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U.S. DEPARTMENT OF ENERGY

NEVADA TEST SITE
ENVIRONMENTAL MANAGEMENT
END STATE VISION

January 2006

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EXECUTIVE SUMMARY

The End State Vision is to be used as the primary tool for communicating the individual site end state to involved parties (e.g., U.S. Department of Energy [DOE], regulators, public stakeholders, Tribal Nations). The end state document is not a decisional document. If the DOE decides to seek changes to current compliance agreements, decisions, or statutory/regulatory requirements, the changes will be made in accordance with applicable requirements (DOE/EM, 2003).

This report only addresses sites controlled by DOE National Nuclear Security Administration (NNSA) Nevada Site Office (NSO) Environmental Management (EM). This document does not address corrective action sites on the Nevada Test Site (NTS) and Nevada Test and Training Range (NTTR) under the responsibility of NNSA/NSO Defense Programs nor those under the U.S. Department of Defense (DoD) Defense Threat Reduction Agency. Environmental restoration at these sites is not under the purview of NNSA/NSO EM and information about planned strategies for cleanup is not available for all corrective action sites. These sites are few in number compared to those under EM, so the overall impact to the comprehensiveness of the NTS and NTTR End State Vision is modest.

The NTS is located 65 miles northwest of Las Vegas and occupies approximately 1,375 square miles (mi^2). The NTS is surrounded by approximately 4,500 mi^2 of federally owned and DoD controlled land. This land area has been withdrawn from all forms of appropriation under public land laws. The NTS is surrounded by the NTTR (formerly known as the Nellis Air Force Range) on the north, east, and west boundaries, and land managed by the U.S. Department of the Interior, Bureau of Land Management (BLM) on the south and southwest boundaries. The NTTR, which includes the Tonopah Test Range (TTR), is used for military training; the BLM lands are used for grazing, mining, and recreation. Near the eastern boundary of the NTS, the NTTR shares use of land with the U.S. Fish and Wildlife Service's Desert National Wildlife refuge. The NTS is in a remote and arid region, with approximately three-fourths of the perimeter surrounded by federal installations, with strictly controlled access, and approximately one-quarter of the south and southwestern perimeter adjacent to public lands that are open to public entry.

The long-term end state vision for the NTS is to restore the environment to an extent that will allow the maximum continuation of the national security mission conducted by the NNSA/NSO, the national laboratories, and contractors. This vision includes the removal of only the contamination that poses an unacceptable risk to workers conducting planned site operations in support of the NNSA/NSO mission and characterizing/stabilizing the rest of the contamination to ensure that remaining levels do not spread to the surrounding environment and pose an unacceptable risk. The near-term vision is to maintain sufficient low-level and mixed low-level radioactive waste disposal capabilities to support accelerated cleanup across the DOE Complex. Disposal of radioactive waste adds risk to the NTS while removing risk from other sites. Disposal will be conducted in accordance with applicable federal and state regulations in a manner that does not result in unacceptable environmental conditions at the NTS.

The discussion of “hazard areas” at the NTS and NTTR has been divided into three areas based on historic activities, type of contaminants, common fate in the environment, and potential for impacting common receptors. Deep subsurface radiological contamination (Hazard Area 1) and surface and shallow subsurface radiological contamination (Hazard Area 2) are the direct result of nuclear testing. Industrial sites (Hazard Area 3) are areas of environmental contamination that include impacts from facilities, infrastructure, manufacturing processes, and waste disposal that were a by-product of nuclear testing and rocket nuclear engine development.

The Underground Test Area (UGTA) Project, which addresses deep underground radioactive contamination (Hazard Area 1), is the largest project in the NNSA/NSO EM mission. The UGTA Project addresses groundwater contamination resulting from past underground nuclear testing conducted in vertical shafts and tunnels on the NTS and focuses on the potential for radioactive contamination reaching receptors. From 1951 to 1992, 828 underground nuclear tests were conducted at the NTS. This underground testing was limited to specific areas of the NTS including Pahute Mesa, Rainier Mesa/Shoshone Mountain, Frenchman Flat, and Yucca Flat. Most of these tests were conducted hundreds of feet above the groundwater table; however, more than 200 of the tests were in proximity of, or within, the water table. This testing resulted in over 132 million curies of radioactivity in the subsurface of the NTS. Tritium is the primary contaminant of concern because of its mobility and abundance. Risks to human health are associated with the subsurface contamination via the groundwater pathway both on and off the NTS. The end state for Hazard Area 1 will require the completion of a modeled contaminant boundary, a negotiated compliance boundary, monitoring well network(s), and successful five-year “proof of concept” monitoring. Closure-in-place with monitoring is considered to be the only feasible corrective action, because cost-effective groundwater technologies have not been developed to effectively remove or stabilize these subsurface contaminants. The potential risk is to workers, the public, and the environment. The UGTA Project activities addressing Hazard Area 1 are the highest priority with the State of Nevada regulator due to the limited availability of water resources within the state.

The end state for Hazard Area 1 will include development of contaminant boundaries based on the results of the groundwater flow and transport modeling to define areas that contain water that may be unsafe for domestic and municipal use. A monitoring network will be installed to ensure future protection of the public and the environment. Institutional controls will be continued and wells will be monitored, sampled, and refurbished/replaced, as applicable.

Surface and shallow subsurface radiological contamination (Hazard Area 2) exists on the NTS and NTTR. Contamination at these sites is the result of historic nuclear detonations, safety related tests, and hydronuclear experiments. Atmospheric nuclear weapons tests were initiated in 1951 with the detonation of a 1-kiloton air-dropped weapon over Frenchman Flat. A total of 100 atmospheric tests were conducted on the NTS before the signing of the *Limited Test Ban Treaty* in August 1963. Portions of the NTS and the NTTR were used between 1954 and 1963 for chemical explosion tests of plutonium-bearing materials. The safety experiments and storage-transportation tests were conducted to evaluate the safety of nuclear weapons in accident scenarios. Contaminants of concern include transuranics and uranium, as well as fission and fusion products. Metals, particularly lead, and other contaminants associated with the instrumentation and structures specific for each test may exist in small quantities at some of these locations.

The end state for Hazard Area 2 envisions sites on the NTTR to be cleaned up to total transuranics equating to a less than 25 millirem per year dose for military land-use scenario and formally closed and site control relinquished to the U.S. Air Force. Sites on the NTS will be further characterized fenced, posted, and monitored as necessary, and relinquished to DoD and NNSA/NSO by the end of 2022.

Industrial sites (Hazard Area 3) are potentially contaminated surface and near-subsurface areas impacted by the by-products of nuclear weapons, and safety test activities conducted on the NTS and NTTR, and rocket engine development on the NTS. The industrial sites have been organized into corrective action units based on geography, technical similarity, or other appropriate reasons, to determine corrective actions. Under NNSA/NSO EM, 1,047 of these historic areas have been identified, verified, and inventoried for characterization, restoration, and/or closure under the NNSA/NSO EM program. Of these, more than 700 sites have been formally closed.

The end state for Hazard Area 3 envisions applicable corrective actions completed for all 1,047 sites. Most sites will be available for unrestricted surface use while others will be stabilized for restricted use appropriate to the risk posed by residual contamination. For those sites where contamination remains in place, appropriate long-term stewardship activities will be in place, including monitoring, cap inspections, and use restrictions as applicable.

The NNSA/NSO EM is advancing toward meeting the cleanup goals identified in its Life-Cycle Baseline Revision 6. According to the Life-Cycle Baseline Revision 6, completion of the EM mission for the NTS will be phased with closure of the Industrial Sites Project (Hazard Area 3) in fiscal year (FY) 2018, the Soils Project (Hazard Area 2) in FY 2022, and the UGTA Project (Hazard Area 1) in FY 2027. Once NNSA/NSO EM activities are completed, responsibilities for long-term stewardship will be turned over to the landlords; the U.S. Air Force (for NTTR) and the NNSA/NSO for the NTS. Appropriate planning and mitigation strategies are in process and will continue to be implemented to ensure proper stewardship of the remaining contaminated sites to ensure protection of workers, the public, and the environment, now and for future generations.

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List of Acronyms

ALARA	As-low-as-reasonably-achievable
BLM	Bureau of Land Management
CAB	Community Advisory Board
CAI	Corrective action investigation
CAS	Corrective action site
CAU	Corrective Action Unit
CSM	Conceptual Site Model
DOE	U.S. Department of Energy
DoD	U.S. Department of Defense
DSA	Documented Safety Analysis
EM	Environmental Management
EPA	U.S. Environmental Protection Agency
°F	Degrees Fahrenheit
FFACO	*Federal Facility Agreement Consent Order*
ft^3	Cubic foot
FY	Fiscal year
HE	High explosives
LLW	Low-level waste
m^2	Square meter
mi	Mile
mi^2	Square mile
MLLW	Mixed low-level waste
mph	Miles per hour
mrem/yr	Millirem per year
NAEG	Nevada Applied Ecology Group
NDEP	Nevada Division of Environmental Protection
NNSA/NSO	U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office
NTS	Nevada Test Site
NTTR	Nevada Test and Training Range
OSHA	Occupational Safety and Health Administration
PA	Preliminary Assessment
pCi/g	Picocuries per gram
PLO	Public Land Order

RCRA	*Resource Conservation and Recovery Act*
RWMS	Radioactive Waste Management Sites
SAFER	Streamlined Approach for Environmental Restoration
SDWA	*Safe Drinking Water Act*
TRU	Transuranic
TTR	Tonopah Test Range
UGTA	Underground Test Area
WIPP	Waste Isolation Pilot Plant

1.0 INTRODUCTION

This document describes the proposed Environmental Management (EM) Program site-wide end state goal for environmental management activities at the Nevada Test Site (NTS) and Nevada Test and Training Range (NTTR), which includes the Tonopah Test Range (TTR). The proposed goal is described as a "vision" of how the NTS and adjacent impacted locations will appear when the U.S. Department of Energy (DOE) EM Program cleanup mission is complete and the National Nuclear Security Administration (NNSA) assumes full responsibility for environmental management. The end state vision juxtaposes land-use, program, and facility plans with remediation and waste management requirements, establishing a conceptual completion goal (or end state) that is both realistic and protective of human health and the environment. The purpose of the vision is to identify where and how potentially harmful exposures to hazardous or radioactive contaminants might occur under projected future conditions, and to determine what actions will be necessary to minimize the potential for harm under those conditions. Consistent with the objectives of cleanup, the vision conceptualizes specific end state conditions that will minimize the potential for harm in the future. Because this paradigm is consistent with the federal government's definition of risk as the probability that a substance or situation will produce harm under specified conditions, the vision is referred to as an *end state*.

The July 2003 DOE Policy 455.1, "Use of Risk-Based End States" requires DOE EM sites to define and document an end state vision that is acceptable to regulators and stakeholders, and then to revise cleanup program plans as necessary to achieve that end state in the most efficient manner (DOE, 2003b). The policy is a formal mandate for EM sites to implement risk-based corrective action programs as described in multiple DOE Orders and guidance, U.S. Environmental Protection Agency (EPA) publications, American Society of Testing and Materials Standard Guides, and National Research Council recommendations (including DOE expedited site characterization and streamlined approach for environmental restoration [SAFER]).

Risk-based corrective action is an application of standard scientific, engineering, and mathematical principles, enabling steady progress in solving even very complex cleanup problems. The complexities of cleanup at a typical EM site are generally similar: multiple contaminants distributed in multiple environmental media, released over long periods of time and over large areas of land. Uncertainties in source(s), nature, extent, transport, and fate of contaminants are very large and can never be absolutely eliminated. Risk-based corrective action provides an objective means of managing uncertainties to the necessary degree and sufficiently to make defensible decisions about effective cleanup actions.

Risk-based corrective action is one of the defining elements of the NNSA/Nevada Site Office (NSO) EM integrated strategy for addressing contaminants on the NTS and surrounding areas (i.e., the NTTR). Additionally, proposed corrective actions are presented, negotiated, and agreed to under the *Federal Facility Agreement and Consent Order* (FFACO) (1996) by the State of Nevada's Division of Environmental Protection (NDEP), the DOE, and the U.S. Department of Defense (DoD). Corrective action proposals and discussions are conducted for manageable subsets (fiscal year plus two) of the total environmental restoration work in accordance with baseline plans. The baselines portray projected environmental restoration activities and serve as the initial information source to prioritize and schedule work.

In accordance with the FFACO, prioritization is initially done on a site-wide scale (corrective action units [CAUs]). The CAUs consist of similar or proximal individual corrective action sites (CASs) that are grouped together. Prioritization is accomplished by evaluating the following factors: risk to the public, workers, and environment; capability to store, treat, or dispose of waste generated from remedial activities; cost; resource availability; time span to remediate; stakeholder concerns; internal priorities; and current and future land use. The proposed remedial actions (i.e., closure in place, clean closure, or varying clean-up standards) are based on the following factors: risk to human health, ecological risk, current and future land use, cost, and feasibility. Baseline plans are adjusted to optimize work sequences in a logistically sound order to ensure timely and efficient completion of established corrective actions and to keep costs at a minimum (e.g., combine mobilization/demobilization efforts).

The end state vision describes cleanup goals that would be protective under planned future uses described in the *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DOE/NV, 1996) the NTS *Resource Management Plan* (DOE/NV, 2000), and *Renewal of the Nellis Air Force Range Land Withdrawal Legislative Environmental Impact* (DoD, 1999). The NNSA/NSO EM life-cycle baselines have been developed to describe specific elements of the planned EM scope of work. Individual EM baselines have been developed to address contamination at surface soil sites, industrial sites, and the underground test areas and to cover the management of transuranic waste and material, low-level waste and material, and mixed low-level waste. Each baseline covers the activities through the end of the projected completion for the specific element. Future use of the land currently managed by the DOE and the DoD is not anticipated to change. Once EM has completed its characterization/ remediation scope of work, the remaining monitoring and long-term management activities will revert to the respective organizations responsible for conducting on-going missions (currently DoD for the NTTR and NNSA/NSO for the NTS). There are currently no plans to relinquish any of the DoD or DOE withdrawals for any parcels of land currently under their responsibility. The original landowner (U.S. Department of the Interior, Bureau of Land Management [BLM]) would need to be informed of, and agree to, any return of responsibility to them should that option ever be pursued; however, this is not likely in the foreseeable future.

The DOE end state initiative is fully consistent with the recent EPA endorsement of "systematic planning," which uses risk-based and other decision methods to ensure objectivity, defensibility, and cost-effectiveness in corrective action programs (EPA, 2001). Additionally, NNSA/NSO has reviewed this vision document and found no inconsistencies with the NTS Ten Year Plan. The NNSA/NSO has collaborated with its stakeholders (NTS Community Advisory Board [CAB] and NDEP) to revise the proposed end state vision as needed to define clear goals for completion of its EM-sponsored cleanup work. Once the final end state goal is resolved with public and regulatory stakeholders, NNSA/NSO will use decision analysis to objectively, defensibly, and cost effectively align its remediation project plans to achieve that goal. Other decision methods are identified in Section 1.3.2.

1.1 Organization of the Report

The format and content of this report strictly adheres to DOE's *Guidance for Developing a Risk-Based End State Vision* (DOE/EM, 2003).

This document does not address CASs on the NTS under the responsibility of NNSA/NSO Defense Programs or those under the DoD Defense Threat Reduction Agency. Environmental restoration at these sites is not under the purview of the NNSA/NSO EM, and information about planned strategies for cleanup is not available for all CASs. These sites are few in number compared to those under EM, so the overall impact to the comprehensiveness of this end state vision document is modest.

The remainder of this section provides background and programmatic context for the descriptive information in Sections 2.0, 3.0, and 4.0. The descriptive information in Sections 2.0 3.0, and 4.0 focuses on attributes that relate to risk on three spatial scales that include regional, site-wide, and hazard-specific. The attributes of risk are natural and man-made features, events, and processes that impact the potential for harm to living systems from exposures to environmental hazards. Major risk attributes include the types and amounts of contamination in the environment; the current distribution and potential migration of contamination in the environment; and the conditions and situations that may result in contact between living organisms and contamination at specific locations. These attributes will change over time as remediation actions and radioactive waste management are completed and DOE, DoD, and national laboratory operations continue.

To differentiate between the present state and the planned end state, the three spatial descriptions in Sections 2.0, 3.0, and 4.0 depict two timeframes: present day and end state. As prescribed by the DOE, the end state vision represents site conditions that reflect and are consistent with the planned future use of the property and are appropriately protective of human health and the environment. For the NNSA/NSO, the end state vision is consistent with a planned EM completion in 2027.

Section 2.0 depicts the NTS and NTTR in the regional context under current and planned conditions. The current conditions reflect factual knowledge as of 2004, while the planned conditions reflect objective goals to be achieved through 2027. Section 3.0 depicts the current and planned conditions at a slightly smaller scale that encompasses the NTS boundary and directly adjacent environments. Finally, Section 4 describes the current and end state at the scale within which one or more contaminant sources coexist. The site- and hazard-scale descriptions in Sections 3.0 and 4.0, respectively, are both graphical and narrative.

1.2 Site Mission

The NTS is located 65 miles (mi) northwest of Las Vegas and occupies approximately 1,375 square miles (mi^2). The NTS is surrounded by approximately 4,500 mi^2 of federally-owned and DoD-controlled land. This land area has been withdrawn from all forms of appropriation under public land laws. The NTS is surrounded by the NTTR (formerly known as the Nellis Air Force Range) on the north, east, and west boundaries, and land managed by the BLM on the south and southwest boundaries. The NTTR is used for military training and the BLM lands are used for grazing, mining, and recreation. Near the eastern boundary of the NTS, the NTTR shares the use of land with the U.S. Fish and Wildlife Service's Desert National Wildlife Refuge. The NTS is in a remote and arid region with approximately 75 percent of its perimeter surrounded by federal installations with strictly controlled access, and 25 percent adjacent to public lands that are open to public entry.

The TTR comprises 624 mi^2 and has been used by the DOE since the early 1950s. The facility is part of, and surrounded on three sides by, the NTTR and to the north by BLM's open range. The TTR is an area of the NTTR where NNSA/NSO has a large part of its off-NTS environmental restoration responsibility. The town of Tonopah is located 20 mi northwest of the main gate of the TTR and approximately 150 mi from Las Vegas.

The primary mission of the NTS was to conduct nuclear weapons tests. Since the current moratorium on testing began in October 1992, this mission has changed to maintaining a readiness to conduct future nuclear tests, if so directed. In addition to its primary mission, and because of its favorable environment and infrastructure, the NTS supports DOE national security-related research, development and testing programs, and environmental management activities.

The TTR offers a unique location for testing DOE and DoD weapons. In 1963, DOE conducted several storage-transportation tests designed to study distribution of nuclear materials during accidents in several transportation and storage configurations, which resulted in surface soil contamination of three sites. These sites are subject to corrective actions and are under the responsibility of the DOE.

1.2.1 Environmental Management Program

The EM Program consists of two primary tasks, waste management and environmental restoration. The primary mission of waste management is to support the closure of DOE sites across the United States by maintaining the capability to dispose of low-level waste and to develop the capability to dispose of mixed low-level waste (MLLW). The Environmental Restoration Program mission is to assess and perform appropriate corrective actions at 878 former underground test locations (from 828 tests), 100 atmospheric test locations, and more than 1,000 other sites that are the result or by-product of previous testing and support activities.

Waste Management

The NTS is designated as a regional disposal site for LLW and a secondary disposal site for MLLW generated as the result of cleanup activities. The NNSA/NSO EM is committed to ensuring that risk reduction at its sites will be achieved cost effectively and efficiently, while effectively protecting workers, the public, and the environment and proactively addressing State regulator and stakeholder concerns. Simultaneously, NNSA/NSO EM is committed to providing indispensable, efficient, cost-effective LLW and MLLW disposal capability to meet the needs of other DOE sites as they pursue their risk reduction and acceleration goals and objectives.

The NNSA/NSO EM has provided safe waste disposal capability since the inception of the DOE EM Program. This facility will remain open to serve the DOE Complex until at least 2021 to ensure waste disposal capability exists to meet the requirements and needs of the national EM

Program. As of October 2004, a total of 26,500,000 cubic feet (ft^3) of LLW and 300,000 ft^3 of MLLW have been disposed at the NTS. Disposal volumes are anticipated to be very large in the next few years as a result of accelerated complex-wide cleanup initiatives. Approximately 99 percent of the waste forecast for disposal at the NTS in recent years originates from non-NNSA/NSO off-site generators. Figure 1.1 indicates currently approved generators that may dispose of waste at the NTS.

Low-level waste disposal operations occur at the Area 3 and Area 5 Radioactive Waste Management Sites (RWMSs). These waste management sites are operating as Hazard Category 2 Nuclear Facilities in accordance with an approved Documented Safety Analysis (DSA). The DSA identified the potential hazards associated with the Area 3 and Area 5 nuclear operations ranked risk using unmitigated dose consequences and frequency levels. Based on the DSA, the overall risk from the Area 3 and Area 5 RWMSs are considered to be very low and acceptable. Based on implementation of the DSA, Disposal Authorization Statements were issued for both RWMSs. These statements serve as the license to operate (NNSA/NSO, 2003c; NNSA/NSO, 2003d).

Environmental Restoration

Environmental restoration sites are distinguished as CASs, which are sites that have been identified as needing remediation. These sites can include everything from a simple vehicle battery to an entire building. A CAU is a grouping of CASs that is similar in identified remediation technique, type of contaminants, or proximity to each other. The CAUs are implemented via three categories: deep subsurface radiological contamination areas, surface and shallow subsurface radiological contamination areas, and industrial sites.

The three categories of CAUs addressed in this document are defined in the hazard area descriptions as follows:

- The deep subsurface radiological contamination areas (Hazard Area 1, Section 4.0) mission is to establish a long-term program to monitor the groundwater quality for radionuclides. This investigation is defining the site-specific hydrologic boundaries encompassing groundwater resources that may be unsafe for domestic or municipal use as a result of 828 underground nuclear tests will require the completion of a modeled contaminant boundary, a negotiated compliance boundary, monitoring well network(s), and successful five-year “proof of concept” monitoring.

- The surface and shallow subsurface radiological contamination areas (Hazard Area 2, Section 4.0) mission is to characterize and remediate (where necessary) surface soil contamination resulting from hydronuclear experiments, surface safety experiments, and storage-transportation tests historically occurring on the NTS and NTTR.

- The Industrial Sites (Hazard Area 3, Section 4.0) mission is to characterize and remediate (where necessary) potentially impacted sites which are the result or by-product of previous testing and support activities and nuclear rocket engine development.

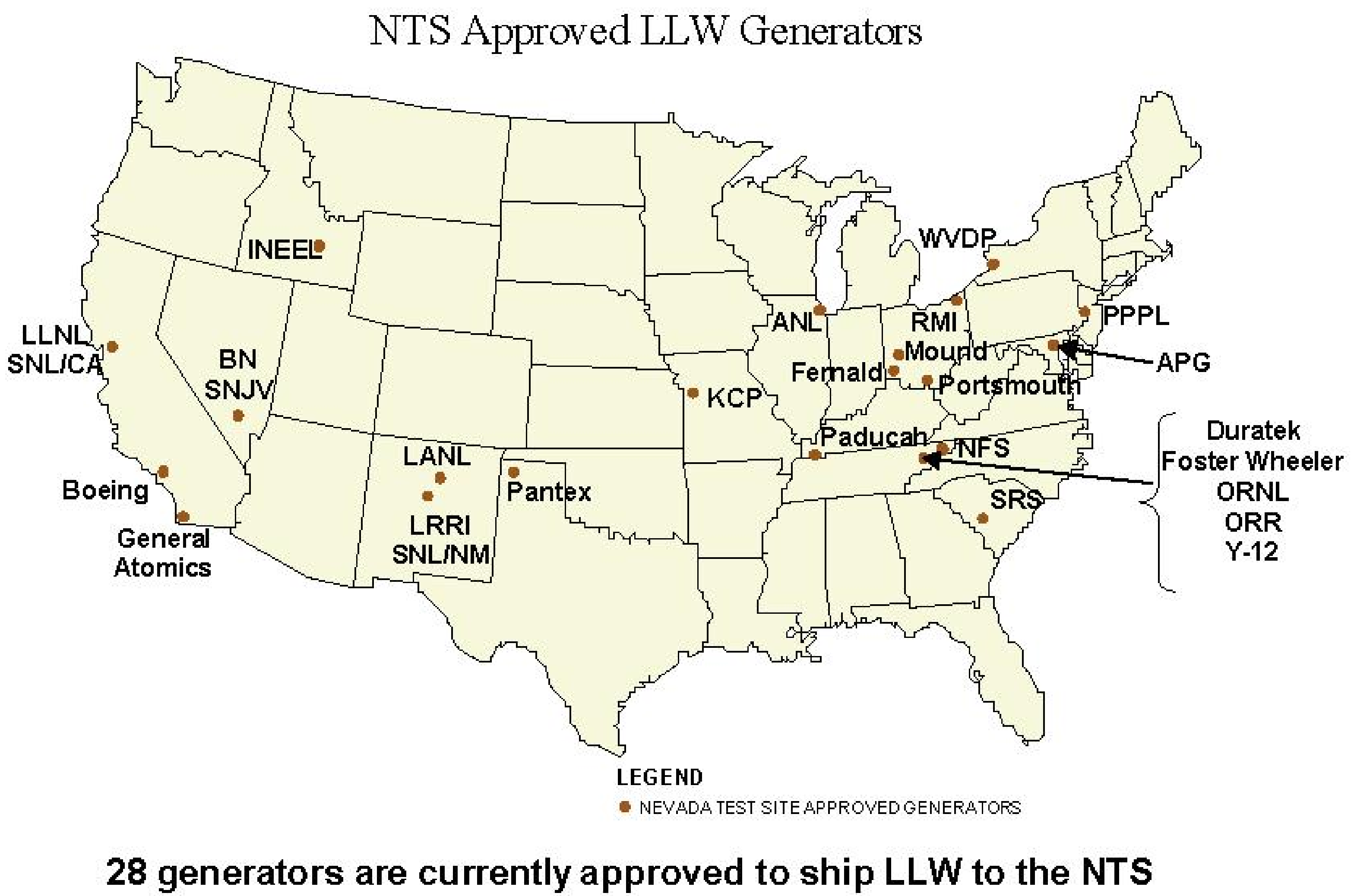


Figure 1.1

Approved Low-Level Waste Generators

1.2.2 Management of National Security Risks

Under the current structure of the federal government, the NNSA sponsors the core national security mission and stockpile stewardship work conducted at the NTS. It is expected that the NTS will remain a center of testing in support of national security research and development into the foreseeable future.

The goal of the national security mission is to develop and test countermeasures to threats posed by weapons and tactics of modern warfare and terrorism. These countermeasures include surveillance and monitoring of existing and emerging weapons and tactics and developing and maintaining a deterrent arsenal. The development of technologies to understand threats and develop deterrents and countermeasures requires a significant level of research in nearly every branch and specialty of science, from the most fundamental to the most esoteric. Much of the research and development is done by the national laboratories at their respective sites. Most of the large-scale field tests and some development is done at the NTS. Stockpile stewardship activities include the Subcritical Experiment Program, which consists of dynamic experimentation that supports the Stockpile Stewardship Program by assessing the effects of aging of nuclear weapons components and providing parameters to model the performance of weapons in the enduring stockpile. Components of the Subcritical Experiment Program involve the use of special nuclear materials and their exposure to high explosives (HE) in the dynamic part of the experiment.

1.2.3 Management of NNSA/NSO EM Operational Risks

The achievement of the NNSA/NSO EM mission requires the use and disposal of radioactive materials and chemicals. Their use and disposal at the NTS is carefully controlled at every stage through safe operating procedures developed to prevent known conditions of harm. These procedures reflect federal laws, state and federal regulations, and DOE directives. Safe operating procedures limit the doses, exposure frequencies, and exposure durations to protect workers. The limits are typically 10 to 1,000 times lower than thresholds known to cause harm. A radiological dose assessment for both off-site residents and on-site biota has determined that the general public and environment do not receive radiation doses above the limits specified in federal and state regulations or international recommendations (DOE, 2003a).

The NNSA/NSO EM operations are performed within an integrated safety and security management system, which ensures that associated hazards are identified and procedures are developed to mitigate the risks from hazards as a routine part of the work authorization process. Elements of the integrated safety and security management system include radiation protection of workers, non-nuclear authorization basis, and management of nuclear facilities. Before conducting any field activities, a cultural and ecological survey is conducted to ensure that historical artifacts and sensitive or endangered species are not adversely impacted by the proposed action.

The risks associated with operations involving radioactive materials are controlled primarily through procedures that implement the requirements of DOE orders. These orders reflect the state of knowledge about radiological doses as defined, refined, and maintained by national and international scientific organizations. Procedures are followed through every phase of the NNSA/NSO EM operations involving radioactive materials to protect against harmful exposure. These procedures are implemented to protect both workers and members of the public.

Analogous procedures are followed to manage the risks associated with toxic chemicals. These procedures comply with standards and regulations administered primarily through the Occupational Safety and Health Administration (OSHA) and the EPA. These regulations and implementing procedures reflect the state of scientific knowledge about the toxicity of various chemicals, and the preventive measures that will ensure against harmful exposures.

Different regulations and policies apply to protect workers and the public against harmful exposures under different/various conditions, including individual office work spaces, field remediation, and waste management. In general, compliance with OSHA regulations prevents workers from being exposed to harmful amounts of toxic chemicals, and compliance with EPA and state regulations and DOE orders likewise protects other members of the public.

1.3 Status of Cleanup Program

Significant progress has occurred since the inception of the NNSA/NSO EM program including:

- Completed closure of more than half (over 700 as of the end of 2004) of the industrial sites on the NTS and TTR.

- Completed initial remediation of two surface radioactive contamination sites on the NTTR to reach interim closure.

- Renegotiated the corrective action strategy for deep underground radioactive contamination with the State of Nevada to allow a better understanding of the activity parameters and requirements, and had the strategy peer reviewed by a prestigious panel of experts from a variety of fields.

- Continued monitoring of air, surface water, groundwater, and biota.

- Completed preparations for receipt of off-site generated MLLW and submitted a *Resource Conservation and Recovery Act* (RCRA) Part B Permit Application to the State of Nevada.

- Continuously maintained a cost-effective LLW disposal capability for the DOE Complex, disposing of over 26,500,000 ft^3 of LLW and 300,000 ft^3 of MLLW to date.

- Initiated shipment of legacy transuranic (TRU) waste from the NTS to the Waste Isolation Pilot Plant (WIPP) in New Mexico.

The NNSA/NSO EM is advancing toward meeting the accelerated cleanup goals identified in its *Performance Management Plan* (NNSA/NV, 2002) although, the schedule dates in the plan have moved out due to the lack of sufficient funding. Many of the NNSA/NSO EM activities are on schedule to be completed by 2010. By 2027, all of the NNSA/NSO EM activities will be completed and responsibilities for long-term stewardship turned over to the landlord, the NNSA/NSO. Appropriate planning and mitigation strategies are in process and will continue to be implemented to ensure proper stewardship of the remaining contaminated sites to ensure protection of workers, the public, and the environment now and for future generations.

The risk-assessment methods used to provide input to the decision analysis is graded to ensure that the level of technical rigor matches the level of information needed for a particular decision in the cleanup process. Decision analyses, including risk-based factors, provide the following benefits:

- Facilitates prioritization of contaminated sites at individual installations.

- Provides a consistent mechanism for addressing both simple low-risk sites and complex high-risk sites, establishing a systematic approach for sites of differing complexity.

- Guides data collection to support the development of site-specific goals, ensuring that data collected are demonstrably linked to enduring protection of human health and the environment.

- Assesses cumulative risks from all sources affecting the same human or ecological receptor, quantifying the overall, facility-wide risk encountered by potential target receptors.

- Encourages early action at sites where the risk is imminent and at sites where the risk is low but remediation is rapid and inexpensive.

- Considers relevant uncertainties explicitly using stochastic modeling approaches, and considers options for reducing relevant uncertainties.

- Integrates the selection of cleanup options with the cleanup goals, evaluating multiple options in a quantitative framework.
- Provides a means of revisiting remedies over the long term through repeated risk evaluations if site conditions change over time.
- Takes place in a public forum, explicitly presenting all relevant science, assumptions, and judgments.
- Undergoes external, public, and independent scientific peer review before decisions are implemented.

1.3.1 Waste Management Strategy and Goals

The near-term vision of waste management is to maintain sufficient low-level and mixed low-level radioactive waste disposal capabilities to support accelerated cleanup across the DOE Complex. Disposal will be conducted in accordance with applicable federal and state regulations, in a manner that does not result in unacceptable environmental conditions at the NTS.

Transuranic waste management activities address the approximately 23,730 ft^3 legacy TRU waste in storage at the NTS that requires characterization and preparation for shipment to WIPP and development of a path forward for TRU waste packaged in oversize containers, classified material, and legacy experiment spheres in storage with no path forward for disposition. Contaminants of concern are TRU radionuclides. Risks associated with activities that potentially affect workers and the environment are: maintaining compliant storage configurations, processing of waste for disposal, and transportation of the waste to WIPP for disposal.

Mobile vendors will be used for characterization and certification of TRU. Technologies will be investigated to determine a potential alternative for TRU materials/waste in storage with no path forward for disposition. If the proposed treatment for NTS legacy TRU is unsuccessful, the Western Small Quantity Site Acceleration Program identified in the WIPP Performance Management Plan will be the alternative path forward.

Waste Management Operations activities include those actions required to ensure LLW and MLLW disposal capability is maintained in a cost-effective, efficient, safe manner, and available for use by the DOE Complex. Contaminants of concern are a broad array of hazardous and radionuclide constituents. Risks associated with the activities are primarily associated with disposal operations.

Waste management operational controls and closure strategies have been established based on regulatory requirements, a Documented Safety Analysis, and a site-specific risk analysis in the form of the Performance Assessment and Composite Analyses. These controls include a site-specific waste acceptance criteria, strict operational controls, radionuclide inventory thresholds, and long-term stewardship obligations.

1.3.2 Environmental Restoration Strategy and Goals

The long-term end state vision for environmental restoration at the NTS is to restore the environment to an extent that will allow the maximum continuation of the national security mission conducted by the NNSA/NSO, the national laboratories, and contractors. This vision includes the removal of only the contamination that poses an unacceptable risk to workers conducting planned site operations in support of the NNSA/NSO mission and characterizing stabilizing the rest of the contamination to ensure remaining levels do not spread to the surrounding environment.

Remedial actions are based on negotiated clean-up levels. Clean-up levels are based on applicable regulatory standards, assessment of the risk posed by the contamination, current and anticipated land uses, resource management considerations, costs, feasibility, ecological and human health risks, performing corrective actions, and stakeholder considerations. Clean closure (i.e., specific clean-up standards) versus closure in place are determined by weighing these factors, and where appropriate, establishing risk-based clean-up standards, or implementing engineering and administrative controls to minimize potential exposure to workers or the public.

A Preliminary Assessment (PA) investigation provides detailed historical information, aids the refinement of estimate parameters, and updates out-year planning information. The PA investigation process begins with the assignment and preparation phase, followed by the research phase, and concludes with the investigation summary phase. Sites are categorized as the following:

- **Complex** - A site that requires an in depth investigation process to obtain the additional information needed to evaluate possible corrective action alternatives.
- **SAFER -** A site for which sufficient information exists about the nature and extent of contamination to predict the appropriate corrective action before completion of a corrective action investigation.
- **Housekeeping** - A site where data gathered during record searches and field verification activities sanction the removal of source materials, directly impacted soil, and subsequent confirmatory sampling without additional investigation.

Work at the NTS is prioritized by the NNSA/NSO based on several factors including risk. The initial criteria used for this prioritization is described in Table 1.3.3.

Table 1.3.3
Potential Criteria for Prioritization

Category	Criteria	Description
Human, Health and Ecological Risk	Assessment of Risk	Does the potential risk to workers, and/or the general public, and/or to the ecosystem require a Corrective Action Investigation (CAI), a corrective action, or no further action?
	Future Use	What are the possible future land or resource uses?
	Geographic Location	Is the corrective action unit (CAU) located in an area that requires more immediate action than others (e.g., near foods, facilities, etc.)?
	Presence of Cultural Resources or Sensitive Species	Do CAUs contain (corrective action site) CASs where cultural resources or sensitive species are known or expected to be encountered? Will these CAUs require additional time and cost for surveys and mitigation before or concurrently with the corrective action?
	Regulatory Requirements	Are some CAIs and/or corrective actions mandated by regulatory requirements to be accomplished first? Are there other regulatory requirements that must be met (for example, must a *National Environmental Policy Act* document be completed or a threatened and endangered species survey accomplished prior to the start of a CAI and/or corrective action)?
	Waste Management Concerns	Are facilities and technologies available to effectively manage the waste expected to be generated by corrective actions?
Project Risk	Available Technology	Are the technologies available for corrective action effective and not cost prohibitive?
	Cost	Can the CASs within the CAUs be addressed within known or expected budget constraints?
	Interdependency of Action	Are planned or ongoing operations likely to have an effect on the priority of a CAI and/or corrective action?
	Optimization of Resources	Have all resources been analyzed and used to their fullest practical extent?
	Schedule	Are CAIs and/or corrective actions scheduled to allow efficient utilization of resources such as labor and equipment?
	Time required to complete action	How long will it take to complete the CAI and/or corrective action?
Other	Stakeholders' Concerns	Do stakeholders have additional criteria, concerns, or alternatives to propose?

1.3.2.1 Deep Subsurface Radiological Contamination Areas

The recently renegotiated UGTA Project corrective action strategy will be implemented. Data collection will occur in Phase 1 to fill data gaps and reduce uncertainty with additional data to be collected in Phase 2 if needed. Data will allow evaluation of contaminant transport to predict future extent of contaminant movement so that groundwater flow and transport models can be developed to predict contaminant boundaries. Independent peer reviews will be conducted to assess the technical aspects of groundwater models. Regulator and stakeholder involvement will be ongoing throughout the process to ensure better understanding of the steps in reaching a contaminant boundary for each group of sites.

A contaminant boundary will be established to define areas that contain water that may be unsafe for domestic and municipal use. A monitoring network will be in place to ensure future protection of the public and the environment. Institutional controls will be continued, and wells will be monitored, sampled, and refurbished/replaced as applicable.

1.3.2.2 Surface and Shallow Subsurface Radiological Contamination Areas

An appropriate corrective action level of total transuranics is being formalized with the U.S. Air Force and NDEP to address surface soil sites on the NTTR. This clean-up level will be based on a 25 millirems per year (mrem/yr) dose rate, which is compatible with future military land-use scenarios. Access and institutional controls for the NTTR are the responsibility of the U.S. Air Force. The negotiated corrective action level will be based on soil sampling, characterization data, computer analysis of residual radiation, and as-low-as-reasonably-achievable (ALARA) determinations. Confirmatory sampling of cleanup results will be done in conjunction with the U.S. Air Force. Surface soil contamination sites on the NTS will be characterized, fenced, posted, and monitored, as applicable, and relinquished to NNSA/NSO restricted access.

1.3.2.3 Industrial Sites

Industrial sites on the NTTR are addressed first, because access and institutional controls are the responsibility of the U.S. Air Force. Generally, sites on the NTS will be remediated starting in the southwest corner in accordance with future land-use planning. The most contaminated of these sites will be addressed first. Limited site remediation will be conducted during the site assessment phase, as appropriate, to achieve early closure.

Remediation, stabilization, control of contamination, and monitoring, as appropriate, will occur at multiple industrial sites in parallel. Sites will be aggregated into larger CAUs to achieve more efficient cleanup resulting from fewer required regulatory documents, co-location of sites, commonality of source contamination, required regulatory actions, and better utilization of craft personnel.

Applicable corrective actions will be completed for all industrial sites, and most sites will be open for free, unrestricted use while others will be stabilized for restricted use appropriate to the risk posed by residual contamination. For those sites where contamination remains in place, appropriate long-term stewardship activities will be in place, including monitoring, cap inspections, and use restrictions as applicable to the site.

1.3.2.4 Remedy Selection

The NNSA/NSO EM has identified likely remedies for cleanup sites. Each remedy will be optimized using human health and environment risk-based decision analysis, and project risk (e.g., cost, schedule, scope) to compare the effectiveness of alternative remedy designs in achieving applicable performance standards under the conditions of planned land use.

Exposure scenarios have been developed to represent future land use according to existing plans. The vast majority of clean-up sites are on property that is expected to remain under DOE or U.S. Air Force ownership.

1.3.3 EM Completion

For cleanup sites located on DOE property, EM completion will coincide with the attainment of performance standards through remedies approved by the administrative authority. The NNSA/NSO EM intends for the final goal performance standards to meet the intent of the end state, which represents EM completion.

Long-term performance monitoring and response actions to maintain the end state will be integrated into the NNSA/NSO environmental management system consistent with the requirements of DOE Order 450.1 (DOE, 2003a). The location, frequency, and duration of monitoring will be established using systems engineering design principles, and a logical exit strategy will be defined to ensure that resources are not wasted on unnecessary data collection and reporting.

By 2022, risk reduction activities agreed to by NNSA/NSO EM and State regulators will have occurred at all NNSA/NSO EM sites, and objectives achieved as follows:

- Closure of all 1,047 industrial sites on the NTS and NTTR.
- Establishment of a total transuranics corrective action level, radioactive contaminated soils, and investigation and acceleration of soils clean-up activities on the NTTR.

- Complete characterization of radioactive contaminated soils on the NTS.
- Shipment of legacy drums of TRU waste currently in storage at the NTS to WIPP for disposal.
- Evaluation and implementation of new technology for TRU waste with no path forward for disposition (e.g., oversize boxes, classified materials in storage, and legacy experiment spheres).
- Transuranic waste facilities will have been decontaminated and transitioned to other uses.
- Continued cost-effective capability to receive large quantities of LLW from generators throughout the DOE Complex.
- Receive State of Nevada approval of RCRA Part B Permit to receive MLLW from off-site generators.

Activities remaining beyond 2022 include:

- Closures and long-term stewardship obligations (such as monitoring) will be implemented in accordance with regulatory requirements to ensure there is no risk to workers, the public, and the environment as the result of disposed waste.
- Data acquisition and modeling required for deep subsurface radiological contamination to establish contaminant boundaries.
- Develop long-term monitoring network for deep subsurface radiological contamination.

1.3.4 Long-Term Risk Management

Consistent with the *Atomic Energy Act* of 1954, as amended, DOE retains responsibility for radioactive materials used in its programs. This includes responsibility for residual environmental contamination as long as it poses a threat to human health and/or the environment. At the NTS, EM sites that cannot be remediated to contaminant levels allowing unrestricted use (either now or in the foreseeable future) will transition to the NNSA. As required by DOE Order 450.1 “Environmental Protection Program,” NNSA will explicitly incorporate long-term environmental stewardship activities into an integrated environmental management system supported by NNSA/NSO (DOE, 2003a). These long-term stewardship activities will:

- Allow continuous evaluation, research, and developments toward innovative solutions to resolve long-term risks (i.e., uncertainties) while conventional remedies are implemented to manage short-term risks.
- Periodically reevaluate previous remediation decisions that do not meet long-term environmental stewardship goals, even if they are currently protective.
- Integrate public stakeholders in each decision phase.

1.3.5 Public Involvement

In order to accomplish the goals, objectives, strategies, and milestones identified in the NNSA/NSO EM *Performance Management Plan* (NNSA/NV, 2002), it is crucial that EM continue positive, proactive relationships with state regulators and stakeholders. To ensure these relationships remain proactive and positive, NNSA/NSO EM and future landlords as applicable will continue to:

- Work closely with state regulators and stakeholders to ensure issues/concerns are addressed and that the state and stakeholders are informed of NNSA/NSO EM activities.
- Conduct its activities safely, efficiently, and cost-effectively.
- Complete all regulatory-required milestones as planned.
- Meet regularly with state regulators and stakeholders to keep channels of communication open.
- Fund state regulators and appropriate stakeholder involvement initiatives.
- Require federal and contractor staff to provide support of regulator and stakeholder initiatives.

The laws, regulations, and DOE/State of Nevada agreements with specific requirements for public interactions include the following:

- *National Environmental Policy Act*
- *Resource Conservation and Recovery Act*
- *Federal Facility Compliance Act*
- *Federal Facility Agreement and Consent Order* (FFACO, 1996)

The NNSA/NSO, the State of Nevada, and the DoD entered into the FFACO. The FFACO addresses sites and facilities potentially contaminated by past DOE and DoD activities and mandates effective investigations and corrective actions be established to protect public health, and the environment. Within this agreement and consent order, there is a *Public Involvement Plan* (Appendix V) that specifies the requirements relating to public awareness and participation for NNSA/NSO EM activities. The *Public Involvement Plan* is a key resource to gain information on public participation options that relate to NNSA/NSO environmental restoration activities.

The *Public Involvement Plan* serves two purposes: (1) it provides a broad public involvement strategy for the EM Program, and (2) fulfills requirements contained in the FFACO. The major goal of the NNSA/NSO EM public involvement program is to establish and maintain a two-way exchange of information and ideas between the public and the NSO regarding environmental management issues and priorities. The plan is a "working document" and will be reviewed and revised periodically to reflect changing information and/or to incorporate new public involvement opportunities that arise as the EM program evolves. Changes to the plan will be communicated to the public and made available for review in the NNSA/NSO Public Reading Facilities in Nevada.

In 1994, the DOE Nevada Operations Office (now NNSA/NSO) began conducting formal community relations interviews to establish a dialogue with the public. The interviews helped identify participants' key concerns, attitudes, knowledge, and understanding of the EM Program at NNSA/NSO. The addition of the CAB for NTS EM Programs and the periodic CAB meetings provided additional opportunities for public input. This information was candid and helpful, setting in motion a number of programs that would appeal to diverse audiences with different informational needs and interests.

Information regarding NNSA/NSO EM activities is provided to the public through a variety of sources including:

- The EM mailing list
    - Comprehensive list maintained by NNSA/NSO
    - Over 2,000 names and addresses of individuals and organizations
    - Receive meeting notices and information
    - Additional CAB mailing list for meetings and events
- The EM Internet sites provided by DOE
    - http://www.nv.doe.gov/programs/envmgmt
    - http://www.em.doe.gov/
    - http://ndep.state.nv.us (under the Federal Facilities link)
- Fact sheets and other materials
    - Available for most NNSA/NSO EM activities
- The EM Update
    - Describes current EM activities, programs, and personnel

- Provides CAB recommendations
- Provides a variety of other related information

- New releases and public service announcement

  - Communicates achievements and events
  - Provides notices of workshops and meetings
  - Provides items of particular interest

- The NNSA/NSO Speakers Bureau

  - Provides speakers to community, academic, civic, and professional groups
  - Provided at the request of interested parties
  - Includes both federal and contractor staff

- Public outreach events

  - Uses NNSA/NSO EM exhibits, displays, and provides written information
  - Presented at annual events such as Earth Day, Science Bowl, etc.
  - Visits to schools, libraries, conferences, and special events

- Tours at the Nevada Test Site

  - Conducted at the request of interested individuals and groups

2.0 REGIONAL CONTEXT END STATE DESCRIPTION

This section is intended to place the NTS within its larger geographical context. The major regional population centers and land surface features are shown in relation to the site.

2.1 Physical and Surface Interface

Maps 2.1b1 and 2.1b2 show the physical and surface characteristics of the region surrounding the NTS. These maps emphasize the remote character of the NTS. The small towns of Indian Springs and Tonopah are the nearest to the NTS and TTR, although federal lands provide a buffer between them and the NTS. Las Vegas (65 mi southeast) is the nearest metropolitan area in the region.

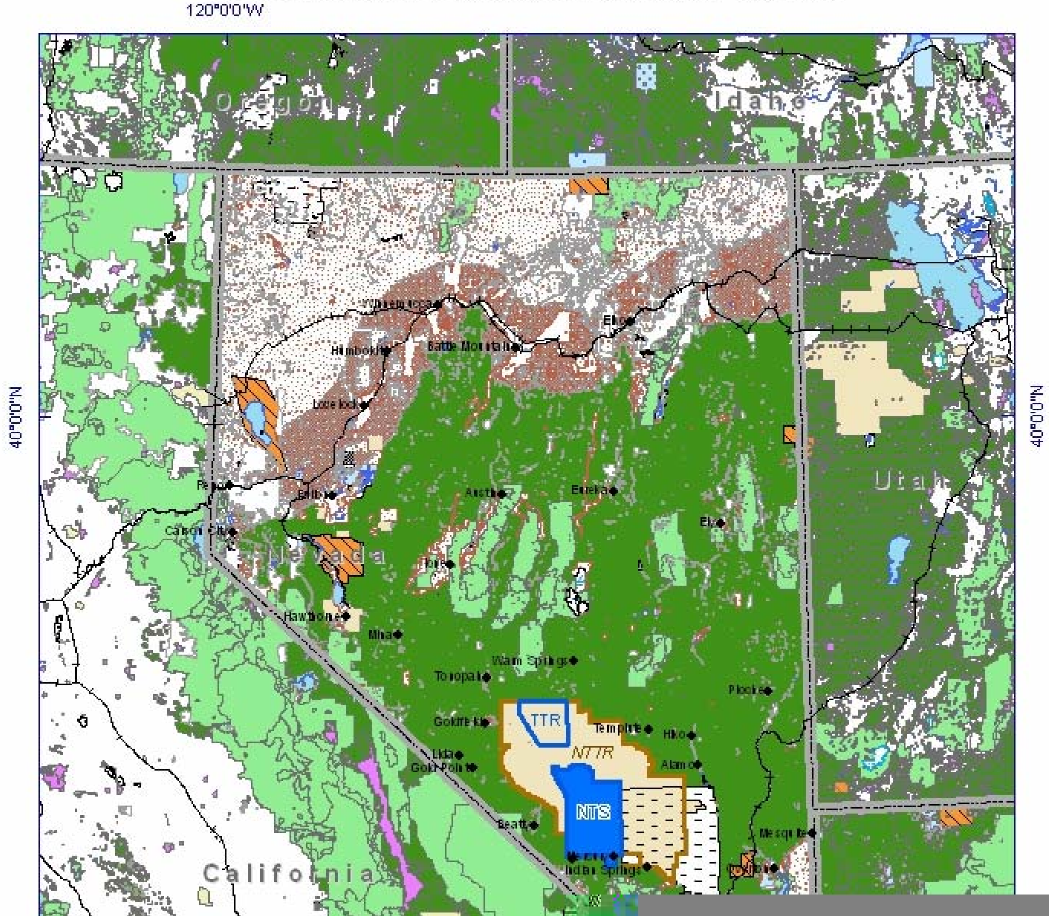
There are no expected physical surface changes during the timeframe when the EM's mission will be completed and the end state achieved.

2.2 Human and Ecological Land Use

Map 2.2b shows the human and ecological land-use characteristics of the region surrounding the NTS. The largely undeveloped nature of the area surrounding the NTS is evident from these maps, with most land under the control of the federal government. BLM and National Forest Lands near the borders of NTS and NTTR allow for recreation and grazing; however, humans and livestock are restricted from gaining long-term access by site security controls. No major changes in land use are anticipated near the NTS in the timeframe under consideration.

2.3 Other Information

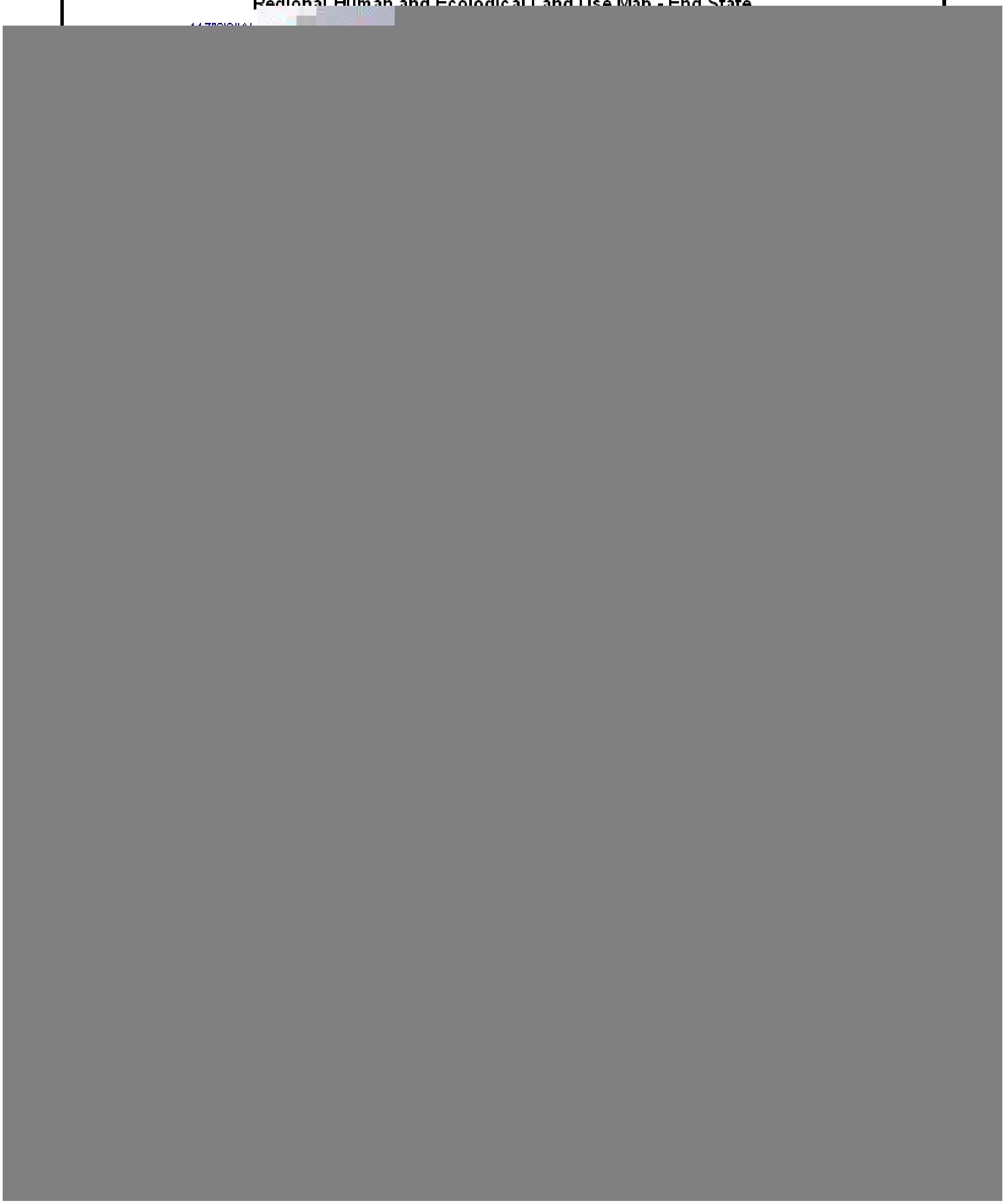
Map 2.3a shows the regional monitoring locations for the NTS and TTR. It is not possible to show the end state for the monitoring sites until the closure reports are approved.



Map 2.1b1 Nevada Test Site and Nevada Test and Training Range, Nevada
State Wide Physical and Surface Interface Map - End State

Map 2.1b2 Nevada Test Site and Nevada Test and Training Range, Nevada
Regional Physical and Surface Interface Map - End State

Map 2.2b Nevada Test Site and Nevada Test and Training Range, Nevada
Regional Human and Ecological Land Use Map - End State



Map 2.3a Nevada Test Site and Nevada Test and Training Range, Nevada
Regional Monitoring Locations Map - Current State

3.0 SITE SPECIFIC END STATE DESCRIPTION

This section describes the site-specific physical and surface interface, human and ecological land use, and compares the current land use to the planned end state. This section also contains information regarding the legal ownership of the NTS and NTTR, adjacent lands, and the area demographics.

3.1 Physical and Surface Interface

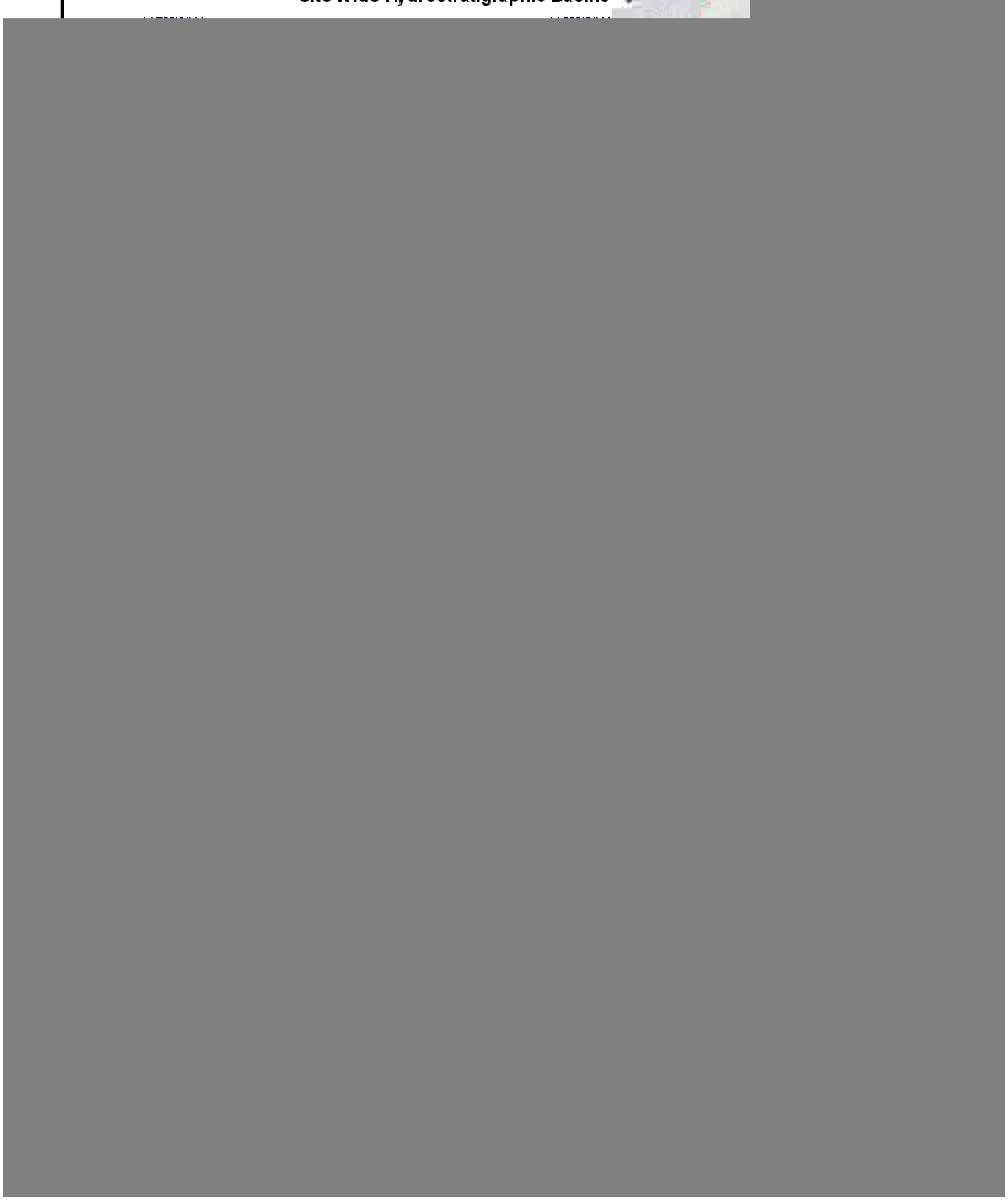
The NTS and NTTR terrain is typical of much of the Basin and Range physiographic province in Nevada, Arizona, and Utah. North to northeast trending mountain ranges are separated by gently sloping, linear valleys, and broad flat basins at the NTS. The principal valleys within the NTS are Frenchman Flat, Yucca Flat, and Jackass Flats, with the principal highlands consisting of Pahute Mesa, Rainier Mesa, Timber Mountain, and Shoshone Mountain. The NTS elevations range from about 3,000 to 4,000 ft in the valleys; to the south and east between 5,500 and 7,300 ft in the high country toward the northern and western boundaries. Maps 3.1b1 and 3.1b2 show the facilities and site roads for the NTS and NTTR. Map 3.1b3 shows the hydrostratigraphic basins located on the NTS and NTTR. Map 3.1b4 shows the topographic areas located on the NTS and NTTR. No major changes in the site physical and surface interface are anticipated near the NTS in the timeframe under consideration.

The NTS and NTTR environment is characterized by desert valley and Great Basin mountain terrain and topography, with a climate, flora, and fauna typical of the southern Great Basin deserts. The key features that afford protection to the inhabitants of the adjacent areas from potential exposure to radioactivity, or other contaminants resulting from operations on the NTS, are: restricted access, extended wind transport times, land bounded on three sides by U.S. Air Force lands, and the general remote location of the NTS. Also characteristic of this area are the deep, slow-moving groundwater, and little or no surface water.

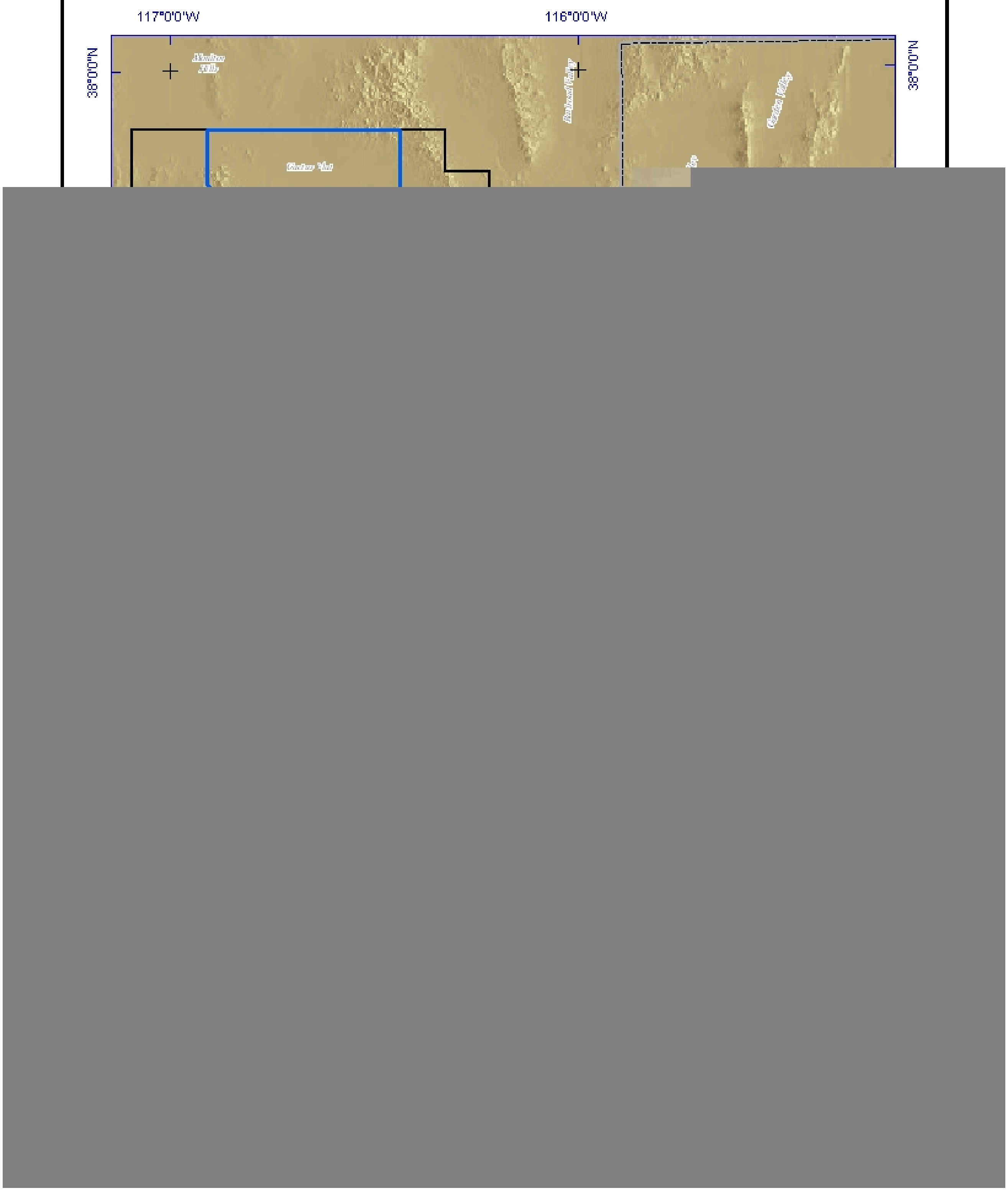
Surface drainage for Yucca and Frenchman Flats (east side of the NTS) are closed-basin systems that drain onto the dry lakebeds (playas) in each valley. The remaining area on the western side of the NTS drains via arroyos and dry streambeds that carry water only during unusually intense or persistent storms. There are no continuously flowing streams on the NTS, and run-off water from contaminated areas does not leave the site.

Map 3.1b1 Nevada Test Site, Nevada
Site Physical and Surface Interface Map - End State

Map 3.1b3 Nevada Test Site and Nevada Test and Training Range, Nevada
Site Wide Hydrostratigraphic Basins - End State



Map 3.1b4 Nevada Test Site and Nevada Test and Training Range, Nevada
Site Physical and Surface Interface Map - End State



The TTR is located in the lowland portions of Cactus Flat and Stonewall Flat. Cactus Flat is a topographically closed basin with a total area of 403 square meters (m^2). Stonewall Flat is topographically open and encompasses 381 m^2. Stonewall Flat is bounded on the south by Stonewall Mountain, which has a maximum elevation of 8,275 ft. On the west, Stonewall Flat is bounded by the Goldfield Hills, which rise to an elevation of almost 7,000 ft. On the valley floors of both basins, the dominant features are a number of small playas and the many washes that drain the upland areas.

The general appearance of the range is barren landscape. The playas support no vegetation, while the lower slopes and mountains support brush, some Joshua trees, and juniper.

Precipitation recorded on the TTR valley floors averages 5 to 6 inches per year.

The NTS is 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 dry mid-latitude or dry subtropical climatic zones. The climate is characterized by low precipitation, a large diurnal temperature range, a large evaporation rate, and moderate to strong winds.

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 storms. The average annual precipitation ranges between 3 and 10 inches, depending on elevation. Lower values of this range are typical in valleys, whereas higher values are typical in the surrounding mountains.

Elevation influences temperatures on the NTS and TTR, with higher elevations having a sustained cooler temperature and lower elevations having a sustained warmer temperature. At an elevation of 6,500 ft, Pahute Mesa recorded a maximum temperature of 102 degrees Fahrenheit (ºF) and a minimum temperature of 11ºF. The average maximum temperature was 61ºF and the average minimum was 41ºF. In the Yucca Flat basin, at an elevation of 3,920 ft, the maximum temperature recorded was 118ºF and the minimum temperature was 8ºF. The average maximum temperature was 73ºF and the average minimum was 38ºF. Monthly average temperatures for the NTS range from 44ºF in January to 90ºF in July.

Winds primarily are southerly during summer months and northerly during winter months. Wind velocities tend to be greater in the spring than in the fall. At the Yucca Playa Station, the average annual wind velocity was 7 miles per hour (mph). The maximum wind velocity at the nearby Meteorological Data Acquisition System Station 4 was 85 mph. At Area 20 Camp on Pahute Mesa, the average wind velocity was 10 mph, and the maximum was 52 mph.

Depth to groundwater under the NTS varies from about 690 ft beneath the Frenchman Flat playa in the southern part of the NTS to more than 2,300 ft beneath part of Pahute Mesa. In the eastern portions, the water table occurs generally in the alluvium and volcanic rocks above the regional carbonate aquifer and is characterized by regional flow from the upland recharge area in the north and east, toward discharge areas at Ash Meadows and Death Valley.

3.2 Human and Ecological Land Use

This section discusses the human and ecological attributes presented in maps following the DOE format. As discussed in the DOE guidance, human and ecological land use attributes fall into the following three categories:

- Human Activities
- Ecological Activities
- Hazard Areas of Concern

3.2.1 Human Activities

Human activities include site-wide and local land-use patterns, which can identify potential points, pathways, and scenarios of human exposure to potentially contaminated media. There are no areas designated for commercial, agriculture, residential, or recreational use on the NTS or TTR.

Existing land use on the NTS is divided into two site categories and nine zone categories. The site and zone category definitions are as follows:

- **Industrial, Research, and Support Site** - These areas are used for the manufacturing, processing, and/or fabrication of articles, substances, or commodities. A research site is used for projects to verify theories or concepts under controlled conditions. Support sites are used for office space, training, equipment storage, maintenance, security, feeding and housing, fire protection services, and health services.

- **Waste Management Site** - Areas designated for the disposal, storage, and/or treatment of wastes.

- **Nuclear Test Zone** - Land area reserved for underground hydrodynamic tests, dynamic experiments, and underground nuclear weapons and weapons effects tests. The stockpile stewardship emplacement hole inventory is located within this zone.

- **Nuclear and High-Explosive Test Zone** - Land area designated within the Nuclear Test Zone for additional underground and aboveground high-explosive tests or experiments.

- **Research, Test, and Experiment Zone** - Land area designated for small-scale research, development projects, pilot projects, and outdoor tests and experiments for the development, quality assurance, or reliability of materials and equipment under controlled conditions.

- **Radioactive Waste Management Zone** - Land area designated for the shallow land burial of low-level and mixed wastes.

- **Solar Enterprise Zone** - Land area designated for the development of a solar energy power generation facility.

- **Defense Industrial Zone -** Land area designated for stockpile management of weapons, including production, assembly, disassembly or modification, staging, repair, retrofit, and surveillance.

- **Military Testing Zone** - Land area reserved for military testing, training, and exercises.

- **Reserved Zone** - This includes areas and facilities that provide widespread flexible support for diverse short-term testing and experimentation. The reserved zone is also used for short-duration exercises and training.

In addition to designated land use areas, additional institutional controls have and will continue to be established for unique site-specific hazard areas. These controls may include a combination of engineered barriers, postings, and/or security controls.

- **Yucca Mountain Site Characterization Zone -** Land area designated for characterization activities associated with Yucca Mountain.

Human habitation of the NTS began as early as 10,000 years ago. Various indigenous cultures occupied the region in prehistoric times. The survey of less than 5 percent of the NTS area has located more than 2,000 archaeological sites. The site types identified include rock quarries, manufacturing areas, hunting locales, rock art, temporary camps, and permanent villages. The prehistoric peoples' existence was sustained by a hunting and gathering economy, which utilized all parts of the NTS.

In the nineteenth century, at the time of initial contact, the area was occupied by Southern Paiute and Western Shoshone Indians. Before 1940, the historic occupation consisted of ranchers, miners, and Native Americans. Stone cabins, corrals, and fencing stand today as testaments to these early settlers.

Known cultural resources recorded at the TTR are limited to certain environmental areas, while the archaeological sites within other areas are virtually unknown. Projectile points found on the TTR suggest that the area has been used for the last 10,000 years. At the time of the first

European explorations of the area, groups of Western Shoshone people occupied the area. Based on current knowledge of cultural resources on the TTR, all areas have the potential to contain significant historic properties. Thus, the current TTR boundaries are considered the area of potential effect for cultural resources.

3.2.2 Ecological Activities

The NTS is located along the transition zone between the Mojave Desert and the Great Basin. As a result, this site has diverse plant and animal communities representative of both deserts, as well as some communities common only in the transition zone between these deserts. This transition zone extends to the east and west far beyond the boundaries of the NTS. Thus, the range of almost all species found on the NTS and TTR also extends far beyond the site, and there are few rare or endemic species found there.

Elevation is the most obvious factor affecting the distribution of plant and animal communities on the NTS and surrounding areas. Elevations increase from south to north, from a low of 2,688 ft to a high of 7,679 ft.

Mojave Desert plant communities are found at elevations below approximately 4,000 ft. Creosote bush is the visually dominant shrub, and it is associated with a variety of other shrubs such as white bursage, shadscale, hopsage, and wolfberry, depending on soil type and elevations. Pinyon and Utah juniper are dominant at elevations over 6,000 ft. No plants that have been listed as threatened or endangered are known to occur on the NTS and TTR.

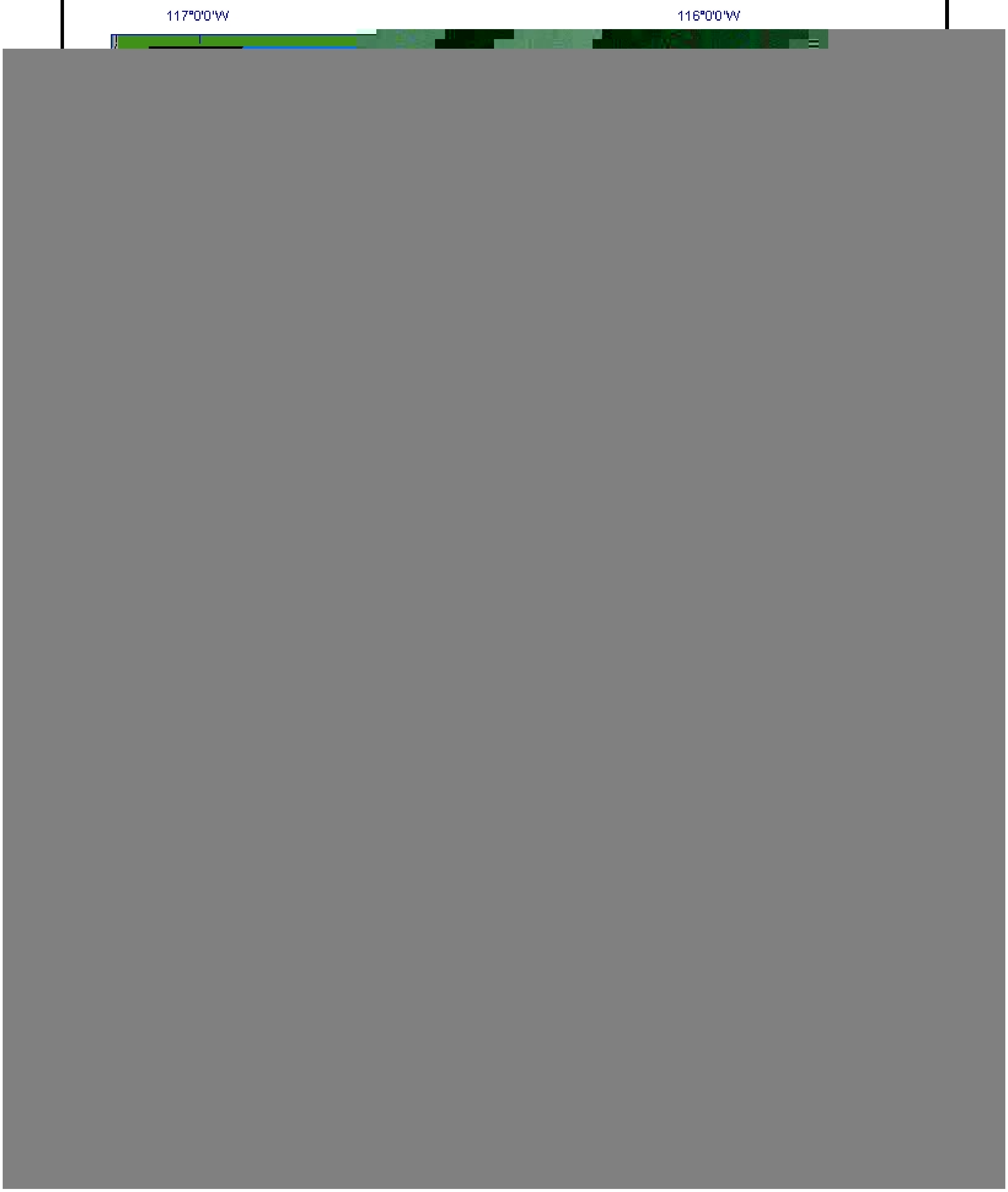
Approximately 280 vertebrate species have been observed on the NTS. Many of the species on the NTS are common only in the Mojave Desert habitats. Typical species found on the NTS include kit fox, Merriam, kangaroo rat, desert tortoise, chuckwalla, and sidewinder snake. Typical Great Basin species in this region include cliff chipmunk, pocket mouse, mule deer, northern flicker, scrub jay, Brewer's sparrow, western fence lizard, and striped whipsnake. Approximately 60 wild horses live on the northern part of the NTS. Predators and scavengers in this region include coyotes, bobcats, common ravens, red-tailed hawks, rattlesnakes, and gopher snakes. Only one animal species listed as endangered, the peregrin falcon, has been reported on the NTS. This is a rare migrant to the NTS and has been reported only once. Map 3.2b provides the site human and ecological land use site context.

3.3 Site Context Legal Ownership

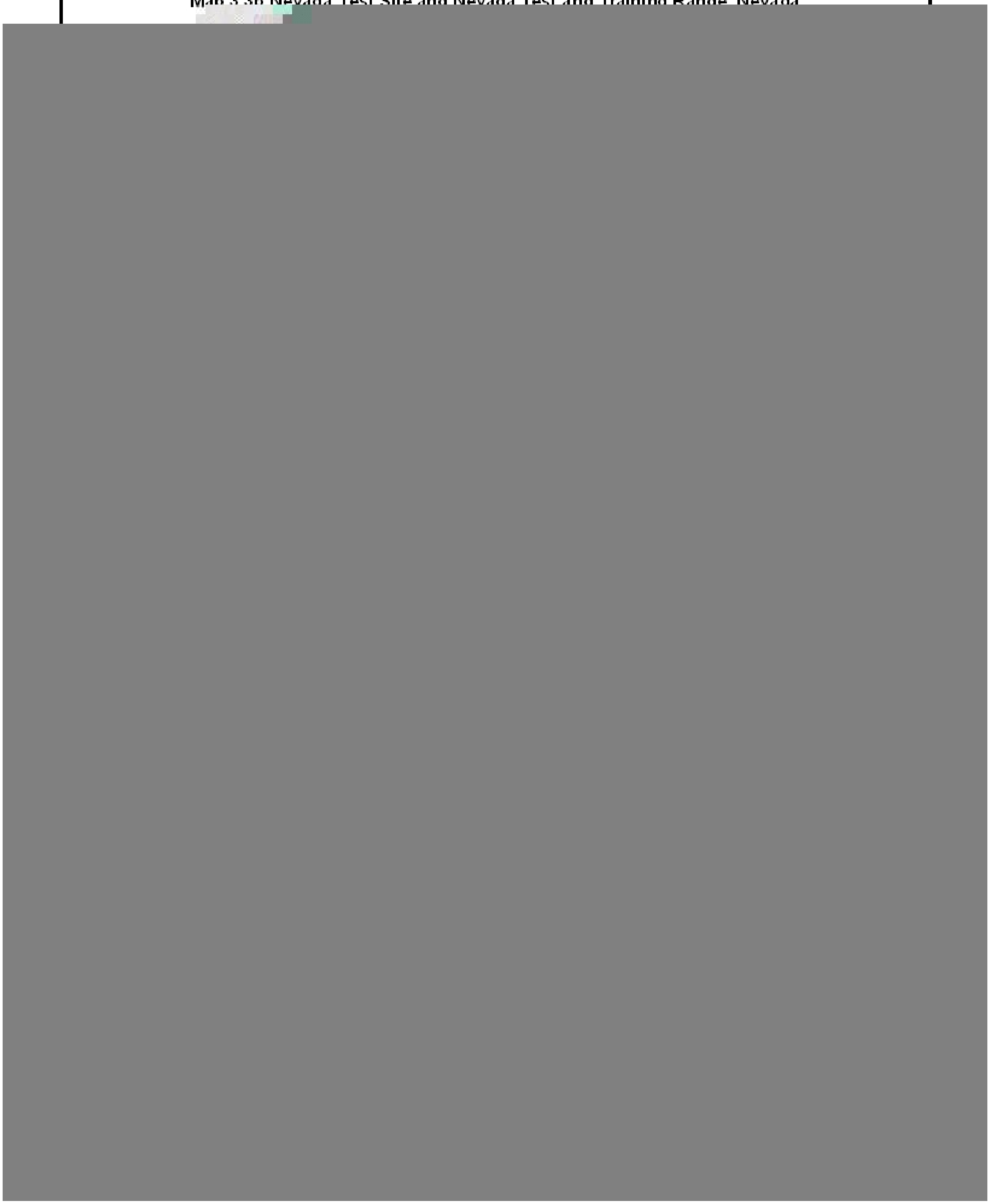
The NTS encompasses approximately 1,375 mi^2 of land area reserved to the jurisdiction of the DOE. Map 3.3b shows the land area as it has been withdrawn through all forms of appropriation under the public land laws, including mining and mineral leasing laws through the public land orders and a Memorandum of Understanding. Under Public Land Order (PLO) 805 (February 12, 1952), 437,020 acres of land were reserved for use by the U.S. Atomic Energy Commission as a weapons testing site. Under PLO 2568 (December 19, 1961), 318,000 acres of land previously reserved for use by the U.S. Air Force were transferred to the jurisdiction of the U.S. Atomic Energy Commission for use in connection with the NTS for test facilities, roads, utilities, and safety distances. Under PLO 3759 (August 3, 1965), 21,108 acres of land were reserved for the jurisdiction of the U.S. Atomic Energy Commission for use in connection with the NTS.

In 1983, the BLM, in accordance with the *Federal Land Policy and Management Act of 1976*, conducted a review of the existing four land withdrawals that comprise the NTS. The BLM District Manager concurred with the review conclusion that the lands were still being used for the purpose for which they were withdrawn. Furthermore, in recognition of the potential end of testing in future years, the BLM recommended that the land withdrawals again be reviewed in 100 years. In April of 1999, the U.S. Air Force filed a Land Withdrawal Extension Application. The application requested that the lands described as Pahute Mesa in the existing Memorandum of Understanding with DOE be transferred to the DOE. Additionally, the application requested that the lands withdrawn for DOE under PLO 1662 be transferred to the U.S. Air Force. As a result, the *Military Lands Withdrawal Act* of 1999 (Public Law 106-65) renewed the withdrawal of about three million acres of land currently withdrawn for defense use as part of the Nellis Air Force Range (now known as the NTTR). This action also increased the size of the NTS from 1,350 mi^2 to approximately 1,375 mi^2. The TTR has been closed to public entry since the 1940s when it was withdrawn for military use, managed by the DOE under a Memorandum of Understanding with the U.S. Air Force. No anticipated changes to the ownership of lands are anticipated during the timeframe under consideration. Map 3.3b depicts the legal ownership of the NTS and TTR.

Map 3.2b Nevada Test Site and Nevada Test and Training Range, Nevada
Site Human and Ecological Land Use Site Context Map - End State



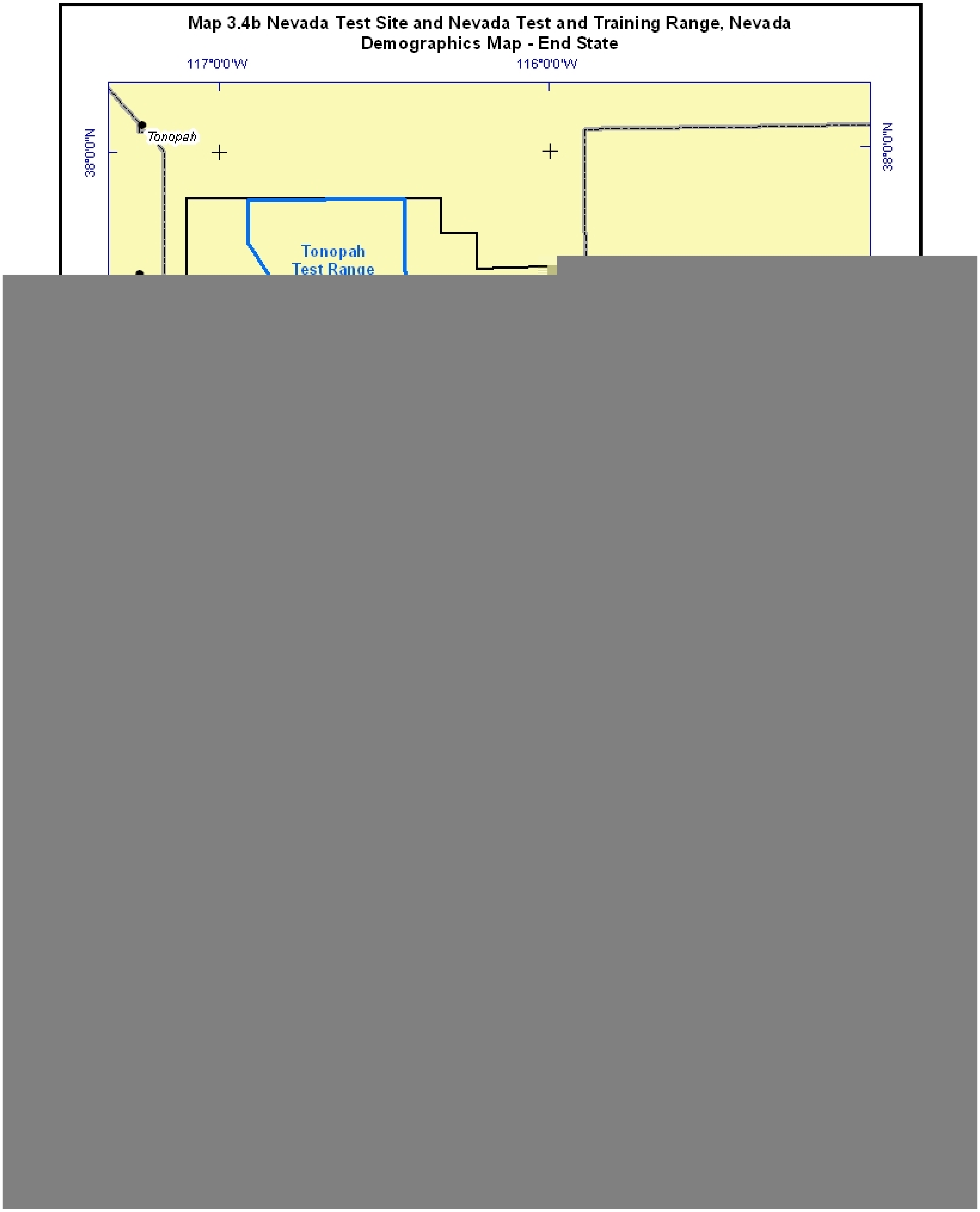
Map 3.3b Nevada Test Site and Nevada Test and Training Range, Nevada



3.4 Site Context Demographics

The NTS is bordered by the NTTR on the north, east, and west, and by BLM lands on the south and southwest. The population density within a 94-mile radius of the NTS is about 1.3 persons per square mile, excluding Clark County which contains the city of Las Vegas. The estimated average population density for all of Nevada (including Clark County) was 18.2 persons per square mile in 2000 (U.S. Census Bureau, 2000). In comparison, the entire United States had a population density of approximately 79.6 persons per square mile.

There are no permanent residents at the NTS. The area within 50 miles of the NTS is predominantly rural. An administrative community called Mercury resides on the southeast portion of the NTS and houses temporary workers for temporary work periods. There are no permanent residents in Mercury. Several other small communities are located southwest; the largest being Pahrump Valley. This growing rural community has an estimated population of 33,000 and is located 50 mi south of the site. The Amargosa farm area, with a population of about 1,000, is located approximately 31 mi southwest. The town of Beatty (population approximately 1,100) is located approximately 40 mi to the west. Tonopah, located to the northwest, has a population of approximately 2,600. The Las Vegas urban area is the closest major metropolitan area and is located 65 mi southeast. According to the Clark County Department of Comprehensive Planning, the Las Vegas urban area population is approximately 1.5 million. Map 3.4b depicts site demographics for the NTS, TTR, NTTR, and the immediate surrounding area.


Map 3.4b Nevada Test Site and Nevada Test and Training Range, Nevada
Demographics Map - End State
117°0'0"W
116°0'0"W
38°0'0"N
38°0'0"N
Tonopah
Tonopah
Test Range

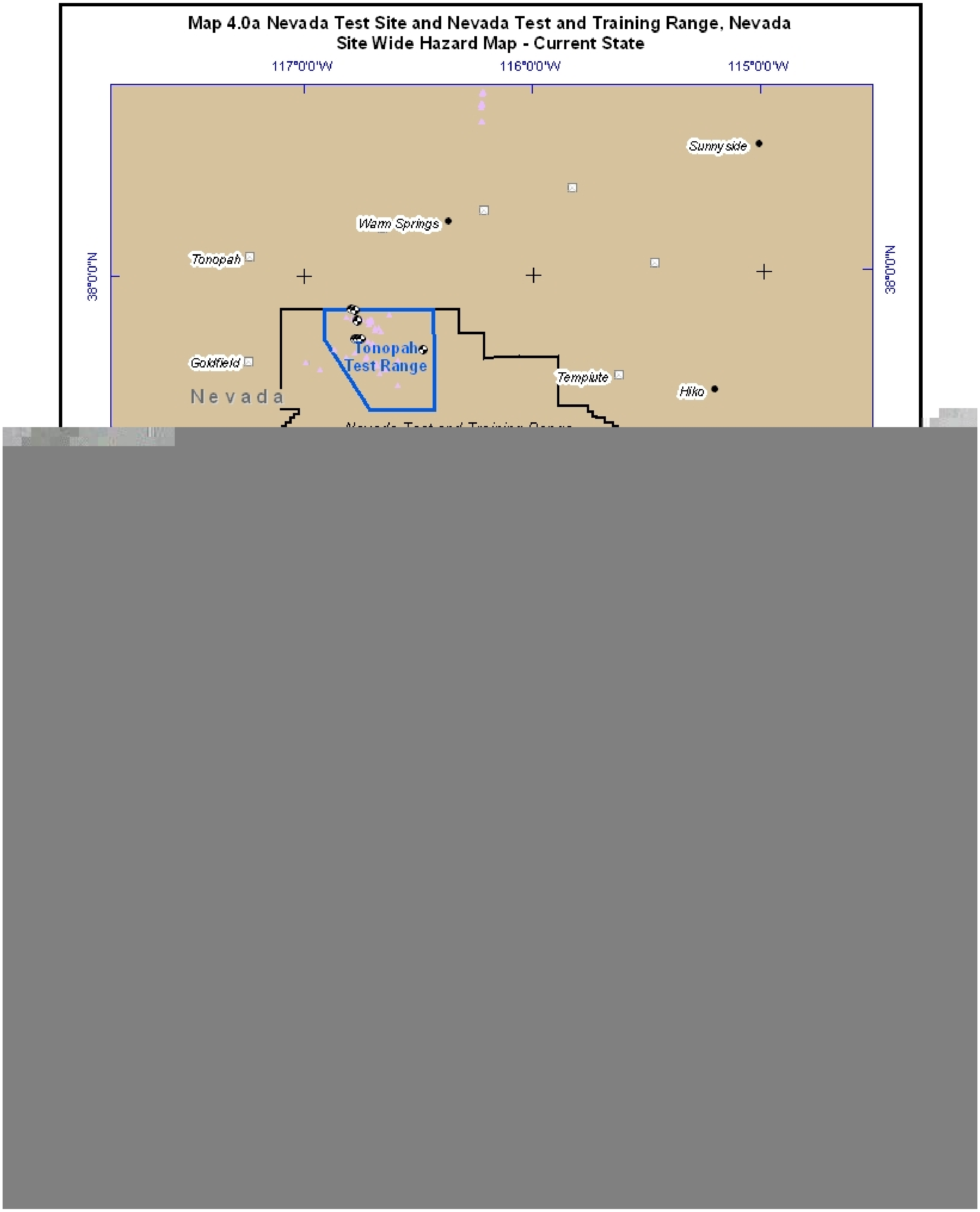
4.0 HAZARD SPECIFIC DISCUSSION

This section describes (via figures and text) the chemical and radiological hazards associated with the NTS and NTTR (including TTR) past, present, and future operations. The discussion of "hazard areas" at the NTS, TTR, and NTTR has been divided into three areas based on historic activities, type of contaminants, common fate in the environment, and potential for impacting common receptors. Deep subsurface radiological contamination (Hazard Area 1) and surface and shallow subsurface radiological contamination (Hazard Area 2) are the direct result of nuclear testing. Industrial sites (Hazard Area 3) are areas of environmental contamination that include impacts from facilities, infrastructure, manufacturing processes and waste disposal that were a by-product of nuclear testing. The only potential connection between these hazard areas are between Hazard Areas 2 and 3. However, the contributing influence between these hazard areas is negligible.

There are two site-wide maps (4.0a and 4.0b) and two for each of the different hazard area representing the current state (i.e., 2004) and the projected end state 20 years after completing the EM mission (i.e., 2047). It is not possible to show the end state for the air and water monitoring sites until the applicable closure reports are approved. In Hazard Area 1, where the end state boundary is not expected to change significantly, only one map is provided.

According to the Life-Cycle Baseline Revision 6, completion of the EM mission for the NTS will be phased, with closure of the Industrial Sites Project (Hazard Area 3) in FY 2018, the Soils Project (Hazard Area 2) in FY 2022, and the UGTA Project (Hazard Area 1) in FY 2027. Table 4.1 summarizes the hazards and risks associated with the NTS.

For each hazard area, there is an associated current and end state conceptual site model (CSM). The conceptual models describe the release, transport, and potential exposure pathways for airborne, surface, and subsurface contaminants within each hazard area. Source contaminants in air, surface, and subsurface media share a common fate in the environment and have a potential for impacting a common receptor. The descriptions of affected media, and transport and exposure pathways provided in Tables 4-2 and 4-3 apply to all of the CSMs in this section, as do the controls identified in the CSM for the current state and the end state.


Map 4.0a Nevada Test Site and Nevada Test and Training Range, Nevada
Site Wide Hazard Map - Current State
117°0'0"W
116°0'0"W
115°0'0"W
38°0'0"N
38°0'0"N
Sunny side
Warm Springs
Tonopah
Goldfield
Nevada
Tonopah Test Range
Tempiute
Hiko

Map 4.0b Nevada Test Site and Nevada Test and Training Range, Nevada
Site Wide Hazard Map - End State

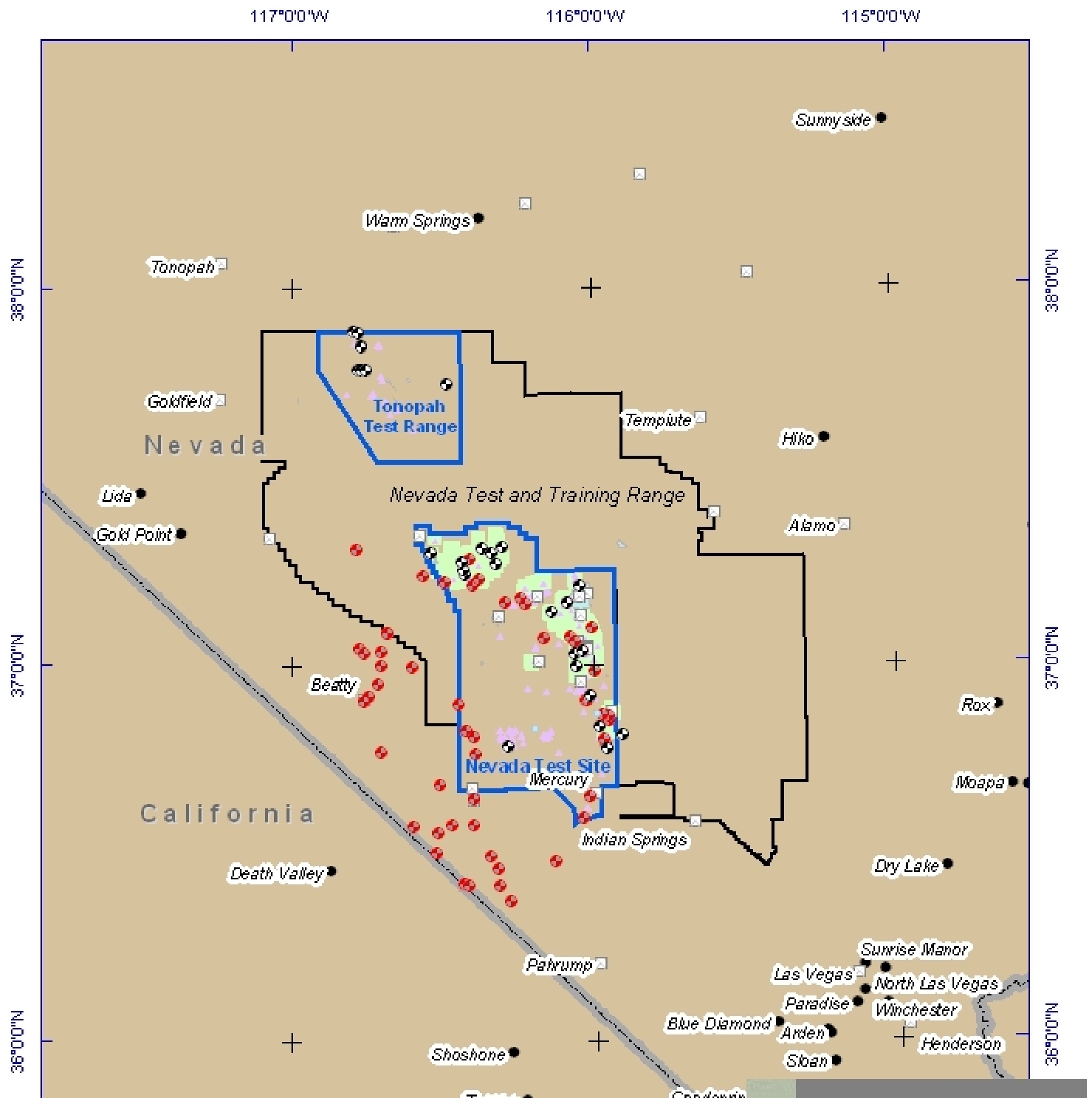


Table 4.1
NTS Hazards and Risks
(Page 1 of 2)

Material Category	Nature of Hazard	Nature of Potential Risk	Status of Current Management	Planned Risk Reduction Control	Anticipated Risk Reduction Progress	End State Disposition and Risk
Deep subsurface radiological contamination (Underground Test Area)	Groundwater and geologic media in the immediate vicinity of the test cavities is contaminated with radionuclides.	Migratory potential of radionuclides in groundwater is believed to be minimal. Radionuclides have not been detected above the regulatory standard in off-site wells or on-site water supply wells. If contaminant migration occurs, the most probable exposure scenarios would be via inhalation, ingestion, and dermal contact with groundwater.	Site subsurface characterization and groundwater modeling activities are ongoing. Site access is restricted to authorized personnel. Migratory potential of the contaminants from the test cavity via groundwater will be modeled and additional subsurface characterization will be used for model refinement.	Subsurface restrictions and institutional controls are in place and maintained. The subsurface risk-based compliance boundaries will be determined based on the subsurface modeling results. A long-term monitoring program will be implemented.	Currently, there is no feasible or cost effective corrective action technology to address test cavities and associated subsurface contamination that will eliminate potential risk. Risk will be reduced by establishing use restrictions within the contaminant boundary.	A contaminant boundary will be established based on the groundwater modeling results to define areas that contain water that may be unsafe for domestic and municipal use. A monitoring network will be in place to ensure future protection of the public and the environment. Eliminating pathogens via use restrictions will reduce risk. Institutional controls will be continued, and wells will be monitored, sampled, and refurbished/replaced as applicable.

Table 4.1
NTS Hazards and Risks
(Page 2 of 2)

Material Category	Nature of Hazard	Nature of Potential Risk	Status of Current Management	Planned Risk Reduction Control	Anticipated Risk Reduction Progress	End State Disposition and Risk
Industrial Sites	Surface and shallow subsurface soil contaminated with hazardous organic and inorganic chemicals, unexploded ordnance, petroleum hydrocarbons, and low-level radionuclides. Migratory potential of contamination via wind, soil, surface water, and downward migration.	Potential site exposure scenario is inhalation, incidental ingestion, and dermal contact. Disturbance and subsequent exposure to hazard areas closed in place. Inhalation of resuspended surface soil. Downward migration of contamination from surface soil/water to alluvial aquifers. Soils are available to be transported by wind both on site and off site. Uptake of radionuclides by vegetation and animals and human consumption of game animals.	Surface site closure is ongoing, with all the industrial sites to be clean closed or closed in place by fiscal year (FY) 2018. Access to NTS site is restricted to authorized personnel. Hunting is prohibited at the Nevada Test Site (NTS). Industrial sites closed in place have been marked with signage and land-use restrictions. Soils near industrial sites are relatively immobile unless disturbed. Air monitoring is conducted for particulates and radionuclides. Biota (vegetation and animals) are sampled for radionuclides at the NTS. Surface waters that exist at the NTS are natural springs, containment ponds and sewage lagoons. Containment ponds are fenced to prevent human and animal access.	Removal of contaminated surface and shallow surface media. Surface and shallow subsurface restrictions and institutional controls are in place and maintained. Monitoring of air, groundwater, vegetation, and migratory animals will continue. Monitoring containment ponds and sewage lagoons will continue	Industrial Sites closure by FY 2018.	Applicable corrective actions will be completed for all 1,047 sites, and most sites will be open for free, unrestricted use following clean closure, while others will be stabilized for restricted use appropriate to the risk posed by residual contamination at sites closed in place. For those sites where contamination remains in place, appropriate long-term stewardship activities will be in place, including monitoring, cap inspections, and use restrictions, as applicable to the site.

Table 4.2
Definitions of Media in the Site-Wide Conceptual Site Exposure Model

Indirectly Contaminated Medium	Contextual Definition
Ambient Air	Refers to the earth's atmosphere as a media for contaminant transport.
Surface Water	Includes perennial and ephemeral stream reaches, groundwater discharged via springs, surface impoundments and ponds, and storm water flow.
Surface Soil and Sediment	Includes naturally occurring soil and anthropogenically placed backfill materials.
Unsaturated Zone	The zone between the land surface and the water table.
Saturated Zone	Those parts of the earth's crust in which all voids are filled with water under pressure greater than atmospheric. For the Nevada Test Site Conceptual Site Model, this term is intended to include the alluvial aquifer, the regional aquifers, and the perched water tables.

Table 4.3
Descriptions and Hypotheses of Pathways in the Site-Wide Conceptual Site Exposure Model
(Page 1 of 2)

Transport or Exposure Pathway	Description/Hypothesis
Advection	Dissolved contaminants moving with the bulk flow of water.
Condensation	Concentration and settling of vapor-phase airborne contaminants onto surface media.
Deposition	Gravity-driven settling of suspended particulate contaminants from air or surface water onto surface media, or from groundwater onto solid media.
Desorption	Re-dissolution of solutes that were bound to solid phases of geologic media.
Diffusion	Movement of dissolved contaminants in liquid water and volatile contaminants in air from areas of higher concentration to areas of lower concentration.
Discharge	Groundwater migrating to the surface due to physical forces.
Dispersion	Atmospheric distribution of airborne contaminants controlled by temperature and pressure gradients, wind speed and direction, precipitation, and surface and groundwater distribution of solutes in a saturated condition.
Dissolution	Chemical reaction with surface water or groundwater, causing a solid-phase contaminant to disperse into liquid water as a solute.
Evaporation	Conversion of liquid water and volatile contaminants to vapor phases.
Infiltration	Flow of surface water and solutes into subsurface media through pores or small openings.
Multi-Phase Unsaturated Reactive Transport	Matrix transport coupled with contaminant-specific process like radioactive decay, microbial degradation, sorption/desorption, mineralization, and evaporation.
Recharge	The process of addition of water to the saturated zone; also, the water added.

Table 4.3
Descriptions and Hypotheses of Pathways in the Site-Wide Conceptual Site Exposure Model
(Page 2 of 2)

Transport or Exposure Pathway	Description/Hypothesis
Sorption	Dissolved contaminants in subsurface binding to natural components of the solid porous media, and onto the surface of soil and sediment particles that can be transported by run-off and concentrated in depositional areas in the canyons.
Suspension	Precipitation runoff, surface water flow, and effluent discharge moving contaminants as particles into the groundwater.
Transient Saturated Fracture Transport	Relatively rapid infiltration, transient flow, and transport in the subsurface through cooling joints and faults in bedrock.
Unearthing by Natural Processes	Re-exposure of subsurface materials by natural process such as biotic intrusion, surface erosion, and mass wasting.
Volatilization	The direct release of solutes to the atmosphere.

Figure 4 (a

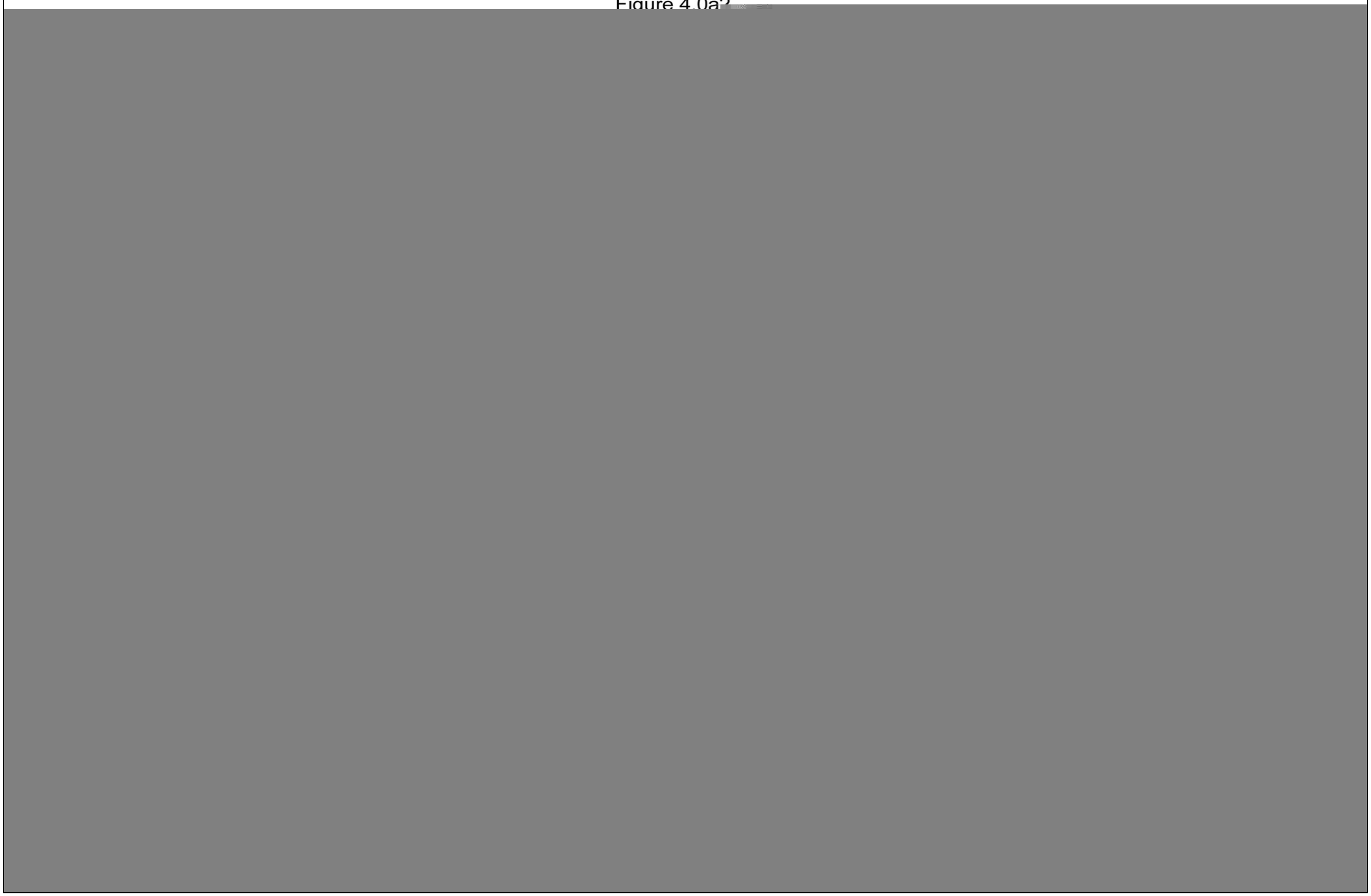


Figure 4.0b2
Site Wide Conceptual Site Exposure Model- End State

Site-wide current and end state CSMs are provided as Figures 4.0a2 and 4.0b2. The CSMs for Hazard Area 1 only apply to the NTS as there were no underground nuclear tests conducted on the NTTR. The CSMs for Hazard Areas 2 and 3 apply to the NTS and NTTR (identified only as the NTS for brevity). The CSM illustrates the relationship between the identified potential sources of contamination, the mechanisms for release and migration away from the potential source, the pathways the contamination would follow once released the exposure routes by which potential contamination would affect receptors, and the receptors that would be impacted by potential contamination (DOE/NV, 2000).

Tables 4-2 and 4-3 provide a contextual definition of each of the indirectly contaminated media and descriptions of and hypotheses associated with the pathways included in Figures 4.0a and 4.0b.

The site-wide CSM shows a number of controls that reduce the risk of hazards under current conditions (Figure 4.0a2). Many of these are associated with institutional and administrative controls pursuant to worker safety and environmental protection regulations, while others are attributed to natural characteristics or process at the site that attenuate hazards along the pathway between hazard and receptor. Together, institutional and natural controls provide layers of protection from risks associated with operational and historical releases of contamination into the environment at the NTS.

Figure 4.0b2 shows the CSM for end state conditions expected to be achieved at the NTS. The potentially impacted media and transport and exposure pathways active in the current state CSM and listed in Table 4.2 apply equally to the end state.

The numbers in the end state model signify enhancements to controls identified in the current state conceptual site-wide exposure model. The number tagging each control mechanism in Figures 4.0a2 and 4.0b2 identify each control as follows:

1. Exposure control and monitoring of operational releases of hazardous materials in compliance with OSHA regulations.

2. Characterization of regional hydrogeology and monitoring conducted in association with the risk and performance assessment/composite analysis and environmental protection programs provide evidence of natural pathway control. This monitoring indicates multiphase unsaturated reactive transport and saturated advection and dispersion that ensure contaminants will not be transported from their source to groundwater exposure points by 2027. Groundwater will be monitored to confirm that flow and transport is within predictions of the contaminant boundary model. The contaminant boundary model will be determined based on characterization and analysis currently under way.

3. Exposure control provided by environmental protection program monitoring and mitigation of potential contamination in air, surface soil, sediment soil, and groundwater. Monitoring types done both on- and off-site as follows:

   - Air
   - Biota
   - Direct radiation
   - Groundwater
   - Surface water
   - Vadose zone

4. Exposure control by institutional controls is provided to reduce risk for all on site activities. These controls include the following:

   - Real Estate/Operating Permit process - Established to provide an effective management and use of the NNSA/NSO real property assets and operations (NSO M 412.XID, April 12, 2005). The process ensures work performed under the purview of NNSA/NSO is:

     – Well defined, including identifiable hazards
     – Inclusive of established and implemented controls to mitigate hazards
     – Properly authorized and effectively managed

   - Routine radiological environmental monitoring plan.

5. Exposure control provided by remoteness and size of the site, restricted access, or physical barriers (i.e., signs and fencing).

6. Exposure controls provided by environmental compliance activities at the NTS include the permitting and monitoring requirements of numerous State of Nevada and federal regulations. These controls include:

   - *National Environmental Policy Act* documentation preparation.

   - *Clean Air Act* compliance for asbestos renovation projects, radionuclide emissions, and state air quality permits.

   - *Clean Water Act* compliance involving state wastewater permits.

   - *Nevada Administrative Code* compliance with adopted federal and state specific regulations.

   - *Safe Drinking Water Act* (SDWA) compliance involving monitoring of drinking water distribution systems.

   - *Resource Conservation Recovery Act* management of hazardous wastes.

- *Comprehensive Environmental Response, Compensation, and Liability Act* reporting.

- *Toxic Substances Control Act* management of polychlorinated biphenyls.

- *Endangered Species Act* compliance involving the conduct of preconstruction and site-wide surveys to document the status of state and federally listed endangered or threatened plant and animal species.

- *National Historic Preservation Act* compliance for the protection of Cultural and Native American Resources.

7. Contaminated soil and sediment removed, treated, or stabilized to achieve end state (including regulatory standards and final risk goal).

8. Landfill closure in accordance with regulatory requirements.

9. Exposure control provided by monitoring of municipal water supply.

10. Groundwater exposure control provided by risk-based modeling boundary, long-term monitoring compliance program, and land use restrictions.

4.1 Hazard Area 1 – Deep Subsurface Radiological Contamination

The UGTA Project, which addresses deep underground radioactive contamination (Hazard Area 1), is the largest project in the NNSA/NSO Environmental Restoration Division. The UGTA Project addresses groundwater contamination resulting from past underground nuclear testing conducted in shafts and tunnels on the NTS. From 1951 to 1992, 828 underground nuclear tests were conducted at the NTS. This underground testing was limited to specific areas of the NTS including Yucca Flat, Frenchman Flat, Rainier/Aqueduct, Oak Spring Butte, Shoshone Mountain, Buckboard Mesa, Pahute Mesa, and Dome Mountain. Most of these tests were conducted hundreds of feet above the groundwater table; however, more than 200 of the tests were in proximity of, or within, the water table. This testing resulted in over 132 million curies of radioactivity in the subsurface of the NTS. Tritium is the primary contaminant of concern for groundwater because of its mobility and abundance. Risk associated with the subsurface contamination is to the groundwater both on and off the NTS. Closure in place with monitoring and institutional controls is considered to be the only feasible corrective action, because cost-effective groundwater technologies have not been developed to effectively remove or stabilize the source of subsurface contaminants. The potential risk via the groundwater pathway is to workers, the public, and the environment. However, the NTS is surrounded by federal land; therefore, minimizing or eliminating access to contaminated areas by inadvertent intruders. The UGTA activities are the highest priority with the State of Nevada regulator due to the limited availability of water resources within the state (NNSA/NSO, 2003a).

The UGTA Project collects data to define groundwater flow rates and direction to determine the nature and location of aquifers (geologic formation of permeable rock containing or conducting groundwater). In addition, project team members gather information regarding the hydrology and geology of the area under investigation. Data from these studies will determine whether or not radionuclides resulting from nuclear testing have moved appreciable distances from the original test location. Numerous surface and subsurface investigations are ongoing to ensure that these issues are addressed (NNSA/NSO, 2003a).

Surface investigations include:

- Evaluating discharges from springs located downgradient of the NTS.
- Assessing surface geology.

Subsurface investigations include:

- Drilling deep wells to access groundwater hundreds or thousands of feet below the ground surface.
- Sampling groundwater to test for any radioactive contaminants.
- Assessing NTS hydrology and subsurface geology to determine possible groundwater flow direction.

The recently renegotiated UGTA Project corrective action strategy will be implemented. Data collection will occur in Phase 1 to fill data gaps and reduce uncertainty with additional data to be collected in Phase 2, if needed. Data will allow evaluation of contaminant transport to predict future extent of contaminant movement so that groundwater flow and transport models can be developed to predict contaminant boundaries. Independent peer reviews will be conducted to assess the technical aspects of groundwater models. Regulator and stakeholder involvement will be increased throughout the process to ensure better understanding of the steps in reaching a contaminant boundary for each group of sites.

4.1.1 Current State

Number and Types of Detonations

Underground nuclear testing at the NTS consisted of a total of 908 nuclear detonations in craters, shafts or tunnels at depths ranging from 89 to 4,764 ft. The underground nuclear detonations were conducted in 878 locations (from 828 individual tests), some of which contained multiple detonations (Map 4.1a1). Approximately one third of these detonations were conducted near or below the water table and have introduced contaminants into the groundwater (DOE/NV, 1997). The 878 locations are categorized into separate CASs assigned to the UGTA Project. These CASs are grouped into five CAUs based on location (FFACO, 1996).

- Frenchman Flat CAU consists of 10 CASs located in the northern part of Area 5 and the southern part of Area 11. These tests were conducted in both vertical emplacement holes and mine shafts. The tests in Frenchman Flat were located in alluvium of great depth (thousands of feet). The deeper geology is not well known. Lateral groundwater transport in the alluvium is very slow due to the low lateral hydraulic gradient.

- Western Pahute Mesa CAU consists of 18 CASs along the western edge of Area 20. These tests were all conducted in vertical emplacement holes. This CAU is separated from Central Pahute Mesa by the Boxcar Fault and is distinguished by the relative abundance of tritium. Transport of contaminants in groundwater on and from Western Pahute Mesa involves groundwater flow in both welded and vitric tuffs, both in the rock matrix and in the fracture system.

- Central Pahute Mesa CAU consists of 64 CASs in Areas 19 and 20 on Pahute Mesa. These tests were all conducted in vertical emplacement holes. Transport of groundwater contaminants on and from Central Pahute Mesa involves groundwater flow in fractures and the rock matrix, in welded and vitric tuffs, and lava flow aquifers. The influence of the large-scale block faulting is not well understood.

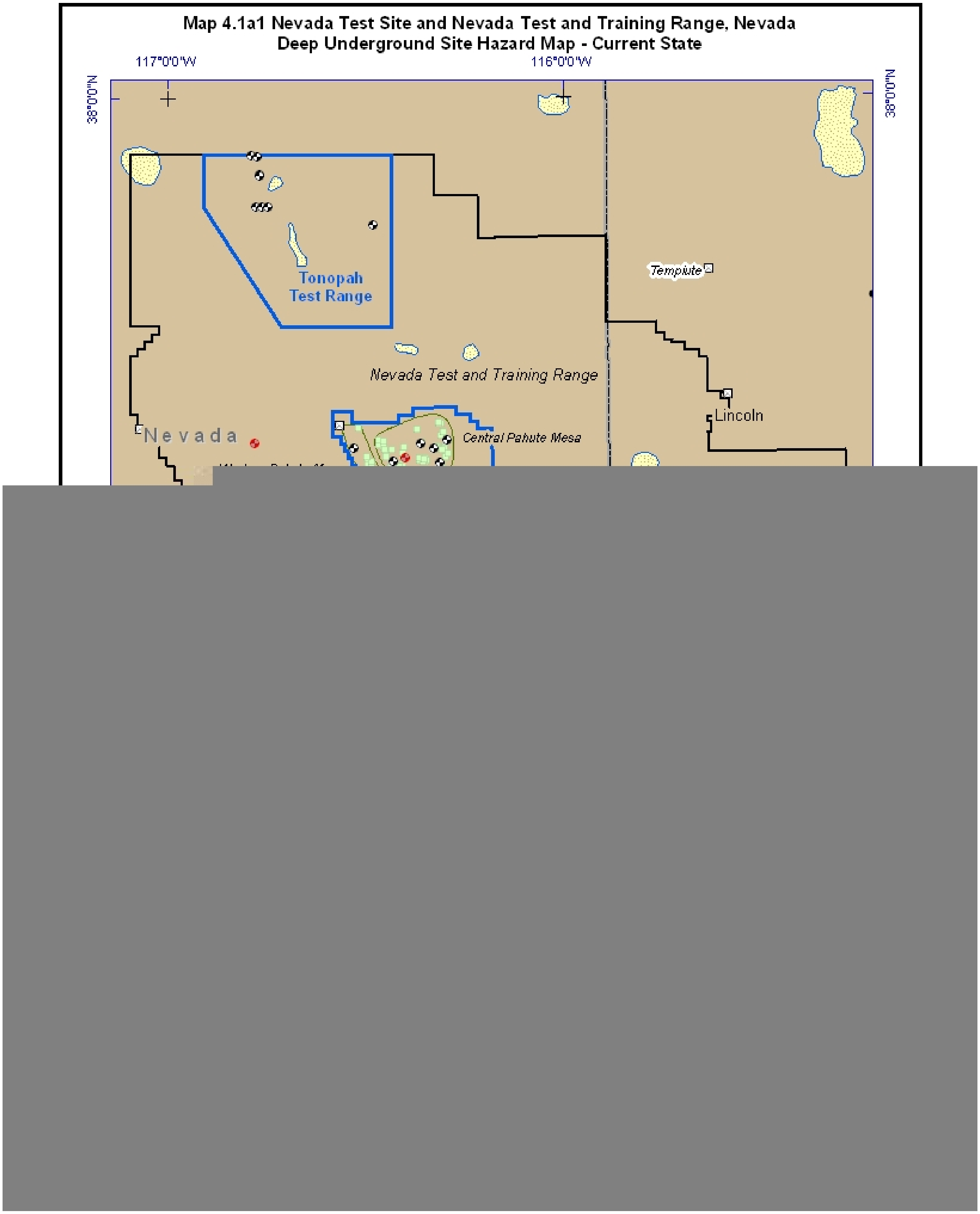
- Yucca Flat/Climax Mine CAU consists of 717 CASs located in Areas 1, 2, 3, 4, 6, 7, 8, 9, and 10, and 3 CASs located in Area 15. These tests were conducted in vertical emplacement holes and tunnels. Groundwater contaminant transport in Yucca Flat/Climax Mine may involve alluvium, both welded and vitric tuffs, fractured granite, and carbonate rocks.

- Rainier Mesa/Shoshone Mountain CAU consists of 60 CASs on Rainier Mesa and six CASs on Shoshone Mountain, located in Areas 12 and 16. These tests were all conducted above the water table in tunnels constructed in bedded and non-welded vitric and zeolitized volcanic tuffs (DOE/NV, 1996).

The majority of underground tests were either vertical shaft tests or horizontal tunnel tests. More than 90 percent of the underground tests were fired in vertical shafts a thousand feet or more below ground surface. Shaft tests were designed primarily to test stockpiled weapons or design features in new weapons systems. The NTS vertical shaft tests were conducted predominantly beneath Yucca Flat (Areas 1, 2, 3, 4, 6, 7, 8, 9, and 10) and Frenchman Flat (Areas 5 and 11) for lower yield experiments and beneath Pahute Mesa (Areas 19 and 20) for higher yield experiments. Approximately 30 percent of the shaft tests were conducted beneath the static water level (water table). Generally, tests conducted on Yucca Flat were buried at depths of approximately 2,000 ft or less. Some higher yield experiments were conducted at depths exceeding 4,000 ft on Pahute Mesa. Horizontal tunnel tests occurred within tunnel complexes excavated in Rainier and Aqueduct Mesas (Area 12), Oak Spring/Butte (Area 15), and Shoshone Mountain (Area 16). Most tunnel tests were fired within zones of discontinuously perched groundwater beneath the Rainier and Aqueduct Mesas (Bowen et al., 2001).

Containment (no escape of radioactivity to the surface) relies on the physical properties of surrounding geologic media including rock elastic strength and porosity, the device depth of burial, and impermeable seals and backfill, known as stemming, which prevent gas release out of the emplacement hole (Bowen et al., 2001).

A regional three-dimensional computer groundwater model has been developed to identify any immediate risk to groundwater users and to provide a basis for developing more detailed groundwater models of specific NTS test areas designated as individual CAUs. The regional model constituted Phase I of the UGTA Project. The CAU-specific models, of which up to five are planned (geographically covering each of the six former NTS testing areas), comprise Phase 2. To date, the Frenchman Flat CAU has entered Phase 2 and the remaining CAUs are in Phase 1. The more detailed CAU-specific groundwater flow and contaminant-transport models will be used to determine contaminant boundaries based on the anticipated maximum extent of contaminant migration to ensure public health and safety (NNSA/NSO, 2003a)



Map 4.1a1 Nevada Test Site and Nevada Test and Training Range, Nevada
Deep Underground Site Hazard Map - Current State

Contaminants of Concern

Only limited information is available based upon actual field data regarding the actual composition of the hydrologic source term. The three predominant types of potential contaminants associated with the source term are *in situ* material or those contained within the device which have not undergone fission or thermonuclear reaction are direct products of the nuclear reactions, such as fission products; and radionuclides produced by activation of the fuel, materials used within the test, and those injected into the surrounding geologic layers during the nuclear test (DOE/NV, 1997).

During the nuclear test, large quantities of materials used to support the test were introduced into the shafts or tunnels. These materials included steel used to support the device, lead and magnetite used as shielding material, and cement and gravel used to backfill the opening. In addition, nuclear devices commonly contained fissionable or fusionable radioactive elements in the critical mass for detonation. These elements included uranium, plutonium, tritium, and lithium. Small amounts of radiochemical detectors were also used. Incomplete consumption of these radioactive materials during detonation from testing would leave them within the subsurface for potential leaching to groundwater (DOE/NV, 1997).

The Environmental Restoration Division of NNSA/NSO, which sponsored the radionuclide inventory effort, administers the UGTA Project. An early priority of the UGTA Project included determining an accurate measure of the total radiological inventory present at the NTS. The quantity of existing contaminants provides an upper bound on the contamination underground at the NTS. This information is vital in the design of remediation strategies and effective resource management. Similarly, risk assessment developed for human health and the environment requires a reliable measure of radionuclides available for potential transport by groundwater to down-gradient receptors. The radionuclide inventory includes long-lived radioactive species produced by or remaining after underground nuclear explosions at the NTS during the period 1951 to 1992 (Bowen et al., 2001).

The inventory represents a starting point for the estimation of radionuclides available for dispersal away from test centers. Not all radionuclides are equally available for transport. A necessary distinction must be drawn between the radionuclide source term that includes all radioactive material remaining after a nuclear test and the hydrologic source term that includes only those radionuclides dissolved in and/or transported by groundwater. The radionuclide inventory reported here does not represent the amount of radioactivity that is or ever will be dissolved in groundwater at the NTS. The hydrologic source term is considerably less than the total radionuclide source term (Bowen et al., 2001).

Table 4.4 presents the unclassified radionuclide source term, which combines inventories compiled for underground nuclear tests conducted by Los Alamos National Laboratory and Lawrence Livermore National Laboratory, as well as tests supporting the DoD. The inventory includes tritium, fission products, actinides, and activation products. These data are grouped according to six geographic test centers at the NTS (five CAU areas with two sub-divisions in Yucca Flat). This inventory provides an estimate of radioactivity remaining underground at the NTS after nuclear testing. Curie activities and atoms are reported as of September 23, 1992, the date of the last underground nuclear test at the NTS. This inventory does not represent the total radioactivity dissolved in the groundwater beneath the NTS, but is strictly a compilation of the residual radionuclide inventory remaining from those underground nuclear tests.

Compliance and Contaminant Boundaries

The corrective action strategy for deep underground radioactive contamination or Hazard Area 1 is based on the complex corrective action process outlined in the FFACO. This process is used when additional information is needed for the evaluation of possible corrective action alternatives. The objective of the corrective action investigation process is to define boundaries around each UGTA CAU to establish areas that contain water that may be unsafe for domestic and municipal use (DOE/NV, 1996).

The Hazard Area 1 corrective action strategy was developed to address the contamination created by the testing of nuclear devices in shafts and tunnels at the NTS. The objective of the strategy is to analyze and evaluate each UGTA CAU through a combination of data and information collection and evaluation, and modeling groundwater flow and contaminant transport. This analysis will estimate the vertical and horizontal extent of contaminant migration for each CAU in order to predict contaminant boundaries.

A contaminant boundary is the model-predicted perimeter that defines the maximum extent of radionuclide-contaminated groundwater from underground testing above background conditions exceeding the SDWA standards (DOE/NV, 1996). The contaminant boundary will be composed of both a perimeter boundary and a lower hydrostratigraphic unit boundary. The computer model predicts the location of this boundary within 1,000 years and must do so at a 95-percent level of confidence. From the contaminant boundary predicted by the computer model and other considerations, a compliance boundary will be negotiated between NDEP and the DOE. The DOE will be responsible for ensuring compliance with this boundary. The compliance boundary may or may not coincide with the contaminant boundary. If the predicted location of the contaminant boundary cannot be accepted as the compliance boundary, an alternate compliance boundary will be negotiated by both parties (DOE/NV, 1996).

Table 4.4
Radionuclide Summary for the Six Principal Geographic Test Centers
(Data in Curies)

Radionuclide[a]	Frenchman Flat[b]	Pahute Mesa - Area 19[b]	Pahute Mesa - Area 20[b]	Rainier Mesa/ Shoshone Mountain[b]	Yucca Flat – Above[b]	Yucca Flat – Below[b]	Total[b]
Hydrogen-3	1.744E+05	1.778E+07	5.903E+07	7.645E+05	1.472E+07	3.316E+07	**1.256E+08**
Carbon-14	6.653E+01	2.193E+02	4.693E+02	1.102E+02	1.137E+03	8.389E+02	**2.841E+03**
Aluminium-26	7.035E-03	8.975E-04	8.370E-03	4.548E-04	5.573E-02	3.595E-02	**1.084E-01**
Chlorine-36	8.907E+00	9.108E+01	1.573E+02	1.130E+01	1.163E+02	2.309E+02	**6.158E+02**
Argon-39	6.166E+00	6.398E+02	1.247E+03	3.663E+01	3.204E+02	9.551E+02	**3.205E+03**
Potassium-40	1.649E+00	1.588E+02	3.171E+02	9.233E+00	8.219E+01	2.422E+02	**8.112E+02**
Calcium-41	6.542E+01	5.050E+02	1.273E+03	7.063E+01	8.545E+02	1.661E+03	**4.429E+03**
Nickel-59	1.634E+00	1.596E+01	2.976E+01	2.021E+00	2.139E+01	4.265E+01	**1.134E+02**
Nickel-63	1.679E+02	1.724E+03	3.126E+03	2.118E+02	2.334E+03	5.229E+03	**1.279E+04**
Krypton-85	1.285E+02	4.981E+04	5.706E+04	1.344E+03	1.137E+04	5.805E+04	**1.778E+05**
Strontium-90	1.879E+03	5.804E+05	6.835E+05	1.592E+04	1.499E+05	7.479E+05	**2.179E+06**
Zirconium-93	1.118E-01	1.887E+01	2.372E+01	7.990E-01	6.852E+00	2.607E+01	**7.641E+01**
Niobium-93m	0.000E+00	2.969E+03	5.100E+03	2.667E+00	6.246E+02	6.730E+03	**1.543E+04**
Niobium-94	6.968E-01	7.938E+01	9.852E+01	9.248E-01	2.296E+01	1.975E+02	**3.999E+02**
Technetium-99	1.167E+00	1.344E+02	1.782E+02	7.817E+00	6.153E+01	1.875E+02	**5.706E+02**
Palladium-107	1.949E-02	5.957E-01	1.002E+00	1.164E-01	7.634E-01	9.226E-01	**3.420E+00**
Cadmium-113m	2.991E+00	5.017E+02	7.469E+02	2.545E+01	1.566E+02	4.994E+02	**1.933E+03**
Tin-121m	1.646E+01	1.782E+03	2.667E+03	1.081E+02	6.738E+02	1.918E+03	**7.165E+03**
Tin-126	8.193E-02	8.085E+00	1.188E+01	5.200E-01	3.402E+00	9.161E+00	**3.313E+01**
Iodine-129	4.542E-03	4.153E-01	5.596E-01	2.920E-02	2.079E-01	5.422E-01	**1.759E+00**
Cesium-135	1.362E-01	1.393E+01	1.838E+01	8.966E-01	6.926E+00	1.970E+01	**5.997E+01**
Cesium-137	5.045E+03	6.971E+05	8.957E+05	3.773E+04	2.919E+05	9.299E+05	**2.857E+06**
Samarium-151	2.949E+02	2.307E+04	3.568E+04	1.939E-03	1.388E+04	3.189E+04	**1.068E+05**
Europium-150	9.859E-03	7.805E+01	1.069E+03	2.057E-03	1.354E+04	1.099E+02	**1.479E+04**
Europium-152	7.569E+02	l.151E+04	2.970E+04	1.703E+03	3.634E+04	7.083E+04	**1.508E+05**
Europium-154	2.622E+02	7.099E+03	1.327E+04	9.090E+02	2.968E+04	5.480E+04	**1.060E+05**
Holmium	2.024E+00	3.083E+01	2.892E+01	3.354E+00	2.665E+01	5.514E+01	**1.469E+02**
Thorium-232	1.196E-01	1.147E+0l	2.319E+01	6.757E-01	5.969E+00	1.752E+01	**5.895E+01**
Uranium-232	l.027E-02	8.730E+01	1.738E+02	9.188E-01	9.004E+01	3.690E+02	**7.211E+02**
Uranium-233	1.334E-03	6.508E+01	1.176E+02	1.107E+01	1.202E+02	1.525E+02	**4.664E+02**
Uranium-234	4.316E-01	1.421E+02	1.179E+02	1.037E+01	1.648E+02	2.8 14E+02	**7. 169E+02**
Uranium-235	8.570E-03	1.293E+00	l.343E+00	1.717E-01	2.557E+00	3.220E+00	**8.593E+00**
Uranium-236	2.995E-03	2.213E+00	2.647E+00	1.483E-01	9.123E-01	3.458E+00	**9.381E+00**
Uranium-238	9.507E-02	6.826E+00	1.250E+01	6.919E-0l	8.674E+00	1.570E+01	**4.449E+01**
Neptumium-237	1.379E-02	1.196E+0l	2.476E+01	6.027E-02	1.140E+00	1.072E+01	**4.865E+01**
Plutonium-238	3.232E+02	2.857E+03	4.768E+03	2.659E+03	1.774E+04	1.115E+04	**3.950E+04**
Plutonium-239	1.415E+03	7.684E+03	1.262E+04	1.085E+04	9.997E+04	2.746E+04	**1.600E+05**
Plutonium-240	3.489E+02	2.041E+03	4.405E+03	2.763E+03	2.532E+04	7.045E+03	**4.193E+04**
Plutonium-241	4.408E+03	2.946E+04	6.952E+04	4.315E+04	3.415E+05	1.034E+05	**5.914E+05**
Plutonium-242	2.882E-02	1.367E+00	2.279E+00	3.962E-01	7.485E+00	4.621E+00	**1.618E+01**
Americium-241	5.022E+02	1.299E+03	3.567E+03	2.555E+03	2.309E+04	6.088E+03	**3.710E+04**
Americium-243	0.000E+00	1.203E-02	1.772E-01	7.900E-01	2.682E+00	3.416E+00	**7.078E+00**
Curium-244	0.000E+00	1.190E+03	2.197E+03	4.961E+01	1.586E+03	2.506E+03	**7.529E+03**
Total	**1.901E+05**	**1.920E+07**	**6.086E+07**	**8.867E+05**	**1.578E+07**	**3.523E+07**	**1.321E+08**

[a]Radionuclides are arranged according to atomic number and atomic mass (Bowen et al., 2001)
[b]Decay corrected to September 23, 1992

No specific, proven cost-effective technologies have been previously demonstrated to remove radioactive contaminants from the groundwater, stabilize them, or remove the source of the contaminants at the CASs. Such technologies may be perfected in the future, which may perhaps alter the choice of corrective action at that time (DOE/NV, 1996).

4.1.2 End State

End State – Continued Use as a Test Site

Achieving the end state for Hazard Area 1 will involve the following steps:

- Flow and transport modeling to predict contaminant boundary
- Compliance boundary negotiated with NDEP
- Five-year proof-of-concept (monitoring) followed by development/deployment of monitoring network
- Development and concurrence of a Closure Plan
- Long-term groundwater monitoring
- Landowner will continue to be the NNSA/NSO
- Institutional controls to prevent public access to contaminated groundwater

A five-year proof-of-concept period follows the modeling of the contaminant boundary and negotiation of the compliance boundary using groundwater wells in a monitoring network to determine if the monitoring network design will provide adequate surveillance. If the monitoring network is found to be acceptable after the five-year proof-of-concept period, a closure plan will then be developed, followed by implementation of a long-term closure monitoring program.

The long-term closure monitoring program will address contamination left in place. This program consists of all activities necessary to ensure protection of human health and the environment following the completion of corrective actions. These activities will include periodic analysis of monitoring results, determining optimum performance indicators, evaluation of monitoring performance criteria, locating new monitoring wells and replacing existing monitoring wells to support performance criteria evaluation at timed intervals of interest within the 1,000-year period.

Under the current plan, the DOE will maintain the readiness and capability to conduct one or more underground nuclear weapons tests at the NTS, if directed by the President. Land use will continue to be restricted at the NTS because of subsurface contamination (FFACO, 1996).

Subsurface and groundwater contamination is being addressed by implementing the end state approach based on defining the contaminant and compliance boundaries at the NTS, and monitoring groundwater to confirm that modeling reasonably and accurately predicts flow and transport. The contaminant boundary will be defined on the basis of modeling, as the maximum extent to which groundwater contaminated above SDWA limits (maximum contaminant levels) is modeled to migrate in 1,000 years. The compliance boundary will be the result of negotiation between the DOE and the NDEP, considering the contaminant boundary. Drilling and water use within the compliance boundary will be prohibited and groundwater production may also be limited for some region outside the boundary. Although it is not technologically possible to remediate the contamination associated with an underground nuclear test, this will be protective because the use (withdrawal) of and exposure to contaminated groundwater will be precluded by implementation of institutional controls restricting the drilling of wells within the boundary. The location of monitoring wells will be determined through negotiation and concurrence with the State of Nevada. Well locations will be based on best available knowledge of the most likely direction and pathways for groundwater migration. In the potential future event that contaminants migrate past the compliance boundary, the monitoring system and groundwater models will be re-evaluated to determine if the drilling restriction areas and associated institutional controls need to be changed. The DOE will achieve the end state for the subsurface at the NTS by completing a modeled contaminant boundary, a negotiated compliance boundary, monitoring well network(s), and five-year proof-of-concept.

The DOE will continue long-term stewardship activities for the subsurface contamination, which is expected to include radioactive fission products, uranium, plutonium, and tritium. This stewardship will entail continued monitoring of the groundwater quality on and near the NTS, maintaining institutional controls, and maintaining subsurface drilling restrictions and exclusion zones sufficient to isolate contamination from potential receptors.

Conceptual Site Model – Discussion of Risk and Receptors

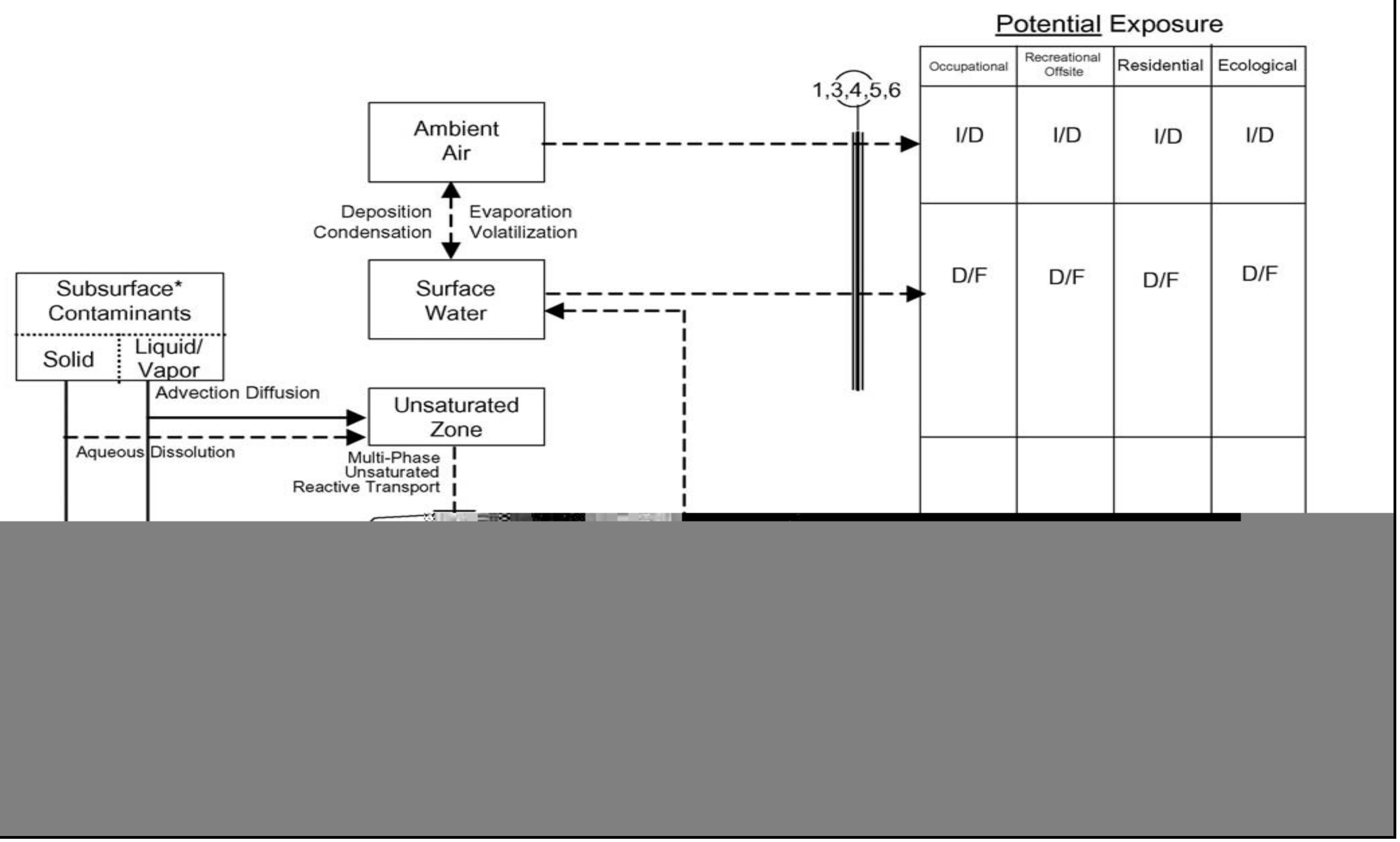
The number tagging each control mechanism in the following CSMs identifies each control as follows:

1. Exposure control and monitoring of operational releases.
2. Characterization of regional hydrogeology and monitoring.
3. Exposure control provided by environmental protection program monitoring and mitigation of potential contamination in air, surface soil, sediment soil, and groundwater.
4. Exposure control provided by institutional controls to reduce risk of all on-site activities.
5. Exposure control provided by restricted access or physical barriers (i.e., signs and fencing).
6. Exposure controls provided by environmental compliance activities at the NTS include the permitting and monitoring requirements of numerous State of Nevada and federal regulations.
7. Contaminated soil and sediment removed, treated, or stabilized to achieve end state (including regulatory standards and final risk goal).
8. Landfill closure in accordance with regulatory requirements.
9. Exposure control provided by monitoring of municipal water supply.
10. Groundwater exposure control provided by risk based modeling boundary and long-term monitoring compliance program.

The end state CSM is provided as Figure 4.1b2. Near-term risks to human health and ecological receptors were conservatively calculated based on tritium migration predictions from nuclear tests located near the west edge of the NTS. The conclusions are as follows:

- In the near-term, tritium migration from a test near the site boundary does not constitute a human health hazard off the NTS.
- Future ecological risks are not expected to occur because high ecotoxicological thresholds associated with estimated tritium exposure.
- Based on transport simulations and the incorporation of several conservative assumptions, a potential risk from long-term exposure to tritium in groundwater may exist at off-site receptor locations along the Tybo nuclear test contaminant transport pathline.

Figure 4.1b2
Hazard Area 1 Conceptual Site Exposure Model- End State



The estimated risks from the Tybo contaminant pathline are not supported by results from the existing environmental monitoring network. Long-term monitoring of water samples from groundwater wells west and south of the Pahute Mesa do not show tritium levels above the background levels. As the transport model was intended to predict contaminant levels if multiple pessimistic conditions existed, monitoring results support the conclusion that tritium is migrating at a more normal, non-exceptional rate. In other words, the conservative assumptions used to predict tritium transport to Oasis Valley do not appear to be valid in reality (DOE/NV, 1997).

In addition to characterization and modeling to establish boundaries and set up a monitoring network, access to the NTS will continue to be restricted to authorized site workers and visitors for the foreseeable future.

Closure of Hazard Area 1

The schedule objective for the UGTA Project is to identify the contaminant boundary and monitoring well network for all the CAUs by 2027. Environmental restoration activities are phased according to regulatory processes and priorities established in the FFACO to facilitate the successful completion of this objective. Work will be performed to correspond with regulatory and FFACO requirements. A contaminant boundary will be established to define areas that contain water that may be unsafe for domestic and municipal use. A monitoring network will be in place to ensure future protection of the public and the environment. Institutional controls will be continued, and wells will be monitored, sampled, and refurbished/replaced as applicable. According to the Life-Cycle Baseline, Revision 6, and the NNSA/NSO expects to complete closure of the UGTA CAUs in FY 2027. Post-closure surveillance and monitoring of the underground test area assumes monitoring will be performed for 100 years; however, post-closure monitoring will be conducted as agreed upon in the site closure reports for each CAU. Due primarily to the nature of the contaminants that will remain in the subsurface areas as a result of historical nuclear testing and the lack of cost-effective technologies to remove radioactive contaminants from the groundwater, stabilize them, or remove the source of the contaminants at the CASs institutional control is expected to continue in perpetuity. In the future, technologies may be perfected that may alter the choice of corrective actions at that time. It is not possible to show the end state for the contaminate boundaries until characterization and flow and transport modeling have been completed.

4.2 Hazard Area 2 – Surface and Shallow Subsurface Radiological Contamination

Surface and shallow subsurface radiological contamination exist on multiple sites on the NTS, TTR, and NTTR. Contamination at these sites is the result of historic nuclear detonations and hydronuclear experiments. Contaminants of concern at one or more of the sites include transuranics and uranium, fission and fusion products, and activation products; metals, particularly lead; and other contaminants associated with the instrumentation and structures specific for each test. All contaminants are not found at all sites.

4.2.1 Current State

The current state of hazards, hazard controls, and exposure controls of Hazard Area 2 are described in this section. Hazard category maps and associated conceptual site exposure models are both presented. The current state hazard-specific map for Hazard Area 2 is shown in Map 4.2a1. The associated end-state conceptual site exposure model for Hazard Area 2 is shown in Figure 4.2a2.

In general, the soils of the NTS are similar to those of surrounding areas and include aridisols and entisols. The degree of soils development reflects their age and origin. Entisols generally form on steep mountain slopes where erosion is active. The aridisols are older and form on more stable fans and terraces.

Soil loss through wind and water erosion is common throughout the NTS and surrounding areas. Portions of some watersheds probably exhibit higher erosion rates, but the erosion conditions and susceptibility of soils on the NTS have not been defined. Some portions of the NTS drain off site but much of the drainage flows to internal closed basins minimizing the potential for contaminants to be carried to off-site receptors.

There are limited areas of soils that can be irrigated on the NTS according to the 1973 Nevada map prepared by the Division of Water Resources, and they occur only in the lower elevations of the Yucca Flat weapons test basin, Frenchman Flat, and Jackass Flats. Elsewhere on the NTS, the soils are generally very limited in both thickness and areal extent.

In the Yucca Flat weapons test basin, the soils include those that can be irrigated with moderately low available water-holding capacity and stony, cobbly soils. In Frenchman Flat, the soil classes present have severe limitations with low available water holding capacities and soil subject to flooding. The soils that can be irrigated in Jackass Flats have very severe limitations, coarse textures, and very low available water-holding capacities.

Map 4.2a1 Nevada Test Site and Nevada Test and Training Range, Nevada
Surface and Shallow Subsurface Radioactive Site Hazard Map - Current State

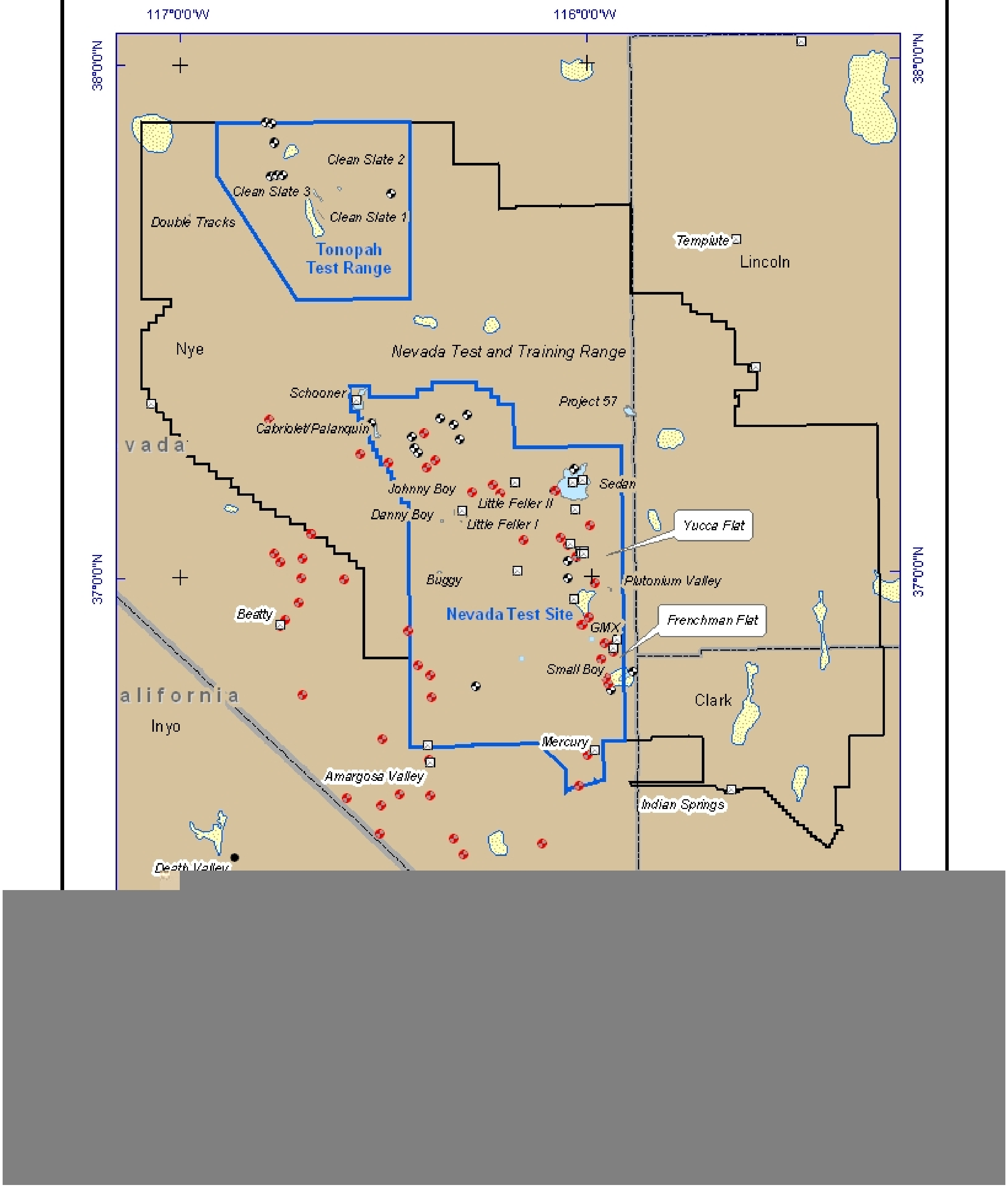
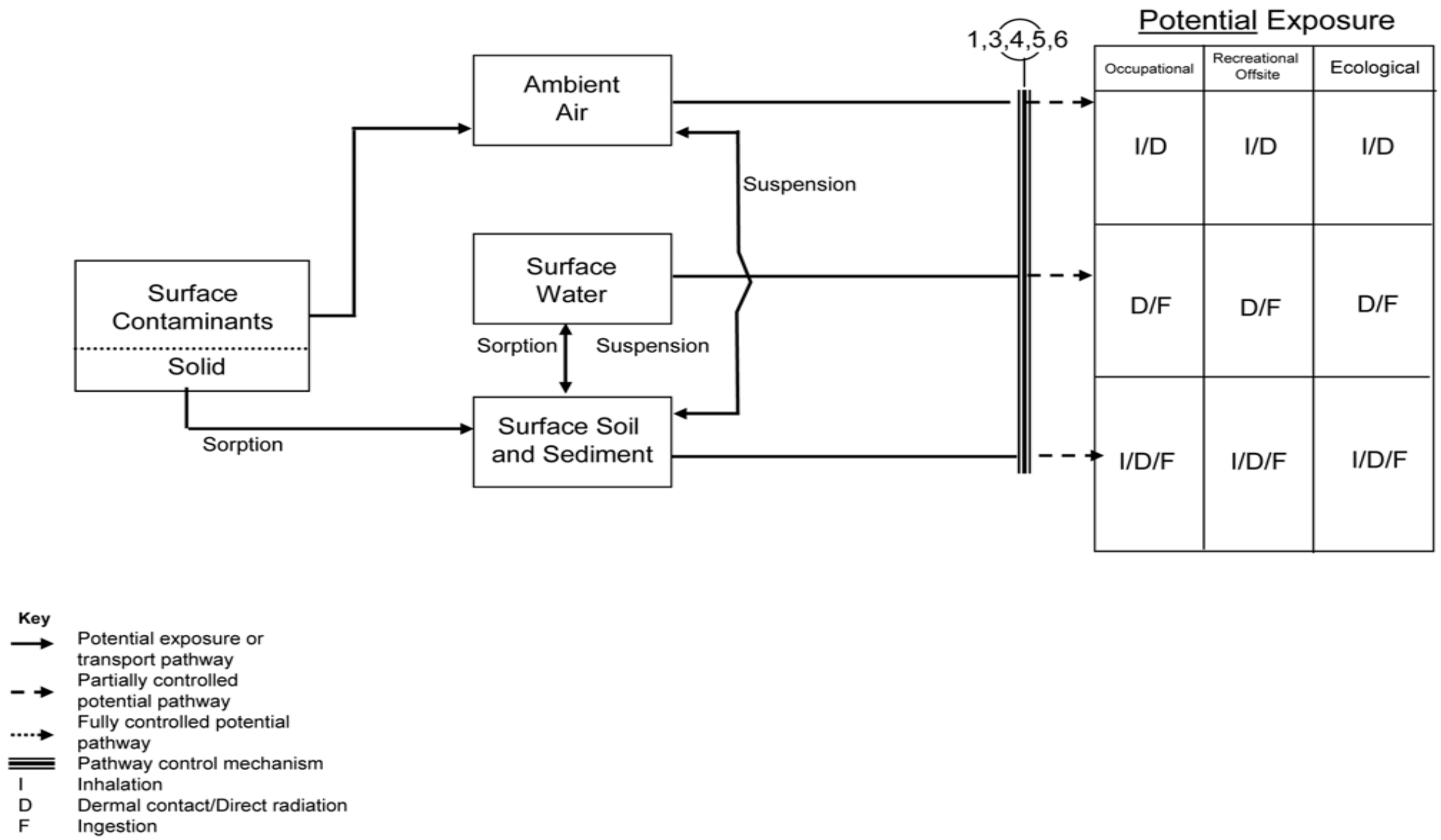


Figure 4.2a2
Hazard Area 2 Conceptual Site Model- Current State



The soils of the southern NTS reflect the mixed alluvial sediments upon which they form. Soils are generally young in profile development and show only weak evidence of leaching. In general, soils texture is gradational from coarse-grained soils near the mountain fronts to fine-grained soils in the playa areas of the Yucca Flat weapons test basin and Frenchman Flat. Most soils are underlain by a hardpan of caliche. Soil salinity generally increases dramatically in the direction of the playa, with the highest level of soluble salts having accumulated in the deeper soil profile horizons in Frenchman Flat.

The soils on portions of the NTS have been contaminated during the conduct of various testing and ancillary operations. The largest areas of surficial contamination are in the Yucca Flat weapons test basin, Frenchman Flat, Plutonium Valley, and in scattered location in the western and northwestern parts of the facility.

Atmospheric Tests

Atmospheric nuclear weapons tests were initiated in 1951 with the detonation of a 1-kiloton (airdropped weapon over Frenchman Flat and a total of 100 tests were conducted before the signing of the Limited Test Ban Treaty in August 1963. Atmospheric tests on the NTS included: airburst, airdrop, balloon and rocket, surface, and tower experiments.

Depending on the proximity of the explosion to the ground surface and the size of the yield, surface disturbances from atmospheric testing vary widely. The greatest surficial disturbances typically occurred when an airdropped weapon penetrated the ground surface to a shallow depth before detonation.

Radioactivity from atmospheric tests was dispersed initially by three primary mechanisms: throw-out, base surge, and fallout. The extent and distribution of contamination from an atmospheric test was variable depending on the height of detonation, the yield and type of device, the nature of the ground surface, the mass of inert material surrounding the device, and weather conditions at the time of the test. Typical isotopes formed during the atmospheric testing in addition to uranium, plutonium, and other transuranics discussed previously, included strontium, cesium, barium, tritium, and iodine. Of these, strontium-90 and cesium-137 are of the most concern, because they are gamma emitters and their relatively longer half-lives of 29 and 30 years, respectively.

The vast majority of radioactivity released during atmospheric testing decayed very quickly after each test was conducted. Many of the fission products released during the detonations were dispersed into the atmosphere, and much of the residual radioactivity has decayed in the more than 30 years since the last test.

Safety and Equation of State Experiments

Portions of the NTS and the NTTR were used between 1954 and 1992 to test the effects of chemical explosion on plutonium- and uranium-bearing materials. The subject of these experiments was related to safety, or equation of state. Some safety experiments were conducted to evaluate the safety of nuclear weapons in accident scenarios. Other safety experiments were conducted to confirm that a nuclear explosion will not occur in case of an accidental detonation of the explosive associated with the device. The equation of state experiments was to study and measure the changes in the physical properties of plutonium materials subjected to detonations from conventional explosives.

A number of safety experiment tests and storage-transportation tests were conducted from 1955 through 1992 both on the NTS and on the NTTR. Project 56 was conducted on the NTS in Area 11 and was comprised of four discrete surface safety experiments. Project 57 (safety experiment) and Double Tracks (storage-transportation) were conducted on the NTTR along with the three Clean Slate (storage-transportation tests) sites on the TTR. An environmental assessment analyzing the potential environmental effects of four remediation alternatives was completed for the Double Tracks Site in 1996.

The equation of state experiments was conducted between 1954 and 1956. The experiments were performed as part of the GMX Project conducted on the NTS in Area 5. The GMX Project site was used for 29 specific "equation-of-state" studies. These experiments took place on or very near one place, and the source can be considered to be at one site.

The safety and equation of state experiments used plutonium and uranium that were subjected to detonations of conventional explosives. The immediate effects of the surface tests included the dispersal of plutonium and uranium over significant areas. To determine the area impacted by these tests, inventories were conducted by the Nevada Applied Ecology Group (NAEG). These inventories were later augmented by extensive field-sampling efforts conducted under the Radionuclide Inventory and Distribution Program. These studies resulted in the definition of affected areas.

At both on- and off-site locations, the primary isotopes are plutonium, uranium, and americium. The storage-transportation tests did not achieve criticality and fission/activation products were not found. These long-lived radionuclides remain today in the surficial soils in the vicinity of the test areas and are available to be transported by wind and uptake by plants and animals. Extensive research into the mobility of the isotopes has found that wind can transport the contaminants and concentrate them in mounds around desert shrubs. The isotopes are now relatively immobile unless the soils are disturbed (NNSA/NSO, 2003b).

Legacy Hydronuclear Experiments

Operations at the NTS have historically included experiments that, though involving both HE and special nuclear materials, were intended to produce no nuclear yield or negligible nuclear energy release. These experiments remained subcritical. They were performed as dedicated stand-alone experiments. Nuclear explosion did not take place; therefore, the environmental impacts of these experiments were principally due to dispersal of special nuclear materials such as plutonium, and other materials, by the detonation of HE. The NNSA/NSO Environmental Management Program is responsible for corrective action of legacy hydronuclear experiment locations in Areas 27 and 6 that were performed in the 1950s and 1960s. All of the subject legacy hydronuclear experiments in Area 27 (total of 76) were conducted in boreholes between 45 and 80 ft below the surface. One of the legacy hydronuclear experiments in Area 6 was conducted on the surface while all the others were conducted in boreholes between 25 and 50 ft below the surface.

Craters

Two types of craters exist on the NTS: subsidence craters produced by rubble chimney collapse following and underground explosion, and throw-out craters resulting from detonations designed to achieve a cratering effect. In the latter cratering detonations, the nuclear device was placed near enough to the surface such that the bubble of explosion gases broke through to the surface producing a crater surrounded by a rubble field of ejecta. The ejecta grades in size from very coarse boulders near the crater to very fine dust particles at considerable distances downwind; much of the smaller ejecta contains radioactivity, and some of the large boulders covered with radioactive materials. The NAEG studied cratering sites but did not study subsidence craters, because these sites are not contaminated at the surface by radioactive residues (DOE/NV, 1992).

Table 4.5 lists the known contaminated areas on the NTS and surrounding areas. Each of these areas are CAUs listed in the FFACO. The contaminated surface area and the corresponding soil concentration refer to characterization activities that have taken place at each of these locations. The majority of these areas have been surveyed at 10 picocuries per gram (pCi/g). The safety experiment sites have been more thoroughly examined and information is known for specific activity levels (McArthur, 1992).

The Double Tracks and Clean Slate 1 areas have been cleaned up to a corrective action level of 400 pCi/g, with the remaining 45 and 83 acres, respectively, at or below this level. These sites are waiting for NDEP approval before being formally closed. The Clean Slate 2 (CS2) and Clean Slate 3 sites have been characterized with a proposed corrective action level of 1,000 pCi/g. If cleaned up to this level, the sites would have 17 and 18 acres, respectively, at or below the 1,000 pCi/g level (NNSA/NSO, 2003a). These clean-up levels equate to less than 25 mrem/yr dose rate appropriate to the planned military land-use scenario.

Project 57 and the portion of Small Boy on the NTTR will be further characterized and cleaned up to a total transuranics equating to a less than 25 mrem/yr dose rate for military land-use scenario. The remaining sites on the NTS will be further characterized, and will be fenced, posted, and monitored, as necessary, and relinquished to DoD and NNSA/NSO according to land withdrawal boundaries. All sites will maintain current use restrictions.

Table 4.5
Radiological Surface Contamination for the Surface and Shallow Subsurface Radiological Contamination Area

Description	CAU	Location	Contaminated Surface Area	Soil Concentrations	4.2.1.1 Type of Test/Experiment
North Yucca Flat	105	NTS – Areas 2, 8, 9, and 10	33,000 acres	> 10 pCi/g	Surface test
Frenchman Flat	106	NTS – Area 5 and 11	550 acres	> 10 pCi/g	Surface test
Buckboard Mesa (Little Feller I,II)	107	NTS – Area 18	1,230 acres	> 10 pCi/g	Surface test
GMX	365	NTS – Area 5	31 acres	> 10 pCi/g	Equation of state experiments
Plutonium Valley	366	NTS – Area 11	643 acres	> 10 pCi/g	Surface test
Sedan	367	NTS – Area 10			Surface test
Johnnie Boy	370	NTS – Area 18			Surface test
Danny Boy	371	NTS – Area 18	140 acres	> 10 pCi/g	Surface test
Cabriolet Palanquin	372	NTS – Area 20	1,300 acres	> 10 pCi/g	Surface test
Schooner	374	NTS – Area 20	400 acres	> 10 pCi/g	Surface test
Buggy-A, -B, -C, -D, -E	375	NTS – Area 30	200 acres	> 10 pCi/g	Surface test
Double Tracks	411	NTTR	45 acres	< 400 pCi/g	Surface test
CS1	412	NTTR	83 acres	< 400 pCi/g	Surface test
CS2	413	NTTR	17 acres	> 1,000 pCi/g	Surface test
CS3	414	NTTR	18 acres	> 1,000 pCi/g	Surface test
Project 57	415	NTTR	1,030 acres	> 10 pCi/g	Surface test
Small Boy	541	NTS – Area 5	TBD	TBD	Surface Test
Hydronuclear Experiments	546	NTS – Area 6-27	TBD	TBD	Hydronuclear Experiments

4.2.2 End State

The end state hazard-specific map for Hazard Area 2 is shown in Map 4.2b1 for anticipated surface contaminant sources in 2027. The associated end state CSM for Hazard Area 2 is attached in Figure 4.2b2. The natural processes that act to attenuate hazards associated with surface media discussed in Section 4.2.1, as well as the clean-up and institutional controls, will provide some control over hazards and exposures.

Map 4.2b1 Nevada Test Site and Nevada Test and Training Range, Nevada
Surface and Shallow Subsurface Radioactive Site Hazard Map - End State

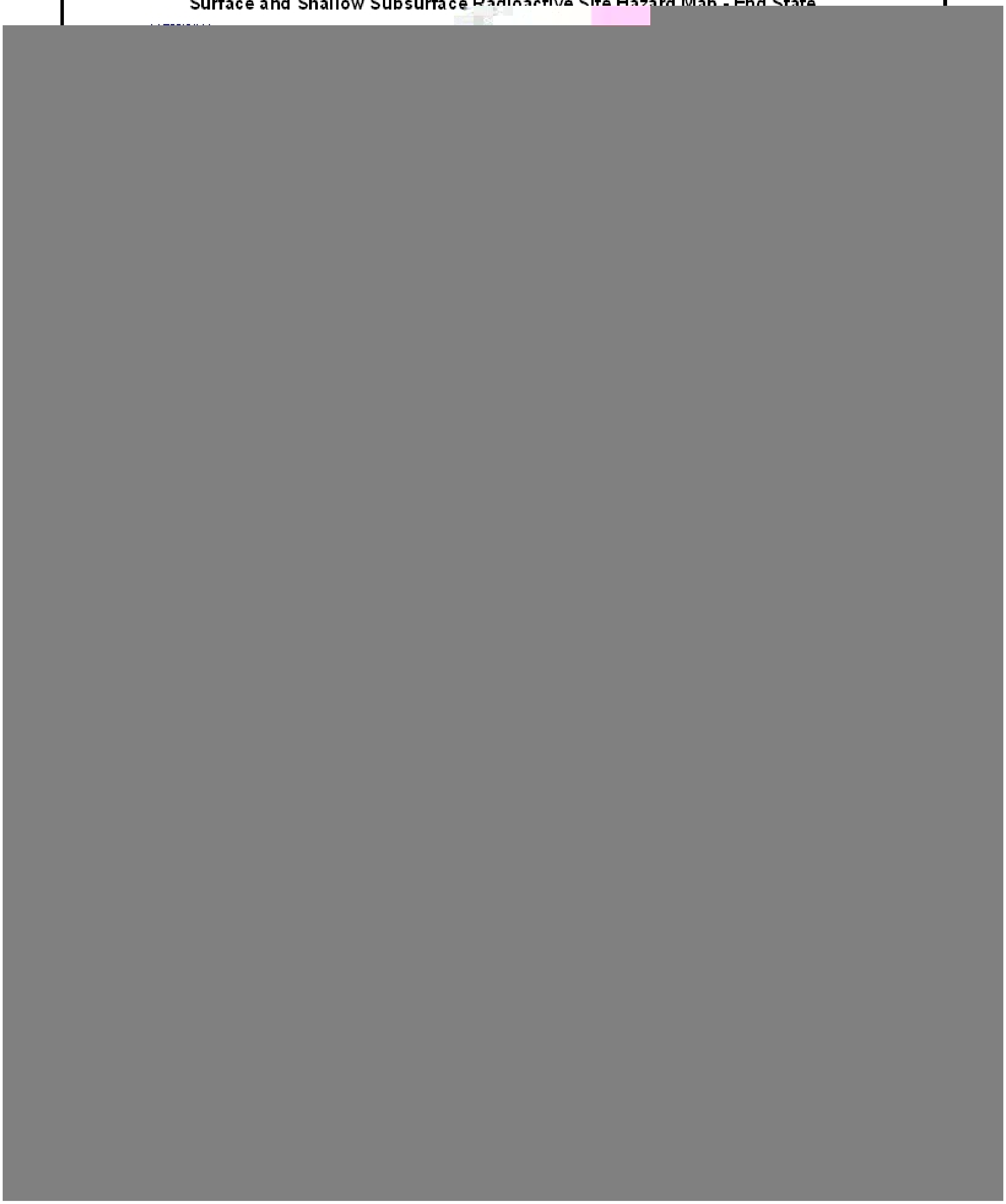


Figure 4.2b2
Hazard Area 2 Conceptual Site Model- End State

These sites will be remediated to allow their use for military purposes, because access and institutional controls are the responsibility of the U.S. Air Force, and human interaction with surface soils on the TTR as part of military activities is likely. The negotiated corrective action level is based on soil sampling, characterization data, computer analysis of residual radiation, and ALARA determinations. These sites will be cleaned up and formally closed, with site control relinquished to the U.S. Air Force. Confirmatory sampling of cleanup results will be done in conjunction with the U.S. Air Force.

Sites on the NTS will be further characterized, and will be fenced, posted, and monitored as appropriate. These actions are sufficient to allow the NTS to continue to support its long-term missions. This contamination on the NTS has existed for approximately 50 years with potential impacts to human health successfully mitigated by site controls as shown by no excessive doses to workers or the public. Any dose assessments resulting in negative human health impacts would be based on analyses scenarios that have not been experienced on the NTS in 50 years.

4.3 Hazard Area 3 – Industrial Sites

Industrial sites are potentially contaminated surface and near-subsurface areas impacted by the by-products of testing activities conducted on the NTS, TTR, NTTR, and nuclear rocket engine development on the NTS. The industrial sites have been organized into CAUs based on geography, technical similarity, or other appropriate reasons, for purposes of determining corrective actions. Examples of types of sites grouped in CAUs are tunnel muckpiles inactive ponds, drains and sumps, disposal wells, inactive tanks, contaminated waste sites, septic tanks and lagoons, spill sites, and deactivation and decommissioning facilities. Although most are located on the NTS, some are located on the TTR, and a few are located north and west of the NTS. Industrial Sites activities focus on the characterization, selection of efficient corrective measures, and implementation of corrective actions at those sites.

Sites on the TTR will be addressed first, because access and institutional controls are the responsibility of the U.S. Air Force. Sites on the NTS will be remediated starting in the southwest corner in accordance with future land use planning. The most contaminated sites will be addressed first. Limited site remediation will be conducted during the site assessment phase, as appropriate, to achieve early closure.

Remediation, stabilization, control of contamination, and monitoring, as appropriate, will occur at multiple sites in parallel. Sites will be aggregated into larger CAUs to achieve more efficient cleanup resulting from fewer required regulatory documents, co-location of sites, commonality of source contamination and required regulatory actions, and better utilization of craft personnel.

Closure begins with a DOE investigation of the industrial site followed by recommendations for possible types of corrective actions. Generally, a specific cleanup method to remediate an industrial site is chosen after characterization has been performed and a plan of action approved. After the plan is implemented, DOE prepares a closure report for the CAU. Some closure reports may include monitoring requirements for the site. Once NNSA/NSO and NDEP are in agreement, NDEP issues a notice of completion, marking the end of the closure process.

Some industrial sites may be closed using the clean closure corrective actions, which may include housekeeping measures, to excavate and remove all contamination. Based on projected limited future land-use restrictions at the NTS that have been established in agreement with the State of Nevada, some industrial sites may be closed in place. Often, industrial sites CAUs are closed through a combination of removal, housekeeping, and closure in place.

After a CAS has been closed, post-closure monitoring of the site is conducted as needed. Post-closure activities are stipulated in the closure report, which provides the inspection and maintenance requirements depending on the specified closure action. Post-closure monitoring may continue for a predetermined period of time negotiated by NNSA/NSO and the State of Nevada under the guidelines specified in the FFACO.

4.3.1 Current State

Industrial Sites

A total of 1,047 of these historic areas have been identified, verified, and inventoried for characterization, restoration, and/or closure (Map 4.3a1) under the NNSA/NSO EM program. Of these, nearly 672 sites have been formally closed. The remaining sites have been grouped according to source of contamination, location, and other technical characteristics. The Industrial sites at NTS consist of 178 active investigations/CASs and 197 future investigations/ CASs. A list of the different categories and the number of sites corresponding to each is provided in Table 4.6. Contaminants may include a wide variety of various combinations of hazardous organic and inorganic chemicals, unexploded ordnance, petroleum hydrocarbons, and low-level radionuclides. Potential risks associated with contamination at these sites and facilities are to workers and the environment.

4.3.2 End State

Applicable corrective actions will be completed for all 1,047 sites, and most sites will be available for unrestricted use, while others will be stabilized for restricted use appropriate to the risk posed by residual contamination. For those sites where contamination remains in place, appropriate long-term stewardship activities will be in place, including monitoring, inspections, and use.

Map 4.3a1 Nevada Test Site and Nevada Test and Training Range, Nevada

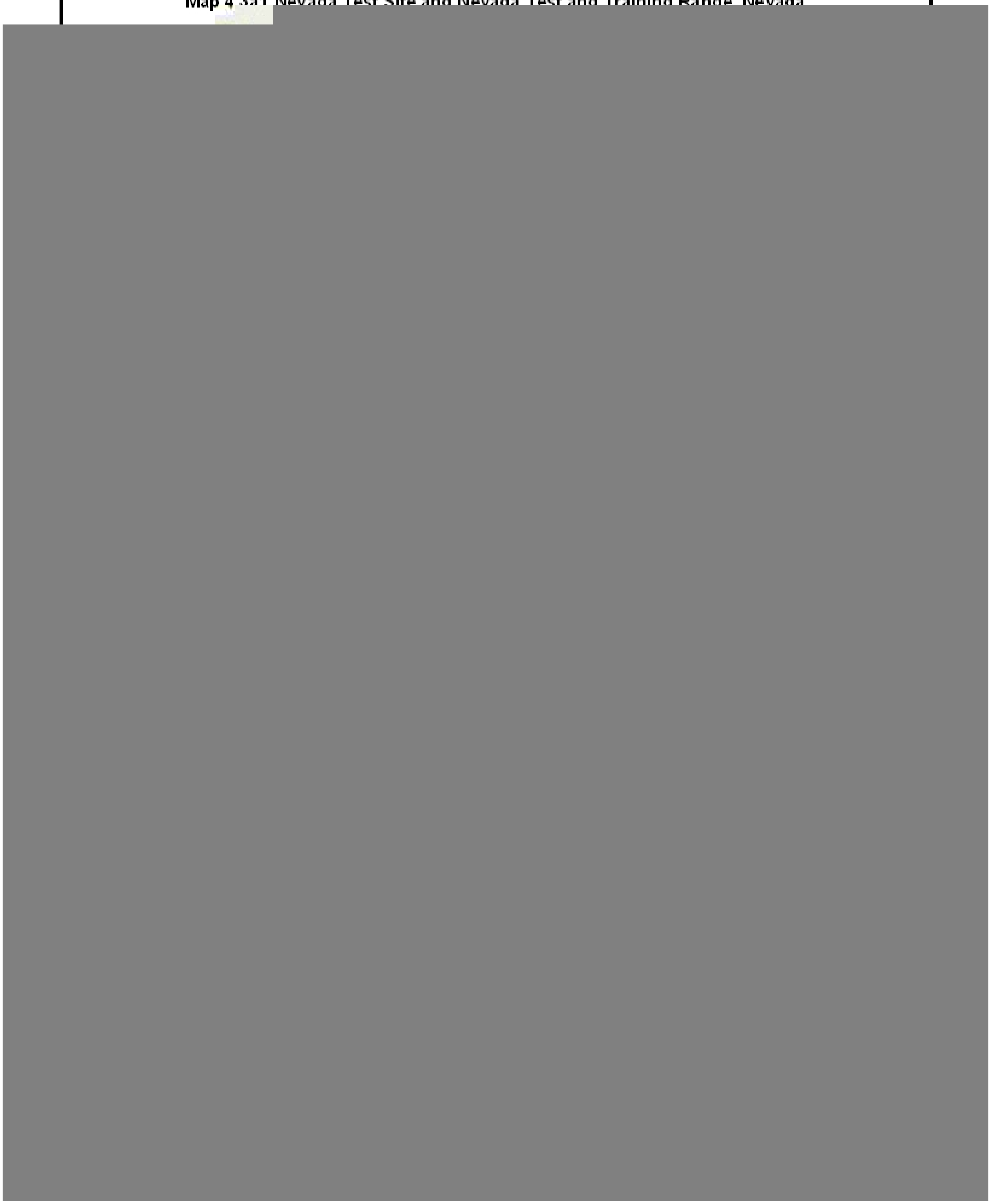


Table 4.6
Industrial Site Categories with Closure Strategies

Functional Industrial Sites Category	Number of CAUs	Closure Strategy
Abandoned Chemicals	2	Clean Closure
Aboveground Storage Tank	23	Clean Closure or Closure in Place
Boiler	2	Clean Closure
Building	1	Clean Closure
Buried Ordnance Site	6	Clean Closure or Closure in Place
Burn Cage/Pit	6	Clean Closure or Closure in Place
Chemical Storage	1	Clean Closure
Conditional Release Storage	6	Clean Closure
Construction Waste Landfill	2	Clean Closure or Close in Place
Contaminated Soil Site	2	Close in Place
D&D Facility (including nuclear rocket engine sites)	4	Clean Closure
Decon Area	1	Clean Closure
Decon Pad	5	Clean Closure or Close in Place
Decon Pad Discharge Piping	1	Clean Closure
DU Surface Debris	5	Clean Closure or Close in Place
Hazardous Waste Site	4	Clean Closure or Close in Place
Housekeeping Waste	23	Clean Closure or Close in Place
Injection Well	25	Clean Closure or Close in Place
Leachfield	8	Clean Closure or Close in Place
Lead	7	Clean Closure
Magazine/Bunker	11	Clean Closure or Close in Place
Muckpile	5	Close in Place
Mud Pit	16	Clean Closure or Close in Place
Oil/Fuel Spills	9	Clean Closure
Ordnance Site	3	Clean Closure or Close in Place
Other	26	Clean Closure
Other Ponds/Lagoons	6	Clean Closure or Close in Place
Other Spill Site	2	Clean Closure
PCB	1	Clean Closure
Rad Contamination Area	42	Clean Closure or Close in Place
Sanitary Landfill	5	Close in Place
Septic System	16	Clean Closure or Close in Place
Septic Tank	8	Clean Closure or Close in Place
Sewage Lagoon	4	Close in Place
Sump (Cellar)	3	Clean Closure or Close in Place
Surface Release Point	7	Clean Closure or Close in Place
Tunnel Pond	1	Close in Place
Tunnel Portal Area	5	Clean Closure or Close in Place
Underground Discharge Point	3	Close in Place
Underground Storage Tank	26	Clean Closure or Close in Place
Waste Disposal Site	21	Clean Closure or Close in Place
Waste Disposal Trench	3	Clean Closure or Close in Place
Waste Dump	9	Clean Closure or Close in Place

restrictions, as applicable to the site. Industrial sites that will be closed in place are shown on Map 4.3b1. It is not possible to show the end state monitoring locations at this time. According to the Life-Cycle Baseline, closure of the Industrial Site Project at the NTS is expected to be completed in 2018.

Site-wide current and end state CSMs for the NTS are provided as Figures 4.3a2 and 4.3b2. The CSM illustrates the relationship between the identified potential sources of contamination, mechanisms for release and migration away from the potential source, pathways contamination follows once released, exposure routes by which potential contamination would affect receptors, and receptors that would be impacted by potential contamination (DOE/NV, 2000).

Stewardship of the NTS will be conducted based on the principles of ecosystem management and sustainable development and will include responsibility for all associated resources, including the land, facilities, and equipment located at the site. Waste management operations will continue at the Area 3 and Area 5 RWMS for as long as necessary. The NTS stewardship program will ensure the disposal facilities perform as designed to confine disposed waste. Should it be necessary as a result of long-term monitoring, additional environmental restoration activities might also be conducted and may include identification, characterization, and remediation. Long-term monitoring and institutional control of the NTS is expected to continue in perpetuity; primarily due to the nature of the contaminants that will remain in surface soils and subsurface areas as a result of historical nuclear testing and activities associated with ongoing waste disposal operations.

Map 4.3b1 Nevada Test Site and Nevada Test and Training Range, Nevada
Industrial Site Hazard Map - End State

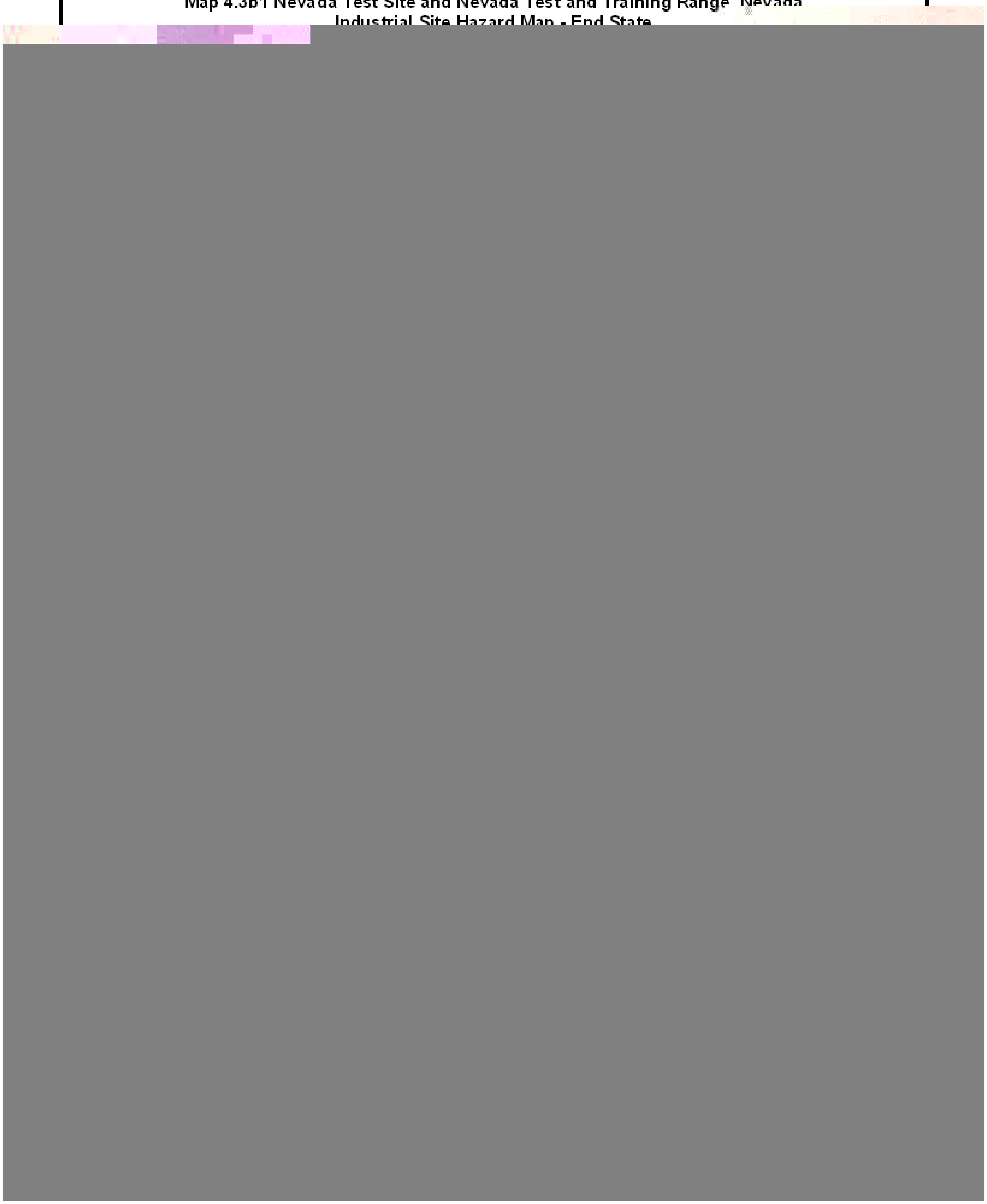


Figure 4.3a2
Hazard Area 3 Conceptual Site Model- Current State

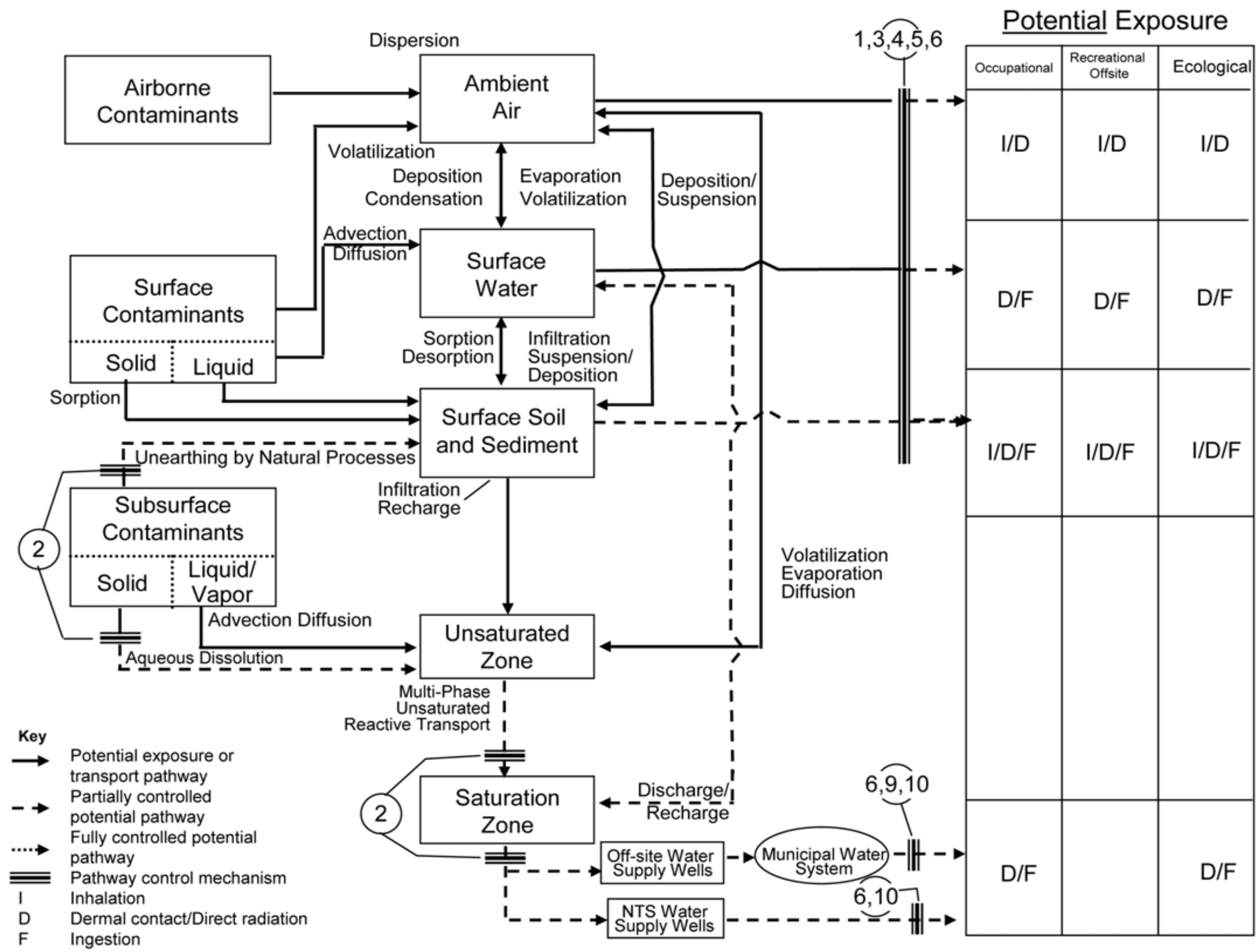


Figure 4.3b2
Hazard Area 3 Conceptual Site Model- End State

5.0 REFERENCES

Bowen, S.M., D.L. Finnegan, J.L. Thompson, C.M. Miller, P.L. Baca, L.F. Olivas, C.G. Geoffrion, D.K. Smith, W. Goishi, B.K. Esser, J.W. Meadows, N. Namboodiri, J.F. Wild. 2001. *Nevada Test Site Radionuclide Inventory, 1951-1992*, LA-13859-MS. Los Alamos National Laboratory: Los Alamos, NM.

DoD, see U.S. Department of Defense.

DOE, see U.S. Department of Energy.

DOE/EM, see U.S. Department of Energy, Office of Environmental Management.

DOE/NV, see U.S. Department of Energy, Nevada Operations Office.

EPA, see U.S. Environmental Protection Agency.

ESRI Streetmap USA 2003.

FFACO, see *Federal Facility Agreement and Consent Order*.

Federal Facility Agreement and Consent Order. 1996, as amended. Agreed to by the State of Nevada, the U.S. Department of Energy, and the U.S. Department of Defense.

McArthur, R.D. 1992. An Estimate of the Amount of Land on the Nevada Test Site that is Contaminated to Greater than 10 pCi/g of Pu 239-240. Las Vegas, NV: Desert Research Institute, Water Resources Center.

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

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

U.S. Census Bureau. 2000. Your Gateway to Census 2000, State and County Quick Facts, Census 2000 Home Page as accessed at http://www.census.gov/main/www/cen2000.html on February 2, 2004.

U.S. Department of Defense, Department of the Air Force. 1999. Renewal of the Nellis Air Force Range Land Withdrawal, Department of the Air Force, Legislative Environmental Impact. Las Vegas, NV.

U.S. Department of Energy. 2003a. DOE Order No. 450.1, “Environmental Protection Program.” Washington, DC: U.S. Government Printing Office.

U.S. Department of Energy. 2003b. DOE Policy No. 455.1, “Use of Risk-Based End States.” Washington, DC: U.S. Government Printing Office.

U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office. 2002. *Performance Management Plan*, DOE/NV--831. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. 2003a. *Annual Site Environmental Report – 2002*, DOE/NV11718--842. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. 2003b. *Clean Slate 2 Corrective Action Decision Document Corrective Action Unit 413*, DOE/NV--895. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. 2003c. *Documented Safety Analysis for the NTS Area 3 Radioactive Waste Management Site*, DSA-2151.200, Rev. 0. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. 2003d. *Documented Safety Analysis for the NTS Area 5 Radioactive Waste Management Site*, DSA-2151.100, Rev. 0. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 1992. *Summary of the Nevada Applied Ecology Group and Correlative Programs*, DOE/NV--357. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 1996. *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada*, Volume 1, Chapters 1-9, DOE/EIS 0243. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 1997. *Regional Groundwater Flow and Tritium Transport Modeling and Risk Assessment of the Underground Test Area, Nevada Test Site, Nevada*, DOE/NV--477 UC-700. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 1998. *Annual Site Environmental Report*, DOE/NV11718--231. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 1999. *Underground Test Area Project Project Management Plan*, DOE/NV--385, Rev. 1. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 2000. *Nevada Test Site Resource Management Plan Annual Summary*, DOE/NV--604. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 2001. "Real Estate/Operations Permit, Notice NV N 412.X1." Las Vegas, NV.

U.S. Department of Energy, Office of Environmental Management. 2003. *Guidance for Developing a Site Specific Risk-Based End State Vision*. Washington, DC.

U.S. Environmental Protection Agency. 2001. *Improving Sampling, Analysis, and Data Management for Site Investigation and Cleanup*, EPA-542-F-01-030a. Washington, DC: Office of Solid Waste and Emergency Response.

USGS, see U.S. Geological Survey.

U.S. Geological Survey. 1990. Land Use and Land Cover.