 5 Inventory v2.021 model (see Section 2.0).

3.2.1.1 *Closure*

The Area 3 RWMS PA/CA assumes that the site will be closed with a vegetated monolayer cover of native alluvium (Shott et al., 2000). The cover is assumed to be 3 m (10 ft) thick after subsidence. The U-3ax/bl disposal unit was closed in FY 2001 with the installation of a monolayer alluvium cover. The existing 2.7-m (8.9-ft) operational cover was supplemented with an additional 0.3 m (1 ft) of soil and sloped to promote drainage off the cover. The installed cover is generally consistent with the CA assumption of a 3-m (10-ft) monolayer cover.

The Area 5 RWMS CA makes similar, but slightly less conservative, assumptions (BN, 2001a). The CA assumes that the cover is maintained for 100 years and public access is restricted for 250 years. The cover is assumed to be a monolayer alluvium cover, 2 to 6 m (6 to 20 ft) thick.

The ICMP remains consistent with the PA assumptions for the U-3ah/at and U-3bh units at the Area 3 RWMS and the units in the Area 5 RWMS (BN, 2005). The current plan is to construct monolayer-ET closure covers. Closure cover thickness will be specified in the specific closure plan for the disposal unit. Current closure plans remain consistent with PA and CA assumptions.

3.2.2 Underground Test Areas

The CAs for the Area 3 and Area 5 RWMSs assumed that land-use controls can control exposure of the public to groundwater contamination from UGTAs on the NTS. There are still no plans to release lands within either Yucca Flat or Frenchman Flat where the Area 3 and Area 5 RWMSs are located, respectively. The results of the flow and transport model that will aid in determining the 1,000-year groundwater contaminant boundaries for Yucca Flat are not expected until FY 2020. The Area 3 RWMS CA assumptions are still consistent with current plans for the Yucca Flat Corrective Action Unit.

Site characterization studies are underway to estimate the extent of groundwater contamination from the Frenchman Flat UGTA. The results of the radionuclide transport model are expected by FY 2009 and require Nevada Division of Environmental Protection approval prior to application. Therefore, the Area 5 RWMS CA is still consistent with the plan to manage the Frenchman Flat UGTA.

3.2.3 Soil Sites

The CAs assume that the NTS Soil Sites will not be remediated. No Soil Sites considered in the CAs have been characterized or remediated since completion of the CAs. The closure of Soil Sites is currently awaiting a regulatory determination of appropriate cleanup levels. Therefore, the results of the CAs remain valid and provide a conservative bounding estimate of site performance.

3.2.4 Industrial Sites

The CAs assume that the impact of the Industrial Sites is insignificant compared with the Soil Sites. No Industrial Sites have been characterized or remediated that impact interacting sources in Frenchman Flat or Yucca Flat since preparation of the CAs. Therefore, the CA assumptions remain unchanged.

3.3 Updated Composite Analysis Results

The Area 3 RWMS CA results were updated with the Area 3 RWMS v2.0 GoldSim model. The model conditions were the same as the PA run, except that the model was placed in CA mode. A slight increase is observed for all sources (Table 14). However, the mean and 95th percentile doses are significantly less than the 0.3 mSv dose constraint. The CA results are still considered valid.

Table 14
Area 3 RWMS v2.0 GoldSim Model CA Results

Source	Limit	2000 Area 3 RWMS CA		FY 2006 Summary	
		Mean	95th Percentile	Mean	95th Percentile
HORNET GZ Soil Site (mSv/yr)	1	2E-2	NA	3.8E-2	7.2E-2
Off-sites (mSv/yr)	1	3E-3	NA	9.8E-3	1.3E-2
RWMS (mSv/yr)	1	2.3E-3	NA	8.9E-3	NA

NA – Monte Carlo simulation results are not available.

The Area 5 RWMS CA results were updated with the Area 5 RWMS v4.001 GoldSim model. The model was run as described for the PA, except that the model was placed in CA mode. A slight decrease is observed for the dose at the Area RWMS boundary (Table 15). The mean and 95th percentile doses are significantly less than the 0.3 mSv dose constraint. Therefore, the Area 5 RWMS CA results are still considered valid.

Table 15
Area 5 RWMS v4.001 GoldSim Model CA Results

Pathway/Scenario	Dose Constraint	Area 5 RWMS CA		FY 2006 Summary	
		Mean	95th Percentile	Mean	95th Percentile
All-Pathways/Resident Farmer (mSv/yr)	0.30	8E-3	2E-2	3.0E-3	NA

NA – Not available; insufficient non-zero realizations.

3.4 Monitoring and Research and Development Results

3.4.1 Monitoring

The monitoring activities discussed in Section 2.2.1 also pertain to the CAs. As discussed in Section 2.2.1, the results of environmental monitoring across the NTS are reported annually in the Annual Site Environmental Report and National Emissions Standards for Hazardous Air Pollutants reports (BN, 2004a, 2004b). $^{239+240}$Pu are the only man-made radionuclides routinely detected at the Area 3 RWMS at slightly elevated levels, the sources being the former atmospheric testing sites throughout Yucca Flat, including ground zeros in the immediate vicinity of the RWMS. The mean result for 2005 was 5.9×10^{-6} Bq/m^3. This is consistent with previous results and the CA model estimated $^{239+240}$Pu concentration of 7×10^{-6} Bq/m^3. Results of the CA resuspension and dispersion models for plutonium are consistent with environmental monitoring results.

3.4.2 Research and Development

There have been no R&D activities in FY 2006 whose results might impact the CA results and conclusions. The discussions of the R&D activities in Section 2.2.2 for PAs are also pertinent for CAs.

The release and transport of radionuclides from the disposal sites and resuspension of radionuclides from the surface soils into the atmosphere are modeled for the CA using the same models developed in the PA. In the CAs, the Industrial Source Complex (ISC) model was used to evaluate the spatial distribution of the concentration of radionuclides in the atmosphere as a result of resuspension of radionuclides from the disposal units, as well as all other pertinent radionuclide sources. The ISC model was also used to evaluate the deposition of airborne radionuclides on the ground. Aside from updating the ISC model results (air concentration source strength ratios) with recent meteorological data from Frenchman Flat, no further revisions were performed.

3.5 Summary of Changes

There have been no changes in FY 2006 that affect the conclusions of the CAs, as indicated by reviews of the disposal unit closure inventories, estimated inventories of the ER sources of residual radionuclides, the progress of the ER cleanup projects, land-use planning, and the results of the monitoring and R&D activities.

Current inventories have been analyzed with the new Area 3 and Area 5 RWMS CA models. The results indicate a high probability that the doses from all interacting sources are less than the 0.3 mSv dose constraint. Therefore, the results of the CAs appear to remain valid.

3.6 Recommended Changes

There are no recommended changes to the ER programs that could affect the CAs. Likewise, there are no recommended changes to the monitoring and R&D activities. There have been no significant changes that would impact CA results and conclusions. Therefore, the Area 3 and Area 5 RWMS CAs are assumed to still be adequate and revision is not required at this time.

4.0 REFERENCES

Bechtel Nevada, 2001a. *Composite Analysis for the Area 5 Radioactive Waste Management Site at the Nevada Test Site, Nye County, Nevada.* DOE/NV--594. Bechtel Nevada, Las Vegas, NV. September 2001.

———, 2001b. *Addendum 1, Performance Assessment for the Area 5 Radioactive Waste Management Site at the Nevada Test Site, Nye County, Nevada*. DOE/NV/11718--176-ADD1. Bechtel Nevada, Las Vegas, NV. November 2001.

———, 2001c. *Addendum 1, Composite Analysis for the Area 5 Radioactive Waste Management Site at the Nevada Test Site, Nye County, Nevada.* DOE/NV--594-ADD1. Bechtel Nevada, Las Vegas, NV. November 2001.

———, 2003. *Nevada Test Site Routine Radiological Environmental Monitoring Plan*. DOE/NV/11718--804. Bechtel Nevada, Las Vegas, NV. June 2003.

———, 2004a. *Nevada Test Site Environmental Report 2003.* DOE/NV/11718--971. Bechtel Nevada, Las Vegas, NV. October 2004.

———, 2004b. *National Emissions Standards for Hazardous Air Pollutants Calendar Year 2003*. DOE/NV/11718--929. Bechtel Nevada, Las Vegas, NV. June 2004.

———, 2004c. *Waste Management Monitoring Report Area 3 and Area 5 Radioactive Waste Management Sites 2003.* DOE/NV/11718--930. Bechtel Nevada, Las Vegas, NV. June 2004.

———, 2004d. *Nevada Test Site 2003 Data Report: Groundwater Monitoring Program, Area 5 Radioactive Waste Management Site*. DOE/NV/11718--894. Bechtel Nevada, Las Vegas, NV. February 2004.

———, 2005. *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. Bechtel Nevada, Las Vegas, NV. September 2005.

———, 2006a. *Addendum 2 to the Performance Assessment for the Area 5 Radioactive Waste Management Site at the Nevada Test Site, Nye County, Nevada*. DOE/NV/11718--176-ADD2. Bechtel Nevada, Las Vegas, NV. January 2006.

______, 2006b. *2005 Annual Summary Report for the Area 3 and Area 5 Radioactive Waste Management Sites at the Nevada Test Site, Nye County, Nevada.*. Bechtel Nevada, Las Vegas, NV. January 2006.

BN, see Bechtel Nevada.

Desotell, L. T., D. B. Hudson, V. Yucel, and J. T. Carilli, 2006. "Use of Long-Term Lysimeter Data in Support of Shallow Land Waste Disposal." In: *Proceedings of the Waste Management '06 Conference*. Tucson, AZ. February 26-March 2, 2006.

DOE, see U.S. Department of Energy.

Kennedy, W. E., and D. L. Strenge, 1992. *Residual Radioactive Contamination from Decommissioning*. NUREG/CR-5512. U.S. Nuclear Regulatory Commission, Washington, D.C.

National Security Technologies, LLC, 2006. *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.* DOE/NV/25946--091. January 2007.

NNSA/NSO, see U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office.

NSTec, see National Security Technologies, LLC.

Rogers, V. C., and K. K. Nielson, 1991. "Correlations for Predicting Air Permeabilities and Rn-222 Diffusion Coefficients of Soils." *Health Physics* 61(2): 225 – 230.

Shott, G. J., L. E. Barker, S. E. Rawlinson, M. J. Sully, and B. A. Moore, 1998. *Performance Assessment for the Area 5 Radioactive Waste Management Site at the Nevada Test Site, Nye County, Nevada, Rev. 2.1.* DOE/NV/11718--176/UC-721. Bechtel Nevada, Las Vegas, NV. January 1998.

Shott, G. J., V. Yucel, M. J. Sully, L. E. Barker, S. E. Rawlinson, and B. A. Moore, 2000. *Performance Assessment/Composite Analysis for the Area 3 Radioactive Waste Management Site at the Nevada Test Site, Nye County, Nevada, Rev. 2.1.* DOE/NV--491-Rev 2.1. Bechtel Nevada, Las Vegas, NV. October 2000.

Title 40 Code of Federal Regulations, Part 191, July 2005. Environmental radiation protection standards for management and disposal of spent nuclear fuel, high-level, and transuranic radioactive wastes.

U.S. Department of Energy, 1999. *"Maintenance Guide for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments and Composite Analysis."* DOE G 435.1-3. U.S. Department of Energy, Washington, DC. November 1999.

———, 2000. "Disposal Authorization for the Nevada Test Site Area 5 Low-Level Waste Disposal Facility." Memorandum from EM-35 to Kathleen Carlson, Manager, Nevada Operations Office. December 5, 2000.

———, 2002. “Disposal Authorization for the Nevada Test Site Area 3 Radioactive Waste Management Site – Submittal of Revised Performance Assessment and Composite Analysis dated December 17, 2001.” Memorandum from EM-43 to Kathleen Carlson, Manager, Nevada Operations Office. August 2, 2002.

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office, 2006a. “Low-Level Waste Acceptability Report for the Area 5 Radioactive Waste Management Site GoldSim Probabilistic Performance Assessment Model Version 4.0.” Correspondence from Jhon Carilli, NNSA/NSO, to J. K. Wrapp, NSTec. November 2, 2006.

______, 2006b. “Low-Level Waste Acceptability Report for the Area 3 Radioactive Waste Management Site GoldSim Probabilistic Performance Assessment Model Version 2.0.” Correspondence from Jhon Carilli, NNSA/NSO, to J. K. Wrapp, NSTec. November 22, 2006.

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