Final

Supplemental Environmental Impact Statement

for a

Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada

Volume I – Impact Analyses
Chapters 1 through 14

U.S. Department of Energy
Office of Civilian Radioactive Waste Management

DOE/EIS-0250F-S1

June 2008

ACRONYMS AND ABBREVIATIONS

To ensure a more reader-friendly document, the U.S. Department of Energy (DOE) limited the use of acronyms and abbreviations in this Repository supplemental environmental impact statement. In addition, acronyms and abbreviations are defined the first time they are used in each chapter or appendix. The acronyms and abbreviations used in the text of this document are listed below. Acronyms and abbreviations used in tables and figures because of space limitations are listed in footnotes to the tables and figures.

°C	degrees Celsius
CFR	Code of Federal Regulations
dBA	A-weighted decibels
DOE	U.S. Department of Energy (also called *the Department*)
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
°F	degrees Fahrenheit
FEIS	final environmental impact statement
FR	*Federal Register*
GNEP	Global Nuclear Energy Partnership
MTHM	metric tons of heavy metal
NEPA	*National Environmental Policy Act*
NRC	U.S. Nuclear Regulatory Commission
NWPA	*Nuclear Waste Policy Act*, as amended
PM_{10}	particulate matter with an aerodynamic diameter of 10 micrometers or less
$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 micrometers or less
REMI	Regional Economic Models, Inc.
RMEI	reasonably maximally exposed individual
SEIS	supplemental environmental impact statement
Stat.	United States Statutes
TAD	transportation, aging, and disposal (canister)
TSPA	Total System Performance Assessment
U.S.C.	United States Code
VdB	vibration velocity in decibels with respect to 1 micro-inch per second

TERMS AND DEFINITIONS

In this Repository SEIS, DOE has italicized terms that appear in the Glossary (Chapter 12) the first time they appear in a chapter.

UNDERSTANDING SCIENTIFIC NOTATION

DOE has used scientific notation in this Repository SEIS to express numbers that are so large or so small that they can be difficult to read or write. Scientific notation is based on the use of positive and negative powers of 10. The number written in scientific notation is expressed as the product of a number between 1 and 10 and a positive or negative power of 10. Examples include the following:

Positive Powers of 10	Negative Powers of 10
$10^1 = 10 \times 1 = 10$	$10^{-1} = 1/10 = 0.1$
$10^2 = 10 \times 10 = 100$	$10^{-2} = 1/100 = 0.01$
and so on, therefore,	and so on, therefore,
10^6 = 1,000,000 (or 1 million)	10^{-6} = 0.000001 (or 1 in 1 million)

Probability is expressed as a number between 0 and 1 (0 to 100 percent likelihood of the occurrence of an event). The notation 3×10^{-6} can be read 0.000003, which means that there are 3 chances in 1 million that the associated result (for example, a fatal cancer) will occur in the period covered by the analysis.

Substantive changes in this document are indicated in the margins with change bars.

Final

Supplemental Environmental Impact Statement

for a

Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada

Volume I – Impact Analyses
Chapters 1 through 14

U.S. Department of Energy
Office of Civilian Radioactive Waste Management

DOE/EIS-0250F-S1

June 2008

COVER SHEET

RESPONSIBLE AGENCY: U.S. Department of Energy (DOE)

TITLE: *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F-S1) (Repository SEIS).

CONTACTS:

For more information about this document, write or call:

U.S. Department of Energy
Office of Civilian Radioactive Waste Management
U.S. Department of Energy
1551 Hillshire Drive M/S 011
Las Vegas, NV 89134
ATTN: Dr. Jane Summerson
Telephone: (800) 967-3477
Fax: (800) 967-0739

For general information on the DOE NEPA process, write or call:

Carol M. Borgstrom, Director
Office of NEPA Policy and Compliance (GC-20)
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, DC 20585
Telephone: (202) 586-4600
Or leave a message: (800) 472-2756

Information about this document is available on the Internet at the Yucca Mountain Project Web site at http://www.ocrwm.doe.gov and on the DOE *National Environmental Policy Act* (NEPA) Web site at http://www.eh.doe.gov/nepa/.

ABSTRACT: DOE's Proposed Action is to construct, operate, monitor, and eventually close a geologic repository at Yucca Mountain for the disposal of spent nuclear fuel and high-level radioactive waste. Under the Proposed Action, spent nuclear fuel and high-level radioactive waste in storage or projected to be generated at 72 commercial and 4 DOE sites would be shipped to the repository by rail (train), although some shipments would arrive at the repository by truck. The Repository SEIS evaluates (1) the potential environmental impacts from the construction, operations, monitoring, and eventual closure of the repository; (2) potential long-term impacts from the disposal of spent nuclear fuel and high-level radioactive waste; (3) potential impacts of transporting these materials nationally and in the State of Nevada; and (4) potential impacts of not proceeding with the Proposed Action (the No-Action Alternative).

COOPERATING AGENCIES: Nye County, Nevada, is a cooperating agency in the preparation of the Repository SEIS.

PUBLIC COMMENTS: In preparing this Repository SEIS, DOE considered written comments received by letter, electronic mail, and facsimile transmission, and oral and written comments given at public hearings at six locations in Nevada, one location in California, and in Washington, DC.

FOREWORD

The U.S. Department of Energy (DOE or Department) has prepared three analyses under the National Environmental Policy Act (NEPA) associated with the proposed disposal of spent nuclear fuel and high-level radioactive waste in a geologic repository at the Yucca Mountain Site in Nye County, Nevada. The first analysis, the Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada (DOE/EIS-0250F-S1) (Repository SEIS), evaluates the potential environmental impacts of constructing and operating the Yucca Mountain repository under the proposed repository design and operational plans. It supplements the *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F) (Yucca Mountain FEIS) prepared by the Department in 2002.

The second and third analyses are set forth in the Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada – Nevada Rail Transportation Corridor (DOE/EIS-0250F-S2) (Nevada Rail Corridor SEIS) , and the Final Environmental Impact Statement for a Rail Alignment for the Construction and Operation of a Railroad in Nevada to a Geologic Repository at Yucca Mountain, Nye County, Nevada (DOE/EIS-0369) (Rail Alignment EIS). These analyses evaluate the potential environmental impacts of constructing and operating a railroad for shipments of spent nuclear fuel and high-level radioactive waste from an existing rail line in Nevada to the repository at Yucca Mountain, in order to help the Department decide whether to construct and operate a railroad, and if so, within which corridor and along which alignment. Because both the Nevada Rail Corridor SEIS and the Rail Alignment EIS address potential environmental impacts associated with the proposed construction and operation of a railroad, they are bound together in one document for the convenience of the reader.

Background and Context

The Nuclear Waste Policy Act, as amended (NWPA, 42 U.S.C. 10101 *et seq.)* directs the Secretary of Energy, if the Secretary decides to recommend approval of the Yucca Mountain site for development of a repository, to submit a final EIS with any recommendation to the President. To fulfill that requirement, the Department prepared the Yucca Mountain FEIS.

On February 14, 2002, the Secretary transmitted to the President the Secretary’s recommendation (including the Yucca Mountain FEIS) for approval of the Yucca Mountain site for development of a geologic repository. The President considered the site qualified for application to the NRC for construction authorization and recommended the site to the U.S. Congress. Subsequently, Congress passed a joint resolution of the U.S. House of Representatives and the U.S. Senate designating the Yucca Mountain site for development as a geologic repository for the disposal of spent nuclear fuel and high-level radioactive waste. On July 23, 2002, the President signed the joint resolution into law (Public Law 107-200). As required by the NWPA [Section 114(b)], the Department has submitted an application to the NRC seeking authorization to construct the repository

Since completion of the Yucca Mountain FEIS in 2002, DOE has continued to develop the repository design and associated construction and operational plans. As now designed, the surface and subsurface facilities would allow DOE to operate the repository following a primarily canistered approach in which most commercial spent nuclear fuel would be packaged at the reactor sites in transportation, aging, and disposal (TAD) canisters. Any commercial spent nuclear fuel arriving at the repository in packages other than TAD canisters would be repackaged by DOE at the repository into TAD canisters. DOE would construct the surface and subsurface facilities over a period of several years (referred to as phased construction) to accommodate an increase in spent nuclear fuel and high-level radioactive waste receipt rates as repository operational capability reaches its design capacity.

To address the modifications to repository design and operational plans, the Department announced its intent to prepare a Supplement to the Yucca Mountain FEIS, consistent with NEPA and the NWPA (Notice of Intent to prepare *Supplement to the Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, NV*; 71 FR 60490, October 13, 2006). The Repository SEIS supplements the Yucca Mountain FEIS by considering the potential environmental impacts of the construction, operation and closure of the repository under the modified repository design and operational plans, and by updating the analysis and potential environmental impacts of transporting spent nuclear fuel and high-level radioactive waste to the repository, consistent with transportation-related decisions the Department made following completion of the Yucca Mountain FEIS.

On April 8, 2004, the Department issued a Record of Decision announcing its selection, both nationally and in the State of Nevada, of the mostly rail scenario analyzed in the Yucca Mountain FEIS as the primary means of transporting spent nuclear fuel and high-level radioactive waste to the repository (*Record of Decision on Mode of Transportation and Nevada Rail Corridor for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, NV*; 69 FR 18557, April 8, 2004). Implementation of the mostly rail scenario ultimately would require the construction of a rail line to connect the repository site at Yucca Mountain to an existing rail line in the State of Nevada. To that end, in the same Record of Decision, the Department also selected the Caliente rail corridor from several corridors considered in the Yucca Mountain FEIS as the corridor in which to study possible alignments for a rail line. On the same day DOE selected the Caliente corridor, it issued a Notice of Intent to prepare an EIS under NEPA to study alternative alignments within the Caliente corridor (the Rail Alignment EIS; DOE/EIS-0369) (*Notice of Intent to Prepare an Environmental Impact Statement for the Alignment, Construction, and Operation of a Rail Line to a Geologic Repository at Yucca Mountain, Nye County, NV*; 69 FR 18565, April 8, 2004).

During the subsequent public scoping process, DOE received comments suggesting that other rail corridors be considered, in particular, the Mina route. In the Yucca Mountain FEIS, DOE had considered but eliminated the Mina route from detailed study because a rail line within the Mina route could only connect to an existing rail line in Nevada by crossing the Walker River Paiute Reservation, and the Tribe had informed DOE that it would not allow nuclear waste to be transported across the Reservation.

Following review of the scoping comments, DOE held discussions with the Walker River Paiute Tribe and, in May 2006, the Tribal Council informed DOE that it would allow the Department to consider the potential impacts of transporting spent nuclear fuel and high-level radioactive waste across its reservation. On October 13, 2006, after a preliminary evaluation of the feasibility of the Mina rail corridor, DOE announced its intent to expand the scope of the Rail Alignment EIS to include the Mina corridor (*Amended Notice of Intent to Expand the Scope of the Environmental Impact Statement for the Alignment, Construction, and Operation of a Rail Line to a Geologic Repository at Yucca Mountain, Nye County, NV*; 71 *FR* 60484). Although the expanded NEPA analyses, referred to as the Nevada Rail Corridor SEIS and Rail Alignment EIS, evaluate the potential environmental impacts associated with the Mina corridor, DOE has identified the Mina alternative as non-preferred because the Tribe has withdrawn its support for the EIS process.

Relationships Among the EISs

Although the Yucca Mountain FEIS, the Repository SEIS and the Nevada Rail Corridor SEIS and Rail Alignment EIS are all related to the proposal to construct and operate the Yucca Mountain repository, they consider actions involving the jurisdiction of more than one federal agency. The Repository SEIS supplements the Yucca Mountain FEIS and considers the potential environmental impacts associated with the construction and operation of the Yucca Mountain repository. The responsibility for issuing construction authorization and a license to receive and possess radioactive materials at the repository rests with the Nuclear Regulatory Commission (NRC). Should the NRC authorize development of the repository, DOE would be the federal agency responsible for constructing and operating the repository.

The Nevada Rail Corridor SEIS, which supplements the rail corridor analysis in the Yucca Mountain FEIS, analyzes the potential environmental impacts associated with constructing and operating a railroad within the Mina corridor. The Nevada Rail Corridor SEIS analyzes the Mina corridor at a level of detail commensurate with that of the rail corridor analysis in the Yucca Mountain FEIS, and concludes that the Mina corridor warrants further study in the Rail Alignment EIS to identify an alignment for the construction and operation of a railroad.

The Nevada Rail Corridor SEIS also updates relevant information regarding three other rail corridors previously analyzed in the Yucca Mountain FEIS (Carlin, Jean, and Valley Modified). The update demonstrates that there are no significant new circumstances or information relevant to environmental concerns associated with these three rail corridors, and that they do not warrant further consideration in the Rail Alignment EIS. The Caliente-Chalk Mountain rail corridor, which also was included in the Yucca Mountain FEIS, would intersect the Nevada Test and Training Range, and was eliminated from further consideration because of U.S. Air Force concerns that a rail line within the Caliente-Chalk Mountain corridor would interfere with military readiness testing and training activities.

The Rail Alignment EIS tiers from the broader corridor analysis in both the Yucca Mountain FEIS and the Nevada Rail Corridor SEIS, consistent with the Council on Environmental Quality regulations (see 40 CFR 1508.28). Under the Proposed Action considered in the Rail Alignment EIS, DOE analyzes specific potential impacts of constructing and operating a rail line along common segments and alternative segments within the Caliente and Mina corridors for the purpose of determining an alignment in which to construct and operate a railroad for shipments of spent nuclear fuel and high-level radioactive waste from an existing rail line in Nevada to a geologic repository at Yucca Mountain. If DOE were to decide that a railroad should be constructed, it would be the federal agency charged with responsibility for carrying out the actions necessary to construct and operate the railroad.

The Repository SEIS includes the potential environmental impacts of national transportation, as well as the potential impacts in Nevada from the construction and operation of a rail line along specific alignments in either the Caliente or the Mina corridor, to ensure that the Repository SEIS considers the full scope of potential environmental impacts associated with the proposed construction and operation of the repository. Accordingly, the Repository SEIS incorporates by reference appropriate portions of the Nevada Rail Corridor SEIS and the Rail Alignment EIS. To ensure consistency, the Repository SEIS, and the Nevada Rail Corridor SEIS and Rail Alignment EIS use the same updated inventory of spent nuclear fuel and high-level radioactive waste and the same number of rail shipments for analysis. Thus, the associated occupational and public health and safety impacts within the Nevada rail corridors under consideration are the same in the Repository SEIS, and in the Nevada Rail Corridor SEIS and Rail Alignment EIS. Furthermore, to promote conformity, consistent analytical approaches were used where appropriate to evaluate common resource areas.

Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada (DOE/EIS-0250F)

Proposed Action:

- DOE would construct, operate, monitor, and eventually close a geologic repository at Yucca Mountain.
- Repository operations would include transporting spent nuclear fuel and high-level radioactive waste to Yucca Mountain nationally and in Nevada by either mostly rail or mostly truck

Record of Decision

- Mostly rail nationally and in Nevada
- Caliente rail corridor to determine alignment

Repository SEIS
(DOE/EIS-0250F-S1)

1. Supplements the Yucca Mountain FEIS, as modified by:
   - Record of Decision (mostly rail, Caliente corridor) (69 *FR* 18557)
   - Outcome of the Nevada Rail Corridor SEIS (Mina corridor)
2. Otherwise Proposed Action remains unchanged:
   - DOE would construct, operate, monitor, and eventually close a repository
   - During repository operations, shipments would occur by mostly rail
   - In Nevada, rail shipments would occur on a railroad to be constructed along an alignment within either the Caliente or Mina rail corridor
   - Shipments also would arrive at repository by truck
3. To supplement the Nevada transportation analysis, the Repository SEIS incorporate by reference relevant information from the Rail Alignment EIS:
   - Affected environments of Caliente and Mina rail alignments
   - Environmental impacts from constructing and operating a railroad along Caliente or Mina alignment
   - Cumulative impacts associated with Caliente and Mina rail alignments

Nevada Rail Corridor SEIS
(DOE/EIS-0250F-S2)

1. Supplements the Nevada transportation analysis of Yucca Mountain FEIS, as modified by:
   - Record of Decision (mostly rail) (69 *FR* 18557)
   - Proposed consideration of Mina rail corridor
2. Under the Proposed Action, DOE would construct and operate a railroad to connect the Yucca Mountain repository to an existing rail line near Wabuska, Nevada (the Mina rail corridor)
   - Mina rail corridor information and analyses at level of detail commensurate with that of the other corridors in the Yucca Mountain FEIS
3. Consider other corridors in Yucca Mountain FEIS for significant new circumstances or information bearing on environmental concerns
   - Review environmental information available since Yucca Mountain FEIS.
4. Conclusion:
   - The Mina corridor warrants further detailed study to determine an alignment based on impact analysis.
   - There are no significant changes or new information bearing on environmental concerns for the other corridors that would warrant further detailed study determine at the alignment level.

Rail Alignment EIS
(DOE/EIS-0369)

1. The Rail Alignment EIS tiers from the Yucca Mountain FEIS and Nevada Rail Corridor SEIS
2. Proposed Action based on Record of Decision (69 *FR* 18557)
   - Under the Proposed Action, DOE would determine an alignment for the construction and operation of a railroad
     - ⇒ Caliente Implementing Alternative (preferred)
     - ⇒ Mina Implementing Alternative (nonpreferred)

Foreword Figure 1. Relationship among the Repository SEIS, and the Nevada Rail Corridor SEIS and Rail Alignment EIS.

CONTENTS

(Each chapter and appendix contains a complete table of contents.)

Summary

Volume I

Volume II

Volume III

1

Purpose and Need for Agency Action

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. PURPOSE AND NEED FOR AGENCY ACTION

The U.S. Department of Energy (DOE or the Department) completed the *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F; DIRS 155970-DOE 2002, all) (Yucca Mountain FEIS) in February 2002. Since the completion of the FEIS, DOE has continued to develop the *repository* design and associated plans. DOE has prepared this *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F-S1) (Repository SEIS) to address the modifications to repository design and operational plans. This Repository SEIS also updates the analysis and potential impacts of transporting *spent nuclear fuel* and *high-level radioactive waste* to the repository, consistent with transportation-related decisions the Department made following completion of the Yucca Mountain FEIS.

Spent nuclear fuel and high-level radioactive waste are long-lived, highly *radioactive* materials that result from certain nuclear activities. For more than 60 years, these materials have accumulated at commercial power plants and DOE facilities and continue to accumulate across the United States. Because of their nature, spent nuclear fuel and high-level radioactive waste must be isolated from the human environment, and monitored for long periods. The United States has focused a national effort on the siting and development of a *geologic repository* for *disposal* of these materials and on the development of systems for transportation of the materials safely from their present storage locations to the repository.

Through the passage of the *Nuclear Waste Policy Act*, as amended (NWPA) (42 U.S.C. 10101 et seq.), Congress found that:

- The Federal Government has the responsibility to provide for the permanent disposal of high-level radioactive waste and spent nuclear fuel to protect the public health and safety and the environment.

- Appropriate precautions must be taken to ensure that these materials do not adversely affect the public health and safety and the environment for this or future generations.

Pursuant to the NWPA, Congress directed that DOE evaluate the *Yucca Mountain site* in southern Nevada as a potential location for a *geologic* repository. In addition, in 2002, Congress designated the Yucca Mountain site for the development of a repository for the disposal of high-level radioactive waste and spent nuclear fuel (Public Law 107-200; 116 Stat. 735).

A geologic repository for spent nuclear fuel and high-level radioactive waste would permanently isolate radioactive materials in a deep *subsurface* location to limit *risk* to the health and safety of the public. This Repository SEIS addresses actions that DOE proposes to take to construct, operate and monitor, and eventually close a repository at Yucca Mountain, and to transport spent nuclear fuel and high-level radioactive waste from 76 sites to the Yucca Mountain site for disposal.

Figure 1-1 shows the 72 commercial nuclear power sites and 4 DOE sites in 34 states that currently store radioactive materials that DOE would ship to the repository.[1]

Based on its obligations under the NWPA and its decision to select the mostly rail scenario for the transportation of spent nuclear fuel and high-level radioactive waste (69 FR 18557, April 8, 2004), DOE needs to ship the majority of spent nuclear fuel and high-level radioactive waste by rail to the Yucca Mountain site in Nevada. Because there is no rail access to the Yucca Mountain site, to implement its decision DOE also needs to construct and operate a *railroad* to connect the repository to an existing *rail line* in Nevada.

Section 1.1 provides background information related to this Repository SEIS. Section 1.2 describes important documents and actions related to Yucca Mountain. Section 1.3 provides a brief overview of spent nuclear fuel, high-level radioactive waste, and surplus weapons-usable plutonium. Section 1.4 provides an overview of the Yucca Mountain site and the proposed disposal approach. Section 1.5 presents information on the environmental *impact* analysis process as it applies to the *Proposed Action*.

1.1 Background

DOE completed the Yucca Mountain FEIS in February 2002. The Proposed Action addressed in the FEIS is to construct, operate and monitor, and eventually close a geologic repository at Yucca Mountain in southern Nevada for the disposal of spent nuclear fuel and high-level radioactive waste.

The Yucca Mountain FEIS considered the potential environmental impacts of a repository design for surface and subsurface facilities; a range of *canister* packaging scenarios, repository thermal operating modes, and repository sizes; and plans for the *construction*, *operation*, *monitoring*, and eventual *closure* of the repository. In addition, the FEIS examined various national transportation scenarios and Nevada transportation *alternatives* for *shipment* of spent nuclear fuel and high-level radioactive waste to the repository. DOE evaluated two national transportation scenarios, referred to as the “mostly legal-weight truck scenario” and the “mostly rail scenario,” and three Nevada transportation alternatives, including shipment by legal-weight truck, rail, and *heavy-haul truck*. In the FEIS, DOE identified the mostly rail scenario as its preferred mode of transportation, both nationally and in Nevada, due in part to public preference and somewhat lower potential impacts on the health and safety of workers and the public (DIRS 155970-DOE 2002, p. 1-3).

The Yucca Mountain FEIS acknowledged that these repository design concepts and operational plans would continue to evolve during the design and engineering process and that determination of a specific *rail alignment* in which to construct a rail line would require further analysis under the *National Environmental Policy Act* (NEPA; 42 U.S.C. 6901 et seq.).

1. Spent nuclear fuel and high-level radioactive waste currently are stored at 121 sites in 39 states. However, this Repository SEIS addresses the 76 sites from which DOE would ship radioactive materials to Yucca Mountain. The balance of the sites would ship their materials to one of the DOE sites included in this Repository SEIS in accordance with DOE’s Record of Decision published on June 1, 1995 (60 FR 28680), before the Department shipped them to the repository.

Figure 1-1. Commercial and DOE sites from which DOE would ship radioactive materials to Yucca Mountain.

Since completion of the Yucca Mountain FEIS in 2002, DOE has continued to develop the repository design and associated construction and operational plans. As now proposed, the newly designed surface and subsurface facilities would allow DOE to operate the repository following a *primarily canistered approach* in which most *commercial spent nuclear fuel* would be packaged at the *reactor* sites in *transportation, aging, and disposal (TAD) canisters*. DOE would repackage any commercial spent nuclear fuel that arrived at the repository in packages other than TAD canisters in TAD canisters. The Department would construct the surface and subsurface facilities over a period of several years (referred to as phased construction) to accommodate an increase in spent nuclear fuel and high-level radioactive waste receipt rates as repository operational capability reached its design capacity. This Repository SEIS evaluates potential environmental impacts of the repository design and operational plans as described in the application that DOE has submitted to the U.S. Nuclear Regulatory Commission (NRC) seeking authorization to construct the repository, as required in Section 114(b) of the NWPA (DIRS 185301-DOE 2008, all). The responsibility for issuing construction authorization and a license to receive and possess radioactive materials at the repository rests with the NRC. Should the NRC authorize development of the repository, DOE would be the federal agency responsible for actions related to constructing and operating the repository.

1.2 Site Recommendation and Update of Yucca Mountain Decisions

On February 14, 2002, after more than two decades of scientific investigations, the Secretary of Energy submitted a comprehensive statement to the President of the United States that recommended Yucca Mountain as the site for development of a geologic repository. The Yucca Mountain FEIS accompanied the site recommendation.

On February 15, 2002, in accordance with the NWPA, the President recommended the Yucca Mountain site to Congress. On April 8, 2002, the Governor of Nevada submitted to Congress a notice of disapproval of the Yucca Mountain site designation. On May 8 and July 9, 2002, the House of Representatives and the Senate, respectively, passed a joint resolution that overrode the notice of disapproval and approved the development of a repository for the disposal of spent nuclear fuel and high-level radioactive waste at Yucca Mountain. On July 23, 2002, the President signed into law the joint resolution of the House of Representatives and the Senate that designated the Yucca Mountain site for development as a geologic repository (*Yucca Mountain Development Act of 2002*, Public Law 107-200; 116 Stat. 735). On October 25, 2002, following DOE's distribution of the Yucca Mountain FEIS, the U.S. Environmental Protection Agency (EPA) published its Notice of Availability of the Yucca Mountain FEIS (67 FR 65564).

On December 29, 2003, DOE published "Notice of Preferred Nevada Rail Corridor" (68 FR 74951) that named the Caliente rail corridor as its preferred *corridor* in which to construct a rail line in Nevada.

On April 8, 2004, DOE published "*Record of Decision* on Mode of Transportation and Nevada Rail Corridor for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, NV" (69 FR 18557) that announced the selection of the mostly rail scenario the Department analyzed in the Yucca Mountain FEIS for transportation of spent nuclear fuel and high-level radioactive waste nationally and in Nevada. DOE based its decision to select the mostly rail scenario on analyses in the Yucca Mountain FEIS (specifically those analyses related to impacts on the health and safety of workers and the public), public preferences, consideration of irreversible and irretrievable commitments of resources, and *cumulative impacts* from transportation of other radioactive materials. Also on April 8, 2004, DOE announced it had selected the Caliente rail corridor from several corridors the Department considered in the Yucca Mountain FEIS as the corridor in which to study possible rail alignments for the construction and operation of a rail line in Nevada (69 FR 18565). The Department based this decision primarily on the analyses in the Yucca Mountain FEIS, which included land use conflicts and their potential to affect adversely the timely construction of a proposed rail line.

In 2006, DOE proposed a modified approach to repository design, development, and operation. Central to this proposed approach is the use of a canister concept for commercial spent nuclear fuel that minimizes handling of individual spent fuel assemblies; limits the need for complex surface facilities; and simplifies repository design, licensing, construction, and operation. DOE would use a TAD canister to transport, age, and dispose of commercial spent nuclear fuel without ever reopening the canister, thereby simplifying and reducing the number of handling operations involved in the packaging of spent nuclear fuel for disposal. In addition, the canistered approach offers the advantage of the use of practices that are familiar to the nuclear industry and the NRC, which would make the repository easier to design, license, construct, and operate. Although DOE has a small amount of spent nuclear fuel of commercial origin that it could ship to the repository uncanistered in a *cask*, consistent with the analysis in the Yucca Mountain FEIS, this Repository SEIS assumes that it would transport and receive all *DOE spent nuclear fuel* and high-level radioactive waste in *disposable canisters*. On October 13, 2006, in the Notice of Intent to prepare "Supplement to the Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, NV" (71 FR 60490), DOE announced that it would prepare a supplement to the Yucca Mountain FEIS to evaluate potential environmental impacts of the modified repository design and operational plans. In its Notice of Intent, DOE described the primarily canistered approach whereby most commercial sites would package their spent nuclear fuel in TAD canisters, and all DOE materials would be packaged in disposable canisters at DOE sites.

Also on October 13, 2006, DOE published "Amended Notice of Intent to Expand the Scope of the Environmental Impact Statement for the Alignment, Construction, and Operation of a Rail Line to a Geologic Repository at Yucca Mountain, Nye County, NV" (71 FR 60484). Based on public scoping comments, discussions with the Walker River Paiute Tribe, and a preliminary evaluation of the feasibility of the Mina rail corridor, DOE announced it would expand the scope of the EIS to supplement the *rail corridor* analyses of the Yucca Mountain FEIS and analyze the Mina corridor. Although the Nevada Rail Corridor SEIS analyzes the potential environmental impacts associated with the Mina corridor, it identifies the Mina alternative as nonpreferred because the Mina corridor would cross the Walker River Paiute Reservation, and the Tribe has withdrawn its participation in the EIS process. Table 1-1 lists important documents and actions since DOE published the Yucca Mountain FEIS.

Table 1-1. Important documents and actions since DOE completed the Yucca Mountain FEIS.

Date	Document/Decision	Description
February 14, 2002	Secretary of Energy made Site Recommendation.	Secretary of Energy submitted a comprehensive statement to the President of the United States that recommended Yucca Mountain as the site for development of a geologic repository for nuclear waste. The Site Recommendation was accompanied by the Yucca Mountain FEIS.
February 15, 2002	President recommended Yucca Mountain.	President G. W. Bush recommended the Yucca Mountain site to Congress.
April 8, 2002	Nevada objected to the President's approval.	Governor of Nevada submitted a notice of disapproval of the Yucca Mountain site designation to Congress.
May 8 and July 9, 2002	House of Representatives and Senate approved Yucca Mountain.	House of Representatives and Senate, respectively, passed a joint resolution that overrode the notice of disapproval and approved the development of a repository for the disposal of spent nuclear fuel and high-level radioactive waste at Yucca Mountain.
July 23, 2002	President signed *Yucca Mountain Development Act* into law.	President G. W. Bush signed the joint resolution into law as Public Law 107-200. This law, known as the *Yucca Mountain Development Act*, was codified as 42 U.S.C. 10135 note (Supp. IV 2004). This action completed the site selection process mandated by the NWPA and allowed DOE to seek licenses from the NRC to build and operate a repository at Yucca Mountain.
October 25, 2002	A Notice of Distribution was published (67 FR 65539) and the EPA published its Notice of Availability of the Yucca Mountain FEIS (67 FR 65564).	DOE distributed the Yucca Mountain FEIS and the EPA notified the public of its availability.
November 18, 2003	DOE published *Strategic Plan for the Safe Transportation of Spent Nuclear Fuel and High-Level Radioactive Waste to Yucca Mountain*: *A Guide to Stakeholder Interactions* (DIRS 172433-DOE 2003, all).	This plan laid out the operational approach that DOE would follow in definition and development of the comprehensive transportation system required for the safe and secure shipment of spent nuclear fuel and high-level radioactive waste. The plan presents DOE's strategy and describes the process DOE would use to work cooperatively with states, federally recognized tribes, local governments, utilities, the transportation industry, and other interested parties.
December 29, 2003	DOE published "Notice of Preferred Nevada Rail Corridor" (68 FR 74951).	DOE named the Caliente rail corridor as its preferred corridor in which to construct a rail line in Nevada.

Table 1-1. Important documents and actions since DOE completed the Yucca Mountain FEIS (continued).

Date	Document/Decision	Description
December 29, 2003	BLM segregated public lands for up to 2 years (68 FR 74965).	BLM announced the receipt of a land withdrawal application from DOE that requested the withdrawal of approximately 1,249 square kilometers (308,600 acres) of public land in Nevada from surface entry and mining for a period of 20 years to evaluate the land for the potential construction, operation, and maintenance of a rail line for transportation of spent nuclear fuel and high-level radioactive waste in the Caliente rail corridor. The notice segregated the land from surface entry and mining for as long as 2 years while DOE conducted studies and analyses to support a final decision on the withdrawal application.
April 8, 2004	DOE published "Record of Decision on Mode of Transportation and Nevada Rail Corridor for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, NV" (69 FR 18557).	This Record of Decision selected the mostly rail scenario nationally and in Nevada and selected the Caliente rail corridor to examine potential alignments within which to construct the rail line.
April 8, 2004	DOE published "Notice of Intent to Prepare an Environmental Impact Statement for the Alignment, Construction, and Operation of a Rail Line to a Geologic Repository at Yucca Mountain, Nye County, NV" (69 FR 18565).	DOE announced it would prepare an environmental impact statement for the alignment, construction, and operation of a rail line for shipment of spent nuclear fuel, high-level radioactive waste, and other materials from a site near Caliente, Lincoln County, Nevada, to a geologic repository at Yucca Mountain, Nye County, Nevada.
July 9, 2004	U.S. Court of Appeals upheld *Yucca Mountain Development Act*.	U.S. Court of Appeals issued a decision that rejected the State of Nevada's challenge to the constitutionality of the resolution that approved Yucca Mountain. The Court denied all but one of the challenges to EPA and NRC regulations that govern Yucca Mountain. The agencies have proposed new regulations that would address compliance periods for the first 10,000 years and for post-10,000 years (up to 1 million years). The proposed regulations have not been finalized.
December 6, 2005	DOE published *Environmental Assessment for the Proposed Withdrawal of Public Lands Within and Surrounding the Caliente Rail Corridor, Nevada* (DIRS 176452-DOE 2005, all).	This environmental assessment evaluated the potential impacts of the proposed land withdrawal and the land evaluation activities.

Table 1-1. Important documents and actions since DOE completed the Yucca Mountain FEIS (continued).

Date	Document/Decision	Description
December 28, 2005	BLM issued Public Land Order No. 7653 withdrawing public lands for period of 10 years (70 FR 76854).	BLM withdrew approximately 1,249 square kilometers (308,600 acres) of public lands in the Caliente rail corridor in Nevada from surface entry and the location of new mining claims, subject to valid existing rights, for a period of 10 years to enable DOE to evaluate the lands for potential construction, operation, and maintenance of a rail line, which the Department would use to transport spent nuclear fuel and high-level radioactive waste to the proposed Yucca Mountain repository.
October 13, 2006	DOE published "Amended Notice of Intent to Expand the Scope of the Environmental Impact Statement for the Alignment, Construction, and Operation of a Rail Line to a Geologic Repository at Yucca Mountain, Nye County, NV" (71 FR 60484*)*.	Based on new information, DOE announced it would expand the scope of the Rail Alignment EIS to consider the potential environmental impacts of a newly proposed Mina rail corridor to supplement the Yucca Mountain FEIS rail corridor analysis and and to analyze alternative alignments in the Mina corridor.
October 13, 2006	DOE published Notice of Intent to prepare "Supplement to the Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, NV" (71 FR 60490).	DOE announced it would prepare this supplement to evaluate potential environmental impacts of the modified repository design and operational plans.
January 10, 2007	BLM segregated public lands for as long as 2 years (72 FR 1235).	BLM announced the receipt of a land withdrawal application from DOE requesting the withdrawal of approximately 842 square kilometers (208,037 acres) of public land in Nevada from surface entry and mining until December 27, 2015, to evaluate the land for the potential construction, operation, and maintenance of a rail line for transportation of spent nuclear fuel and high-level radioactive waste in the Caliente or Mina rail corridor. The notice segregated the land from surface entry and mining for as long as 2 years while DOE conducted studies and analyses to support a final decision on the withdrawal application.
October 12, 2007	DOE published Notice of Availability of two draft NEPA documents related to its Yucca Mountain Project (72 FR 58071).	DOE announced the availability of the Draft Repository SEIS and the Draft Nevada Rail Corridor SEIS and Draft Rail Alignment EIS, invited interested parties to comment on the documents during a 90-day public comment period, and announced the schedule for public hearings.
March 8, 2008	DOE applied for a right-of-way from the BLM (DIRS 185486-Larson 2008, all).	DOE submitted a right-of-way application to the BLM that includes public land required to construct and operate the proposed railroad in Nevada.

Table 1-1. Important documents and actions since DOE completed the Yucca Mountain FEIS (continued).

Date	Document/Decision	Description
March 17, 2008	DOE submitted an application to the Surface Transportation Board (DIRS 185339-Vandeberg 2008, all).	DOE submitted an application to the Surface Transportation Board for certification of public convenience and necessity to construct and operate a rail line.
June 2008	DOE submitted an application to the NRC (DIRS 185301-DOE 2008, all).	DOE submitted an application to the NRC seeking authorization to construct the repository, as required by Section 114(b) of the NWPA.

BLM = Bureau of Land Management.
DOE = U.S. Department of Energy.
EPA = U.S. Environmental Protection Agency.
NEPA = *National Environmental Policy Act.*
NRC = U.S. Nuclear Regulatory Commission.
NWPA = *Nuclear Waste Policy Act*, as amended.

1.3 Radioactive Materials Considered for Disposal

This section summarizes and incorporates by reference Section 1.2 and Appendix A of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 1-4 to 1-8 and A-1 to A-71) and provides updated information on high-level radioactive waste and surplus weapons-usable plutonium.

1.3.1 GENERATION OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE

The material used to power commercial *nuclear reactors* typically consists of cylindrical fuel pellets made of a radioactive material, uranium oxide, slightly enriched in uranium-235. Fuel pellets are placed in tubes (called "*cladding*"). The sealed tubes with fuel pellets inside are called "fuel rods." Fuel rods are arranged in bundles called "fuel assemblies," which are placed in a reactor.

After a period of operation in a reactor, the fuel is considered to be "spent." Nuclear reactor operators initially store spent nuclear fuel underwater in pools because of the high levels of *radioactivity* and heat from *decay* of *radionuclides*. When the fuel has cooled and decayed sufficiently, operators can use two storage options: (1) continued in-pool storage or (2) above-ground *dry storage*.

Beginning in 1944, the United States operated reactors to produce materials such as plutonium for nuclear weapons. After discharge of the spent nuclear fuel and other reactor-irradiated nuclear materials, DOE used a chemical *process* called "reprocessing" to extract plutonium and other materials for defense purposes from the reactor-irradiated nuclear materials, which included spent nuclear fuel. One of the chemical byproducts of reprocessing is high-level radioactive waste. In addition, the reprocessing of naval reactor fuels and some commercial reactor fuels, DOE test reactor fuels, and university and other research reactor fuels has produced high-level radioactive waste. As a result of the shutdown of weapons production and some DOE chemical reprocessing plants at the end of the Cold War, DOE did not reprocess all of its spent nuclear fuel. The Department stores some of this fuel at DOE sites, awaiting permanent disposal.

1.3.2 SPENT NUCLEAR FUEL

Spent nuclear fuel consists of nuclear fuel that has been withdrawn from a nuclear reactor, provided the constituent elements of the fuel have not been separated by reprocessing. Spent nuclear fuel is stored at commercial and DOE sites.

1.3.2.1 Commercial Spent Nuclear Fuel

Commercial spent nuclear fuel comes from nuclear reactors that produce electric power. It typically consists of uranium oxide fuel (which contains *actinides*, *fission* products, and other materials), the cladding that contains the fuel, and the assembly hardware. The cladding for commercial spent nuclear fuel assemblies is normally made of a *zirconium alloy*. Commercial spent nuclear fuel is generated and stored at commercial nuclear power plants throughout the United States. Figure 1-1 shows the locations of these sites.

1.3.2.2 DOE Spent Nuclear Fuel

DOE manages spent nuclear fuel from its defense production reactors, U.S. naval reactors, and DOE test and experimental reactors, as well as fuel from university and other research reactors, commercial reactor fuel acquired by DOE for research and development, and fuel from foreign research reactors. DOE stores most of its spent nuclear fuel in pools or dry storage facilities at three primary locations: the Hanford Site in Washington State, the Idaho National Laboratory in Idaho (formerly the Idaho National Engineering and Environmental Laboratory), and the Savannah River Site in South Carolina. Some DOE spent nuclear fuel is stored at the Fort St. Vrain dry storage facility in Colorado. In accordance with DOE's Record of Decision published on June 1, 1995 (60 FR 28680), the Department will transfer the fuel at Fort St. Vrain from Colorado to the Idaho National Laboratory before its shipment to the repository. Also, in accordance with the Record of Decision, spent nuclear fuel from domestic research reactors would be shipped first to Savannah River Site or Idaho National Laboratory before being shipped to the repository. The Department would transport all DOE spent nuclear fuel evaluated in this Repository SEIS to the Yucca Mountain site from the Hanford Site, Idaho National Laboratory, or Savannah River Site.

1.3.3 HIGH-LEVEL RADIOACTIVE WASTE

DOE stores high-level radioactive waste in underground tanks at the Hanford Site, the Savannah River Site, and the Idaho National Laboratory (Figure 1-1). High-level radioactive waste can be in a liquid, sludge, saltcake, solid immobilized glass, or solid granular form (calcine). It can include immobilized plutonium waste and other highly radioactive materials that the NRC has determined by rule to require permanent *isolation*.

The DOE process for preparation of high-level radioactive waste for disposal starts with the transfer of the radioactive waste from storage tanks to a treatment facility. Treatment can include separation of the waste into high- and low-activity fractions, followed by *vitrification* of the high-activity fraction. Vitrification involves the addition of inert materials to the radioactive waste and heating of the mixture until it melts. DOE pours the melted mixture into canisters, where it cools into a solid glass or ceramic form that is very resistant to the leaching of radionuclides. The solidified, immobilized glass and ceramic forms keep the waste stable, confined, and isolated from the environment. DOE will store the solidified high-level radioactive waste onsite in these canisters until eventual shipment to a repository.

DOE has completed solidification and immobilization of high-level radioactive waste at the West Valley Demonstration Project in New York, is continuing to solidify and immobilize waste at the Savannah River Site, and plans to begin solidification and immobilization at the Hanford Site in about 2019. DOE will use the *Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement* (DIRS 179508-DOE 2002, all) to help determine the method for preparation of high-level radioactive waste at the Idaho National Laboratory for geologic disposal.

1.3.4 SURPLUS WEAPONS-USABLE PLUTONIUM

DOE has identified some weapons-usable plutonium as surplus to national security needs. This material includes purified plutonium, nuclear weapons components, and materials and residues that could be processed to produce purified plutonium. DOE currently stores these plutonium-containing materials at sites throughout the United States.

On March 28, 2007, DOE announced its intent to prepare a supplemental EIS to evaluate the potential environmental impacts of plutonium disposition alternatives (72 FR 14543). In that notice, DOE announced that it intends to analyze alternatives that could result in DOE emplacing surplus weapons-usable plutonium in the repository in two forms. One form could be vitrified plutonium waste that DOE would dispose of as high-level radioactive waste. In the Yucca Mountain FEIS, DOE analyzed the impacts of immobilizing surplus plutonium in a ceramic *matrix* surrounded by vitrified high-level radioactive waste. DOE is still considering this alternative. Another immobilization form DOE is considering is containment of this immobilized plutonium in a lanthanide *borosilicate glass* matrix surrounded by vitrified high-level radioactive waste for which DOE would perform analyses similar to those for immobilized ceramic plutonium it evaluated in the Yucca Mountain FEIS. An alternative would be to fabricate mixed uranium and plutonium oxide fuel (called *mixed-oxide fuel*) assemblies that would be used for power production in commercial nuclear reactors and disposed of in the same manner as other commercial spent nuclear fuel.

1.4 Yucca Mountain Site and the Proposed Disposal Approach

This section summarizes, incorporates by reference, and updates Section 1.4 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 1-13 to 1-22).

1.4.1 YUCCA MOUNTAIN SITE

The Yucca Mountain site is on land that is controlled by the Federal Government in a remote area of the Mojave Desert in Nye County in southern Nevada, approximately 145 kilometers (90 miles) northwest of Las Vegas, Nevada (Figure 1-2). The area surrounding the Yucca Mountain site is sparsely populated and is one of the driest regions in the United States, receiving an average of 199 millimeters (7.9 inches) of precipitation per year (DIRS 185301-DOE 2008, Section 2.3.1.2.1.1). The repository would be above the *water table* in the *unsaturated zone*, the zone of soil or rock between the land surface and the water table. Chapter 3 of this Repository SEIS provides detailed information about the environment at the site.

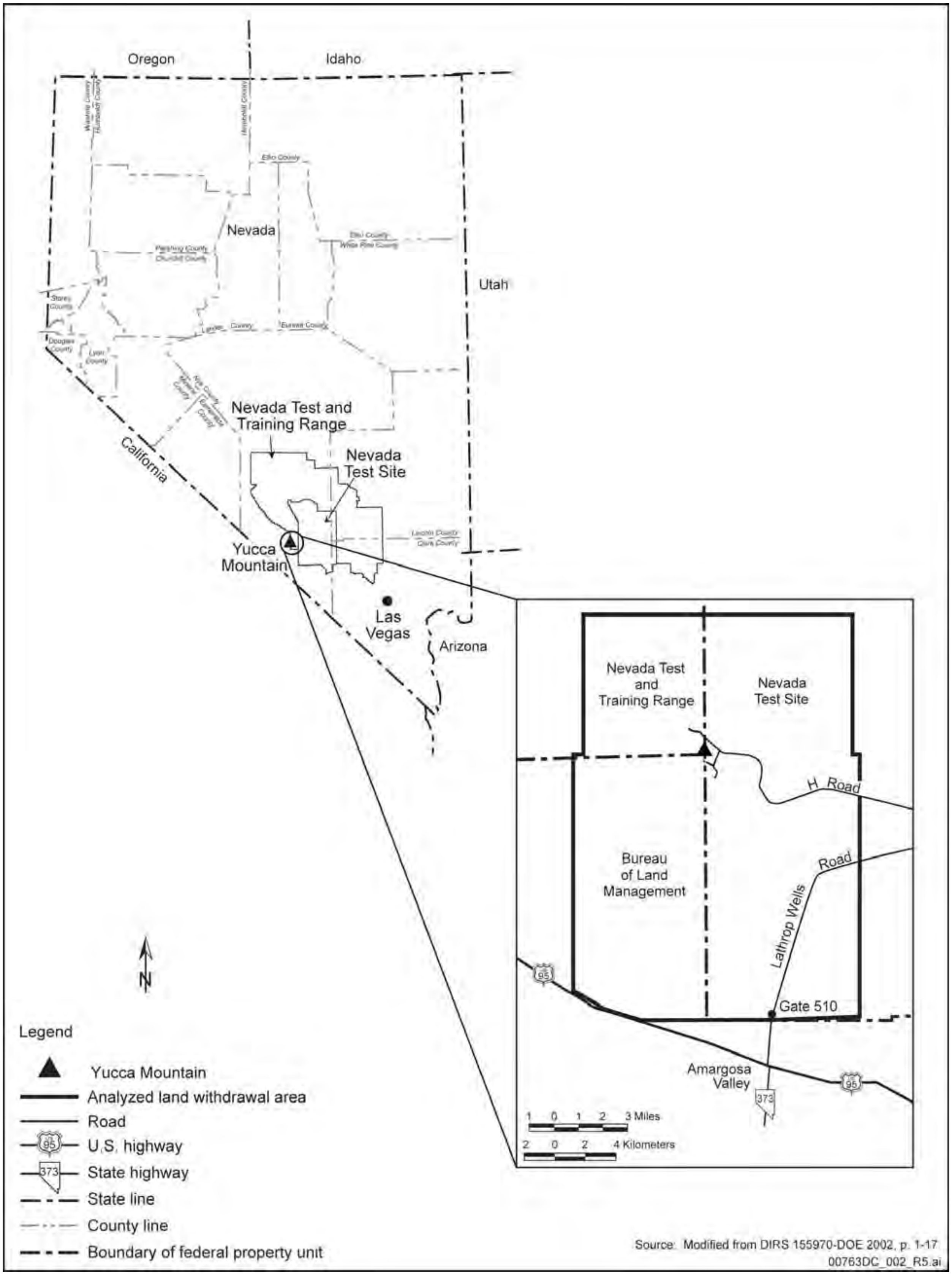


Figure 1-2. Land withdrawal area used for analytical purposes.

The Yucca Mountain site has several characteristics that would limit possible long-term impacts from the disposal of spent nuclear fuel and high-level radioactive waste. It is in a remote area on land the Federal Government controls. The dry climate results in a relatively small volume of water that can move through the unsaturated zone. The water table sits substantially below the level at which DOE wouldlocate a repository, which would provide additional separation between water sources and materials in emplaced *waste packages*. Maximizing the separation of water from the repository would minimize *corrosion* and delay any mobilization and transport of radionuclides from the repository. Chapter 5 of this Repository SEIS contains further discussion about long-term impacts.

SITE-RELATED TERMS

Yucca Mountain site:
The area inside the site boundary over which DOE has control. For the purpose of this Repository SEIS, Yucca Mountain site is synonymous with the land withdrawal area.

Yucca Mountain site boundary:
That line beyond which DOE does not own, lease, or otherwise control the land or property for the purposes of the repository.

Analyzed land withdrawal area:
Because the land has not yet been withdrawn, in this Repository SEIS it is referred to as the analyzed land withdrawal area. DOE uses the same analyzed land withdrawal area for the analyses in this Repository SEIS it used in the Yucca Mountain FEIS, an area of approximately 600 square kilometers (230 square miles or 150,000 acres).

Geologic repository operations area:
As defined at 10 CFR 63.2, the geologic repository operations area is "a high-level radioactive waste facility that is part of a geologic repository, including both surface and subsurface areas, where waste handling activities are conducted."

Region of influence (the region):
A specialized term that indicates a specific area of study for each of the resource areas that this Repository SEIS analysis addresses.

Groundwater beneath Yucca Mountain flows into a closed, sparsely populated hydrogeologic basin. A closed basin is one in which water introduced into the basin by precipitation cannot flow out of the basin to any river or ocean. This closed basin would make farther transport of radionuclides unlikely if radioactive *contamination* were to reach the groundwater. The land withdrawal area analyzed in this Repository SEIS includes about 600 square kilometers (150,000 acres) of land currently under the control of DOE (Nevada Test Site), the U.S. Air Force (Nevada Test and Training Range), and the U.S. Department of the Interior (Bureau of Land Management) (Figure 1-2). Chapter 3, Section 3.1.1 of this Repository SEIS provides more detail on the land use and ownership the *analyzed land withdrawal area*.

DOE would disturb approximately 12 square kilometers (3,000 acres) inside the analyzed land withdrawal area to develop surface repository and rail facilities, with the remainder serving as a buffer zone. Before receipt of construction authorization, 10 CFR 63.121 provides that the *geologic repository operations area* must be located in and on lands that are either acquired lands under the jurisdiction and control of DOE, or lands permanently withdrawn and reserved for its use. In addition, outside the analyzed land withdrawal area, the Proposed Action would disturb approximately 0.57 square kilometer (140 acres) of land in Nevada for an access road and offsite *infrastructure*, and approximately 37 to 58 square kilometers (9,100 to 14,000 acres) for the railroad dependent on the corridor and the alignment within the corridor.

1.4.2 PROPOSED APPROACH TO DISPOSAL

Since completion of the Yucca Mountain FEIS in 2002, DOE has continued to develop the repository design and associated construction and operational plans. As now proposed, DOE would use a primarily canistered approach to operate the repository; under this approach, most commercial spent nuclear fuel would be packaged at the reactor sites in TAD canisters. DOE would repackage commercial spent nuclear fuel that arrived in packages other than TAD canisters into these canisters in newly designed surface facilities at the repository. The Department would package essentially all DOE material in disposable canisters at the DOE sites. Most spent nuclear fuel and high-level radioactive waste would arrive at the repository by rail. Some shipments would arrive by truck. At the repository, DOE would place the TAD and other disposable canisters in waste packages that were manufactured from corrosion-resistant materials. DOE would array the waste packages in the *subsurface facility* in tunnels (*emplacement drifts*). Chapter 2 of this Repository SEIS further describes the disposal approach, which includes the transportation activities necessary to move the spent nuclear fuel and high-level radioactive waste to the Yucca Mountain site.

The NWPA limits the amount of spent nuclear fuel and high-level radioactive waste that DOE can emplace in the first geologic repository to 70,000 *metric tons of heavy metal* (MTHM) until a second repository is in operation [NWPA, Section 114(d)]. The materials DOE would dispose of under the Proposed Action include about 63,000 MTHM of commercial spent nuclear fuel and high-level radioactive waste, about 2,333 MTHM of DOE spent nuclear fuel, and about 4,667 MTHM of high-level radioactive waste. Although the NWPA limits the repository size to 70,000 MTHM, DOE presents the potential impacts associated with a larger repository in the cumulative impacts section of this Repository SEIS.

1.5 National Environmental Policy Act Process

The following information supplements the activities described in Section 1.5 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 1-25 to 1-31).

1.5.1 YUCCA MOUNTAIN FEIS

DOE completed the Yucca Mountain FEIS in February 2002 and submitted the document to the President as part of the Department's comprehensive statement that recommended Yucca Mountain as the site for development of a geologic repository. A Notice of Distribution was published in the *Federal Register* on October 25, 2002 (67 FR 65539) after DOE distributed the Yucca Mountain FEIS to the public and filed it with EPA. EPA published its Notice of Availability of the Yucca Mountain FEIS on the same day (67 FR 65564). DOE made the document available in reading rooms throughout the country and made an electronic copy available on the Internet. The Department distributed paper copies of the Readers Guide, Summary, and an errata sheet, as well as an electronic version on compact disk of the Yucca Mountain FEIS (Volumes I, II, and III) to members of Congress; federal, state, and American Indian tribal governments; local officials, persons, agencies, and organizations that commented on the Draft EIS and Supplement to the Draft EIS (issued on May 11, 2001, and incorporated into the Yucca Mountain FEIS to present the latest design information and the expected environmental impacts that could result from the evolved design); and others who had indicated an interest in the EIS process.

1.5.2 NOTICES OF INTENT AND SCOPING MEETINGS

NEPA regulations do not require public scoping for the preparation of a supplemental EIS. However, on October 13, 2006, DOE published a Notice of Intent to prepare this Repository SEIS (71 FR 60490) and invited comments on the scope of the document to ensure that the document addressed all relevant environmental issues. DOE announced a 45-day public comment period that ended on November 27, 2006, and public scoping meetings in Washington, D.C., and the town of Amargosa Valley and Las Vegas, Nevada. On November 9, 2006, based on input from the public, DOE extended the public comment period to December 12, 2006, and announced an additional public scoping meeting in Reno, Nevada (71 FR 65786). During the scoping period, DOE also conducted scoping on the Rail Alignment EIS. Because public scoping occurred during the same period for both EISs, DOE received many comment documents that contained comments on both EISs. As a consequence, DOE reviewed all scoping documents, regardless of whether the document addressed the Rail Alignment EIS or this Repository SEIS, for applicability to both EISs. This ensured a full and complete consideration of all public input to the scoping process. Section 1.5.3 addresses the relationship between the two documents.

1.5.2.1 Repository SEIS

DOE considered all comments it received as a result of the scoping process and grouped them into categories, as it reported in the *Summary of Public Scoping Comments Related to the Supplement to the Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DIRS 179543-DOE 2007, all). The Department received 263 comment documents that resulted in 723 comments applicable to this Repository SEIS.

DOE evaluated and considered all comments. Most of the comments were not applicable to the scope of this Repository SEIS. These nonapplicable comments fell into four general categories:

1. Comments complimentary or critical of the process;

2. Comments in favor of or opposed to the repository or nuclear power;

3. Comments on items outside the scope of this Repository SEIS, such as alternatives to the repository (for example, reprocessing or interim storage), alternative locations, and need for a citizens' advisory board; and

4. Comments that were general in nature or already were part of the planned scope, analyses, and technical approaches, such as evaluation of impacts to workers and members of the public from any *exposure* to radiological or hazardous substances and consideration of groundwater impacts.

Some comments that DOE received during scoping resulted in changes to the scope or analyses. The following items summarize comments that resulted in modifications to the scope and analyses originally planned for this Repository SEIS and DOE's responses to these comments:

- DOE should present a range of TAD canister implementation scenarios and not rely solely on the 90-percent program goal (90 percent of commercial spent nuclear fuel would be placed in TAD canisters before shipment to the repository for disposal) because of uncertainties associated with implementation at each reactor site and because more than 10 percent of the spent nuclear fuel might already be packaged in *dual-purpose canisters*.

  Response: This Repository SEIS addresses potential impacts of the goal of a 90-percent TAD canister scenario. To provide a perspective of any implementation differences, Appendix A discusses the impacts associated with a variation of the TAD canister implementation ratio of 75 percent.

- Uncertainties associated with worker residency warrant new analytical assumptions for the socioeconomics analyses.

  Response: The socioeconomics analysis for this Repository SEIS used the same relative workforce residence location that DOE used in the Yucca Mountain FEIS, which was 80 percent in Clark County and 20 percent in Nye County. This approach is based on historical data on the residency of workers on the Nevada Test Site or the Yucca Mountain site. To provide a perspective of potential differences in impacts if a larger percentage of the workforce chose to reside in Nye County, Appendix A discusses the impacts associated with a sensitivity case that assumed 20 percent of the workforce would reside in Clark County and 80 percent would reside in Nye County.

1.5.2.2 Rail Alignment EIS

DOE held two public scoping periods for the Rail Alignment EIS between April 8 and June 1, 2004, and October 13 and December 12, 2006. On April 8, 2004, DOE published a Notice of Intent (69 FR 18565) that announced it would prepare an EIS for the alignment, construction, and operation of a rail line for shipment of spent nuclear fuel, high-level radioactive waste, and other materials from a site near Caliente, Lincoln County, Nevada, to a geologic repository at Yucca Mountain, Nye County, Nevada (Rail Alignment EIS). The Notice of Intent also announced the schedule for public scoping meetings, and invited and encouraged comments on the scope of that EIS to ensure that the document addressed all relevant environmental issues and reasonable alternatives. The scoping comment period began with publication of the Notice of Intent in the *Federal Register*. The schedule called for the period to close on May 24, 2004; however, on April 26, 2004, based on a request from the State of Nevada, DOE extended the comment period to June 1, 2004 (69 FR 22496).

DOE received more than 4,100 comments during the first public scoping period for the Rail Alignment EIS and some comments after the close of the scoping period. DOE summarized all these comments in the *Summary of Public Scoping Comments, Related to the Environmental Impact Statement for the Alignment, Construction, and Operation of a Rail Line to a Geologic Repository at Yucca Mountain, Nye County, NV* (DIRS 176463-Craig et al. 2004, all) and considered the content of all comments in its determination of the scope of the EIS. The following are the general modifications to the scope and analyses originally planned for the Rail Alignment EIS:

- The elimination, addition, or modification of rail segment alternatives;
- The addition of a Shared-Use Option that considers commercial use of the proposed rail line; and
- Additional fieldwork in Garden Valley for the noise and aesthetics analyses.

On October 13, 2006, DOE published an Amended Notice of Intent (71 FR 60484) that announced the expanded scope of the Rail Alignment EIS to include detailed analysis of construction and operation of a railroad in the Mina rail corridor, should that corridor warrant further consideration based on the analysis of the Nevada Rail Corridor SEIS. The Notice of Intent also announced the schedule for public scoping meetings, and encouraged comments on the scope of the EIS to ensure that the document addressed all relevant environmental issues and reasonable alternatives. The second scoping comment period began with publication of the Amended Notice of Intent in the *Federal Register* and was originally scheduled to close on November 27, 2006. On November 9, 2006, based on requests from the public, DOE extended the comment period to December 12, 2006 (71 FR 65785).

DOE received nearly 800 comments during the second public scoping period for the Rail Alignment EIS, including some comments after the close of the scoping period. DOE summarized all comments received (including those submitted after the close of the scoping period) in *Summary of Public Scoping Comments on the Expanded Scope of the Environmental Impact Statement for the Alignment, Construction, and Operation of a Rail Line to a Geologic Repository at Yucca Mountain, Nye County, NV* (DIRS 181379-DOE 2007, all) and considered the content of all comments in its determination of the scope of the EIS. Most of the comments that DOE received in the second public scoping period were similar to those received in the first period.

Chapter 1 of the Rail Alignment EIS contains additional information on the evaluation and assessment of comments received during both scoping periods about the Caliente and Mina rail alignments. Chapter 1 of the Nevada Rail Corridor SEIS contains additional information on the evaluation and assessment of comments that DOE received during the second scoping period about the Mina rail corridor and the update of information related to the other corridors DOE analyzed in the Yucca Mountain FEIS.

1.5.2a DRAFT REPOSITORY SEIS PUBLIC COMMENT PROCESS AND PUBLIC HEARINGS

On October 12, 2007, EPA announced in the *Federal Register* (72 FR 58081) the availability of the Draft Repository SEIS, and the Draft Nevada Rail Corridor SEIS and Draft Rail Alignment EIS. Also on October 12, 2007, DOE announced in the *Federal Register* (72 FR 58071) the availability of these draft NEPA analyses related to its Yucca Mountain Project. DOE's Notice of Availability invited interested parties to comment on the NEPA documents during a 90-day public comment period that ended on January 10, 2008, and announced the schedule for public hearings. DOE made the NEPA documents available on the Internet on two DOE Web sites; made the documents available in five reading rooms in Nevada and one in Washington, D.C.; and sent the electronic versions on compact disks, as well as paper copies, of either the summaries or the full draft documents to other federal agencies, members of Congress, American Indian tribal governments, state and local governments, and organizations and individuals who are known to have an interest in the EIS. DOE distributed approximately 3,700 copies of the summaries and approximately 400 full copies of the draft documents.

DOE held eight public hearings on the documents at the following locations:

- Hawthorne, Nevada – Hawthorne Convention Center, 932 E. Street, November 13, 2007;
- Caliente, Nevada – Caliente Youth Center, U.S. Highway 93, November 15, 2007;
- Reno/Sparks, Nevada – Reno/Sparks Convention Center, 4590 South Virginia Street, November 19, 2007;

- Amargosa Valley, Nevada – Longstreet Inn and Casino, Nevada State Highway 373, November 26, 2007;
- Goldfield, Nevada – Goldfield School Gymnasium, Hall and Euclid, November 27, 2007;
- Lone Pine, California – Statham Hall, 138 North Jackson Street, November 29, 2007;
- Las Vegas, Nevada – Cashman Center, 850 North Las Vegas Boulevard, December 3, 2007; and
- Washington, D.C. – Marriott at Metro Center, 775 12th Street, NW, December 5, 2007.

DOE reserved the first hour of the public hearings for an open house, where members of the public could engage DOE representatives in discussions, followed by a formal oral statement process. DOE provided public hearing attendees the opportunity to submit comments in writing at the hearing or in person to a court reporter who was available throughout the hearing. Approximately 518 people attended the hearings (the count is approximate because not all attendees registered) and 110 people provided oral comments. In addition, DOE met with the Consolidated Group of Tribes and Organizations in Pahrump on November 27, 2007, to take comments on the NEPA documents.

The public hearings covered the Draft Repository SEIS, and the Draft Nevada Rail Corridor SEIS and Draft Rail Alignment EIS, and DOE considered all comments it received for applicability to the three NEPA analyses. In total, DOE received approximately 4,000 comments on the NEPA analyses from nearly 1,100 commenters. About 2,600 of these comments were on the Repository SEIS. DOE has prepared a Comment-Response Document for the Repository SEIS (Volume III of this Final Repository SEIS) that provides responses to public comments. The Comment-Response Document contains each comment (as an individual comment or summarized with similar comments) and the DOE response to each comment. The Final Repository SIES reflects changes as a result of public comments received on the Draft Repository SEIS. The responses in the Comment-Response Document note changes to sections of the Final Repository SEIS that resulted from comments DOE received on the Draft Repository SEIS.

About 250 of the comments were on the Nevada Rail Corridor SEIS. DOE has prepared a Comment-Response Document for the Nevada Rail Corridor SEIS (Volume V) that provides responses to public comments. The Comment-Response Document contains each comment (as an individual comment or summarized with similar comments) and the DOE response to each comment. The Final Nevada Rail Corridor SEIS reflects changes as a result of public comments received on the Draft Nevada Rail Corridor SEIS. About 1,200 of the comments were on the Rail Alignment EIS. As with the Nevada Rail Corridor SEIS, DOE has prepared a Comment-Response Document for the Rail Alignment EIS (Volume V) that provides responses to public comments. The Comment-Response Document contains each comment (as an individual comment or summarized with similar comments) and the DOE response to each comment. The Final Rail Alignment EIS reflects changes as a result of public comments received on the Draft Rail Alignment EIS. The responses in the Comment-Response Documents note changes to sections of the Final Nevada Rail Corridor SEIS and Final Rail Alignment EIS that resulted from comments DOE received on the Draft Nevada Rail Corridor SEIS and Draft Rail Alignment EIS.

1.5.2b CHANGES MADE TO THE DRAFT REPOSITORY SEIS

This Final Repository SEIS reflects changes made to the Draft Repository SEIS due to public comments and the availability of new and updated information. Substantive changes in this Repository SEIS are indicated in the margins with change bars. Examples of these changes include:

- Update of impact analyses related to occupational and public health and safety and potential accidents to reflect more recent information that is included in the Safety Analysis Report, which was part of the application DOE recently submitted to the NRC for construction authorization.
- Assessment of greenhouse gases potentially released as a result of the Proposed Action, including repository construction and operations, the transportation of spent nuclear fuel and high-level radioactive waste to the repository, transportation of construction and other materials, and commuting workers.
- Discussion of Inyo County, California, research and findings on the behavior and characteristics of the lower carbonate aquifer as it relates to future postclosure repository performance.
- Inclusion of an integrated schedule that provides DOE's analytical basis for consideration of impacts during the construction and operation of the repository in relation to the proposed railroad and site infrastructure.
- Additional explanatory text and graphics that illustrate the differences between overweight, legal-weight, and heavy-haul trucks for transportation of spent nuclear fuel or high-level radioactive waste.
- Assessment of potential impacts to regional traffic as a result of the Proposed Action.
- Discussion of highway routing alternatives that could be used by shippers if the States of Nevada and California exercised their prerogative to designate alternate preferred highway routes for the transportation of spent nuclear fuel or high-level radioactive waste. DOE first presented this analysis in the Yucca Mountain FEIS and has summarized this analysis in this Repository SEIS.
- Discussion of a process (including establishment of mitigation advisory boards) that DOE could implement to address regional impacts associated with the Proposed Action.
- Update of the cumulative impacts analysis of Inventory Modules 1 and 2 to account for potential cumulative effects from the Global Nuclear Energy Partnership (GNEP) program.
- Addition of a list of interagency and intergovernmental interactions related to this Repository SEIS.

1.5.3 RELATIONSHIP TO OTHER ENVIRONMENTAL DOCUMENTS

A number of completed, in preparation, or proposed DOE NEPA documents relate to this Repository SEIS. In addition, other federal agencies have prepared related EISs. Consistent with Council on Environmental Quality regulations that implement NEPA (40 CFR Parts 1500 to 1508), DOE has used information from these documents in its analyses and has incorporated this material by reference as appropriate in this Repository SEIS. Although the Yucca Mountain FEIS, this Repository SEIS, and the Nevada Rail Corridor SEIS and Rail Alignment EIS are all related to the proposal to construct and operate the Yucca Mountain Repository, they consider actions that would involve the jurisdiction of more than one federal agency. The Repository SEIS supplements the Yucca Mountain FEIS and considers the potential environmental impacts from the construction and operation of the Yucca Mountain Repository.

1.5.3.1 Nevada Rail Corridor SEIS and Rail Alignment EIS

DOE prepared the Nevada Rail Corridor SEIS and Rail Alignment EIS, which supplement the Nevada transportation information in the Yucca Mountain FEIS. The Nevada Rail Corridor SEIS, which supplements the rail corridor analysis in the Yucca Mountain FEIS, analyzes potential environmental impacts from constructing and operating a railroad in the Mina rail corridor. The Nevada Rail Corridor SEIS analyzes the Mina corridor at a level of detail commensurate with that of the rail corridor analysis in the Yucca Mountain FEIS, and concludes that the Mina corridor warrants further study in the Rail Alignment EIS to identify an alignment for the construction and operation of a railroad. In addition, the Nevada Rail Corridor SEIS updates relevant information on three other rail corridors analyzed in the Yucca Mountain FEIS (Carlin, Jean, and Valley Modified). The update demonstrates that there are no significant new circumstances or information relevant to environmental concerns associated with these three rail corridors, and that they do not warrant further consideration in the Rail Alignment EIS. The Caliente-Chalk Mountain rail corridor, which also was in the Yucca Mountain FEIS, would intersect the Nevada Test and Training Range, and DOE eliminated it from further consideration because of U.S. Air Force concerns that a rail line in the Caliente-Chalk Mountain corridor would interfere with military readiness testing and training activities.

The Rail Alignment EIS tiers from the broader corridor analysis in both the Yucca Mountain FEIS and the Nevada Rail Corridor SEIS, consistent with the Council on Environmental Quality regulations (40 CFR 1508.28). Under the Proposed Action that DOE considers in the Rail Alignment EIS, the Department would determine a rail alignment in the Caliente or Mina rail corridor and would construct, operate, and potentially abandon a railroad for the shipment of spent nuclear fuel, high-level radioactive waste, and other materials from an existing railroad in Nevada to a geologic repository at Yucca Mountain. If DOE decided to construct the railroad, it would be the federal agency with the responsibility for performing the actions necessary to construct and operate the railroad.

In all relevant aspects, this Repository SEIS, the Nevada Rail Corridor SEIS, and the Rail Alignment EIS are consistent (Foreword, Figure 1). For example, the Repository SEIS and the Rail Alignment EIS use the same updated inventory of spent nuclear fuel and high-level radioactive waste and the same number of rail shipments for analysis. Thus, the associated occupational and public health and safety impacts in the Nevada rail corridors under consideration are the same in this Repository SEIS and in the Nevada Rail Corridor SEIS and Rail Alignment EIS. Further, to promote conformity, DOE used consistent analytical approaches where appropriate to evaluate common resource areas. This Repository SEIS includes the potential environmental impacts of national transportation, as well as the potential impacts in Nevada from the construction and operation of a railroad in either the Caliente or Mina rail corridor, to ensure that this SEIS considers the full scope of potential environmental impacts from the proposed construction and operation of the repository. Therefore, this Repository SEIS incorporates by reference Chapter 3, Sections 3.2 and 3.3, and Chapters 4, 5, and 8 of the Rail Alignment EIS.

1.5.3.2 Draft Environmental Assessment for the Proposed Infrastructure Improvements for the Yucca Mountain Project, Nevada

In June 2006, DOE published the *Draft Environmental Assessment for the Proposed Infrastructure Improvements for the Yucca Mountain Project, Nevada* (DIRS 178817-DOE 2006, all). In October 2006, the Department decided to prepare this Repository SEIS and not finalize the environmental assessment; however, the Department has incorporated elements of the infrastructure improvements in the Repository

SEIS Proposed Action. The proposed action in the environmental assessment was to repair, replace, or improve certain facilities, structures, roads, and utilities for the Yucca Mountain Project to enhance safety at the Project and to enable DOE to continue ongoing operations, scientific testing, and routine maintenance safely at the *Exploratory Studies Facility* until the NRC decides whether to authorize construction of a repository. Chapter 4 of this Repository SEIS identifies the specific elements, or subelements, of improvements DOE could implement before receiving construction authorization from the NRC. Before implementation, a Record of Decision on this SEIS would identify the improvements DOE decides to make. These actions would be independent of repository construction and would occur under DOE authority.

1.5.3.3 Environmental Impact Statement for the Disposal of Greater-Than-Class-C Low-Level Radioactive Waste

On July 23, 2007, DOE published the "Notice of Intent To Prepare an Environmental Impact Statement for the Disposal of Greater-Than-Class-C Low-Level Radioactive Waste" (72 FR 40135). That EIS will evaluate alternatives for disposal of wastes with a concentration of greater than Class C, as defined in NRC regulations at 10 CFR Part 61, in a geologic repository, in intermediate-depth boreholes, and in enhanced near-surface facilities. Candidate locations for these disposal facilities are the Idaho National Laboratory in Idaho, the Los Alamos National Laboratory and the Waste Isolation Pilot Plant in New Mexico, the Nevada Test Site and the proposed *Yucca Mountain Repository* in Nevada, the Savannah River Site in South Carolina, the Oak Ridge Reservation in Tennessee, and the Hanford Site in Washington. The EIS will also evaluate disposal at generic commercial facilities in *arid* and humid locations. In addition, DOE proposes to include DOE *low-level radioactive waste* and *transuranic waste* that have characteristics similar to Greater-Than-Class-C low-level radioactive waste and that might not have an identified path to disposal. These inventories would include materials evaluated in the Yucca Mountain FEIS (referred to as *Special-Performance-Assessment-Required low-level radioactive wastes*). DOE issued the Notice of Intent to invite the public to provide comments on the potential scope of the EIS and participate in public scoping meetings. This Repository SEIS evaluates potential impacts from disposal of Greater-Than-Class-C low-level radioactive waste in Chapter 8 as reasonably foreseeable cumulative impacts.

1.5.3.4 Programmatic Environmental Impact Statement for the Global Nuclear Energy Partnership

DOE is preparing the *Programmatic Environmental Impact Statement for the Global Nuclear Energy Partnership* (GNEP Programmatic EIS) to consider the potential environmental impacts of implementing GNEP, a proposed domestic and international program designed to support expansion of nuclear energy production while advancing nonproliferation goals and reducing the impacts of spent nuclear fuel disposal.

The United States presently uses a "once-through" fuel cycle in which a nuclear power utility uses nuclear fuel in a reactor only once, and then places the spent nuclear fuel in storage to await disposal. The GNEP Programmatic EIS will evaluate alternative fuel cycles, including a fuel cycle in which the uranium and transuranic materials would be separated from the spent nuclear fuel and reused in thermal and/or advanced nuclear reactors. The GNEP Programmatic EIS will evaluate the impacts of domestic programmatic alternatives. These alternatives involve widespread deployment of fuel technologies that would reduce the volume, thermal output, and/or radiotoxicity of spent nuclear fuel and wastes requiring geologic disposal in the future. The GNEP Programmatic EIS will also evaluate a proposed Advanced Fuel Cycle Facility to conduct research, development, and demonstration at one or more of five DOE sites in the continental United States.

The programmatic alternatives in the GNEP Programmatic EIS vary by reactor type, fuel type, and whether they would incorporate recycling of commercial spent nuclear fuel to recover materials for reuse in other reactor fuels. The alternatives will include a no-action alternative that assumes continued use of light-water reactors without recycling of spent nuclear fuel. Depending on the specific programmatic alternative, the resultant radiological materials that could require geologic disposal could range from only high-level radioactive waste from recycling spent nuclear fuel to only spent nuclear fuel. The estimates of spent nuclear fuel vary widely among the alternatives. However, all fuel–recycle scenarios would produce high-level radioactive waste that would require disposal.

There are many uncertainties associated with the implementation of any programmatic alternative and many factors (such as market forces, research and development, regulatory issues, and public policy) that would affect the successful implementation of an alternative. Because of these factors, it is not possible to predict with confidence when, and to what extent, any of the programmatic action alternatives would be fully implemented. In any event, transition to a new fuel cycle could take many decades to complete.

Chapter 8 of this Repository SEIS addresses the potential cumulative impacts of the GNEP programmatic and project-specific alternatives that could be associated with the impacts of disposal of the additional inventory modules.

Table 1-2 lists the documents published since DOE completed the Yucca Mountain FEIS that relate to the information and analyses in this Repository SEIS.

Table 1-2. NEPA documents and Records of Decision related to this Repository SEIS (since DOE completed the Yucca Mountain FEIS).

Document	Relationship to Repository SEIS
Nuclear materials activities	
West Valley Demonstration Project Waste Management Environmental Impact Statement Final (DIRS 179454-DOE 2003, all)	Examines impacts of shipping radioactive wastes that are either in storage or that will be generated from operations over a 10–year period at West Valley to offsite disposal locations, and to continue its ongoing onsite waste management activities.
Record of Decision, "West Valley Demonstration Project Waste Management Activities" (70 FR 35073, June 16, 2005)	Selects offsite shipment of LLW for disposal at commercial sites and storage of canisters of vitrified high-level radioactive waste at the West Valley Demonstration Project site until DOE can ship them to a geologic repository for disposal.
Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement (DIRS 179508-DOE 2002, all)	Examines impacts of treatment, storage, and disposal of INL high-level radioactive waste and facilities disposition. INL high-level radioactive waste is proposed for repository disposal.
Supplement Analysis for the Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement (DIRS 179524-DOE 2005, all)	Determines if there are substantial changes in the proposed action in the *Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement* that are relevant to environmental concerns or significant new circumstances or information that would require preparation of a supplemental EIS.

Table 1-2. NEPA documents and Records of Decision related to this Repository SEIS (since DOE completed the Yucca Mountain FEIS; continued).

Document	Relationship to Repository SEIS
"Office of Environmental Management; Record of Decision for the Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement" (70 FR 75165, December 19, 2005)	Announces a phased decisionmaking process, meaning DOE will issue amended Records of Decision to address specifically closure of the Tank Farm Facility and the final strategy for high-level radioactive waste calcine disposition. Addresses treatment of sodium-bearing waste using steam reforming technology and management of the waste to enable disposal at the Waste Isolation Pilot Plant near Carlsbad, New Mexico, or at a geologic repository for spent nuclear fuel and high-level radioactive waste. Addresses conduct of performance-based closure of existing facilities directly related to the High-Level Radioactive Waste Program at the Idaho Nuclear Technology and Engineering Center once its missions are complete.
Final Environmental Impact Statement for the Construction and Operation of an Independent Spent Fuel Storage Installation on the Reservation of the Skull Valley Band of Goshute Indians and the Related Transportation Facility in Tooele County, Utah (DIRS 157761-NRC 2001, all)	Addresses the proposal of Private Fuel Storage, LLC, to construct and operate an independent spent nuclear fuel storage installation on the reservation of the Skull Valley Band of Goshute Indians.
"Notice of Intent To Prepare an Environmental Impact Statement for the Disposal of Greater-Than-Class-C Low-Level Radioactive Waste" (72 FR 40135, July 23, 2007)	Will evaluate alternatives for disposal of wastes with a concentration greater than Class C, as defined in NRC regulations at 10 CFR Part 61, in a geologic repository, in intermediate-depth boreholes, and in enhanced near-surface facilities. In addition, DOE proposes to include DOE LLW and transuranic waste with characteristics similar to GTCC LLW and that might not have an identified path to disposal. This Repository SEIS considers cumulative impacts from disposal of GTCC LLW.
"Notice of Intent To Prepare a Programmatic Environmental Impact Statement for the Global Nuclear Energy Partnership" (72 FR 331, January 4, 2007)	GNEP involves a proposal to recycle spent nuclear fuel and destroy the long-lived radioactive components of that spent fuel. This Repository SEIS considers cumulative impacts that could be associated with the proposed GNEP program.
Draft Environmental Assessment for the Proposed Infrastructure Improvements for the Yucca Mountain Project, Nevada (DIRS 178817-DOE 2006, all)	In October 2006, DOE decided to prepare this Repository SEIS. Rather than finalizing this environmental assessment, DOE has incorporated the elements of infrastructure improvements into the SEIS Proposed Action. Chapter 4 of this SEIS identifies the specific elements, or subelements, of these improvements that could be implemented prior to construction authorization from the NRC. Prior to implementation, a Record of Decision on this Repository SEIS will present any decisions DOE might make on the improvements. These actions would be independent of repository construction and would occur under DOE authority.
"Notice of Intent To Prepare a Supplemental Environmental Impact Statement for Surplus Plutonium Disposition at the Savannah River Site" (72 FR 14543, March 28, 2007)	Will analyze the potential environmental impacts of alternative disposition methods of up to about 13 metric tons (14 tons) of non-pit[a] surplus plutonium. These alternatives would result in waste forms (inclusion in high-level radioactive waste canisters produced at Savannah River Site or irradiated mixed-oxide spent fuel) that could be disposed of in a geologic repository.
Regional description and cumulative impact information	
Final Environmental Impact Statement for the Proposed Relocation of Technical Area 18 Capabilities and Materials at the Los Alamos National Laboratory (DIRS 162639-DOE 2002, all)	Evaluates the environmental impacts from relocation of the Technical Area 18 capabilities and materials (presently at Los Alamos) to each of four alternative sites, including the Nevada Test Site.

Table 1-2. NEPA documents and Records of Decision related to this Repository SEIS (since DOE completed the Yucca Mountain FEIS; continued).

Document	Relationship to Repository SEIS
"Record of Decision for the Final Environmental Impact Statement for the Relocation of Technical Area 18 Capabilities and Materials at the Los Alamos National Laboratory" (67 FR 79906, December 31, 2002)	Implements the preferred alternative, which would relocate Security Category I and II missions and related materials to the Device Assembly Facility at the Nevada Test Site.
Draft Complex Transformation Supplemental Programmatic Environmental Impact Statement (DIRS 185273-DOE 2007, all)	Analyzes the potential environmental impacts of reasonable alternatives to continue transformation of the U.S. nuclear weapons complex to be smaller, and more responsive, efficient, and secure to meet national security requirements. The proposed action is to continue currently planned modernization activities and select a site for a consolidated plutonium center for long-term research and development, surveillance, and pit[a] manufacturing; consolidate special nuclear materials throughout the complex; consolidate, relocate, or eliminate duplicative facilities and programs and improve operating efficiencies; identify one or more sites for conducting flight test operations; and accelerate nuclear weapons dismantlement activities.
Draft Programmatic Environmental Impact Statement of the Designation of Energy Corridors in the 11 Western States (DIRS 185274-DOE 2007, all)	Addresses the environmental impacts from designation of corridors on federal land in the 11 western states for oil, gas, and hydrogen pipelines and electricity transmission and distribution facilities (energy corridors), as required by Section 368 of the *Energy Policy Act of 2005* (Public Law 109-58). DOE and the Bureau of Land Management co-led this effort, with the U.S. Department of Agriculture's Forest Service, the Department of Defense, and the Department of the Interior's Fish and Wildlife Service participating as federal cooperating agencies.
Draft Supplement Analysis for the Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada (DIRS 185437-DOE 2008, all)	Presents a systematic environmental impacts review to determine if there were substantial changes in the actions proposed in the 1996 site-wide EIS or significant new circumstances or information relevant to environmental concerns.
Nevada transportation activities	
"Notice of Preferred Nevada Rail Corridor" (68 FR 74951, December 29, 2003)	Announces the Caliente rail corridor, from the five rail corridors studied in the Yucca Mountain FEIS, as DOE's preferred rail corridor in which to construct a rail line.
"Notice of Proposed Withdrawal and Opportunity for Public Meeting; Nevada" (68 FR 74965, December 29, 2003)	Announces the Bureau of Land Management's receipt of a request from DOE to withdraw public land from surface entry and mining for a period of 20 years to evaluate the land for the potential construction, operation, and maintenance of a rail line for the transportation of spent nuclear fuel and high-level radioactive waste in Nevada. Segregates the land from surface entry and mining for as long as 2 years while DOE conducts studies and analyses to support a final decision on the withdrawal application.
Supplement Analysis (DIRS 172285-DOE 2004, all)	Supplement to the Yucca Mountain FEIS. Examines the potential environmental impacts of shipping legal-weight truck casks on railcars from generator sites to Nevada.
"Record of Decision on Mode of Transportation and Nevada Rail Corridor for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, NV" (69 FR 18557, April 8, 2004)	Selects the mostly rail scenario analyzed in the Yucca Mountain FEIS as the mode of transportation on a national basis and in the State of Nevada. Selects the Caliente rail corridor for alignment, construction, and operation of a proposed rail line to Yucca Mountain.

Table 1-2. NEPA documents and Records of Decision related to this Repository SEIS (since DOE completed the Yucca Mountain FEIS; continued).

Document	Relationship to Repository SEIS
"Notice of Intent to Prepare an Environmental Impact Statement for the Alignment, Construction, and Operation of a Rail Line to a Geologic Repository at Yucca Mountain, Nye County, NV" (69 FR 18565, April 8, 2004)	Announces DOE's intent to prepare an EIS for the alignment, construction, and operation of a rail line for the shipment of spent nuclear fuel, high-level radioactive waste, and other materials from a site near Caliente, Lincoln County, Nevada to a geologic repository at Yucca Mountain, Nye County, Nevada.
Proposed Resource Management Plan/Final Environmental Impact Statement for the Ely Field Office, Nevada (DIRS 184767-BLM 2007, all)	Examines implementation of Bureau of Land Management resource management plans, actions, and goals in the Ely area.
Environmental Assessment for the Proposed Withdrawal of Public Lands Within and Surrounding the Caliente Rail Corridor, Nevada (DIRS 176452-DOE 2005, all)	Examines the environmental impacts of withdrawal of public lands from surface entry and new mining claims for as long as 20 years to enable evaluation of the land for the proposed rail line.
"Public Land Order No. 7653; Withdrawal of Public Lands for the Department of Energy to Protect the Caliente Rail Corridor, Nevada" (70 FR 76854, December 28, 2005)	Withdraws public lands in the Caliente rail corridor from surface entry and the location of new mining claims, subject to valid existing rights, for 10 years to enable DOE to evaluate the lands for the potential construction, operation, and maintenance of a rail line.
"Amended Notice of Intent to Expand the Scope of the Environmental Impact Statement for the Alignment, Construction, and Operation of a Rail Line to a Geologic Repository at Yucca Mountain, Nye County, NV" (71 FR 60484, October 13, 2006)	Announces DOE's intent to expand the scope of the Rail Alignment EIS to incorporate an analysis of the potential environmental impacts of a newly proposed Mina rail corridor.
"Notice of Proposed Withdrawal and Opportunity for Public Meeting; Nevada" (72 FR 1235, January 10, 2007)	Announces the Bureau of Land Management's receipt of an application from DOE to withdraw public lands from surface entry and mining through December 27, 2015, to evaluate the land for the potential construction, operation, and maintenance of a rail line. This covers the Mina rail alignment and segments of the Caliente rail alignment not covered in Public Land Order No. 7653. Segregates the land from surface entry and mining for as long as 2 years while DOE conducts studies and analyses to support a final decision on the withdrawal application.
Nevada Rail Corridor SEIS and Rail Alignment EIS	Examine potential impacts for the alignment, construction, and operation of a railroad in Nevada for the shipment of spent nuclear fuel, high-level radioactive waste, and other materials to a geologic repository at Yucca Mountain, Nye County, Nevada.

a. A pit is the central core of a nuclear weapon, which typically contains plutonium-239 that undergoes fission when compressed by high explosives.

DOE = U.S. Department of Energy.
EIS = Environmental impact statement.
GNEP = Global Nuclear Energy Partnership.
GTCC = Greater-Than-Class-C.
INL = Idaho National Laboratory.
LLW = Low-level radioactive waste.
NRC = U.S. Nuclear Regulatory Commission.

1.5.4 CONFORMANCE WITH DOCUMENTATION REQUIREMENTS

For this Repository SEIS, DOE has performed formal documented reviews of data to identify gaps, inconsistencies, omissions, or other conditions that would cause data to be suspect or unusable.

DOE has planned analyses to ensure consistency and thoroughness in the environmental studies conducted for this Repository SEIS. In addition, DOE has used configuration-control methods to ensure that inputs to this SEIS are current, correct, and appropriate, and that outputs reflect the use of appropriate inputs.

All work products for this Repository SEIS have undergone documented technical, editorial, and managerial reviews for adequacy, accuracy, and conformance to project and DOE requirements. Work products related to impact analyses (for example, calculations, data packages, and data files) also have undergone formal technical and managerial reviews. Calculations (manual or computer-driven) generated to support impact analyses have been verified in accordance with relevant project management procedures.

1.5.5 COOPERATING AGENCY

Pursuant to the NWPA, DOE is responsible for the disposal of spent nuclear fuel and high-level radioactive waste to protect public health, safety, and the environment, and for development and implementation of a plan for transportation of spent nuclear fuel and high-level radioactive waste to a repository at Yucca Mountain. Therefore, DOE is the lead agency responsible for preparation of this Repository SEIS. The Council on Environmental Quality regulations emphasize agency cooperation early in the NEPA process and allow a lead agency to request the assistance of other agencies that either have jurisdiction by law or special expertise about issues considered in an EIS.

Nye County, Nevada, is the situs jurisdiction of the Yucca Mountain Repository and has special expertise on the relationship of DOE’s Proposed Action to the objectives of regional and local land use plans, policies and controls, and to the current and planned infrastructure in the county, including public services and traffic conditions. As such, Nye County is a cooperating agency in the development of this Repository SEIS, pursuant to Council on Environmental Quality regulations at 40 CFR 1501.5 and 1501.6, and has provided input (DIRS 182850-Swanson 2007, all).

Consistent with Council on Environmental Quality regulations and guidance on cooperating agencies, Nye County accepted and acknowledges DOE’s authority as the lead agency with respect to the Yucca Mountain Project. Participation as a cooperating agency is consistent with the stated county policy of constructive engagement with DOE (Nye County Board of Commissioners Resolution No. 2002-22) and with the objectives of the county’s Community Protection Plan (approved August 2006).

Representatives from Nye County attended public, project, and technical working group meetings; participated on interdisciplinary teams; compiled and provided socioeconomic data such as population, housing, and other forecasting information; provided relevant reports and studies prepared or conducted by the county; assisted with the identification of environmental issues and with environmental analyses; reviewed working draft and preliminary draft documents; and assisted with the resolution of comments.

REFERENCES

184767 BLM 2007 BLM (Bureau of Land Management) 2007. "Map Volume, Volume II (Chapters 4, 5, and 6)." *Ely Proposed Resource Management Plan, Final Environmental Impact Statement.* BLM-EL-PL-07/09+1793. Ely, Nevada: U.S. Department of the Interior, Bureau of Land Management. Accessed February 1, 2008. ACC: MOL.20080206.0032. http://www.blm.gov/nv/en/fo/ely_field_office/blm_programs/planning/ely_rmp_2007html

176463 Craig et al. 2004 Craig, W.; Lechel, D.; and Morton, L. 2004. *Summary of Public Scoping Comments, Related to the Environmental Impact Statement for the Alignment, Construction, and Operation of a Rail Line to a Geologic Repository at Yucca Mountain, Nye County, NV*. Revision 00. Augusta, Georgia: Dade Moeller & Associates. ACC: MOL.20041011.0344.

155970 DOE 2002 DOE (U.S. Department of Energy) 2002. *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*. DOE/EIS-0250F. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20020524.0314; MOL.20020524.0315; MOL.20020524.0316; MOL.20020524.0317; MOL.20020524.0318; MOL.20020524.0319; MOL.20020524.0320.

162639 DOE 2002 DOE (U.S. Department of Energy) 2002. *Final Environmental Impact Statement for the Proposed Relocation of Technical Area 18 Capabilities and Materials at the Los Alamos National Laboratory*. DOE/EIS-0319. Volume 1. Washington, D.C.: U.S. Department of Energy, National Nuclear Security Administration. ACC: MOL.20030409.0002.

179508 DOE 2002 DOE (U.S. Department of Energy) 2002. *Idaho High-Level Waste and Facilities Disposition, Final Environmental Impact Statement.* DOE/EIS-0287. Idaho Falls, Idaho: U.S. Department of Energy, Idaho Operations Office. ACC: MOL.20070613.0004.

172433 DOE 2003 DOE (U.S. Department of Energy) 2003. *Strategic Plan for the Safe Transportation of Spent Nuclear Fuel and High-Level Radioactive Waste to Yucca Mountain: A Guide to Stakeholder Interactions*. Las Vegas, Nevada: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20041206.0113.

179454 DOE 2003 DOE (U.S. Department of Energy) 2003. *West Valley Demonstration Project Waste Management Environmental Impact Statement, Final Summary.* DOE/EIS-0337F. West Valley, New York: U.S. Department of Energy, West Valley Area Office. ACC: MOL.20070613.0003.

172285	DOE 2004	DOE (U.S. Department of Energy) 2004. *Supplement Analysis*. DOE/EIS-0250/SA-1. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20041122.0203.
176452	DOE 2005	DOE (U.S. Department of Energy) 2005. *Environmental Assessment for the Proposed Withdrawal of Public Lands Within and Surrounding the Caliente Rail Corridor, Nevada*. DOE/EA 1545, Rev. 0. Las Vegas, Nevada: Department of Energy, Office of Civilian Radioactive Waste Management. ACC: HQO.20060227.0001.
179524	DOE 2005	DOE (U.S. Department of Energy) 2005. *Supplement Analysis for the Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement.* DOE/EIS-0287-SA-01. Idaho Falls, Idaho: U.S. Department of Energy, Idaho Operations Office. ACC: MOL.20070613.0002.
178817	DOE 2006	DOE (U.S. Department of Energy) 2006. *Draft Environmental Assessment for the Proposed Infrastructure Improvements for the Yucca Mountain Project, Nevada*. DOE/EA-1566. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: HQO.20060911.0011.
179543	DOE 2007	DOE (U.S. Department of Energy) 2007. *Summary of Public Scoping Comments, Supplement to the Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada.* Las Vegas, Nevada: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20070524.0072.
181379	DOE 2007	DOE (U.S. Department of Energy) 2007. *Summary of Public Scoping Comments, Expanded Scope of the Environmental Impact Statement for the Alignment, Construction, and Operation of a Rail Line to a Geologic Repository at Yucca Mountain, Nye County, Nevada, The Mina Corridor and Alternative Rail Alignments Within this Corridor*. Las Vegas, Nevada: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20070524.0073.
185273	DOE 2007	DOE (U.S. Department of Energy) 2007. *Draft Complex Transformation Supplemental Programmatic Environmental Impact Statement.* DOE/EIS-0236-S4. Summary and two volumes. Washington, D.C.: U.S. Department of Energy, National Nuclear Security Administration. ACC: MOL.20080304.0037.

185274	DOE 2007	DOE (U.S. Department of Energy) 2007. *Draft Programmatic Environmental Impact Statement of the Designation of Energy Corridors in the 11 Western States.* DOE/EIS-0386. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20080328.0086.
185301	DOE 2008	DOE (U.S. Department of Energy) 2008. *Yucca Mountain Repository License Application.* DOE/RW-0573. Las Vegas, Nevada: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20080501.0021.
185437	DOE 2008	DOE (U.S. Department of Energy) 2008. *Draft Supplement Analysis for the Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada.* DOE/EIS-0243-SA-03. Las Vegas, Nevada: U.S. Department of Energy, National Nuclear Security Administration, Nevada Site Office. ACC: MOL.20080513.0176.
185486	Larson 2008	Larson, N.B. 2008. Right of Way (ROW) Application for a Proposed U.S. Department of Energy Rail Line from a Site Near Caliente, Nevada. Letter from N.B. Larson (DOE/OCRWM) to D. Metcalf (BLM/Ely Field Office) March 4, 2008, 0306082829, with attachments. ACC: CCU.20080306.0002.
157761	NRC 2001	NRC (U.S. Nuclear Regulatory Commission) 2001. *Final Environmental Impact Statement for the Construction and Operation of an Independent Spent Fuel Storage Installation on the Reservation of the Skull Valley Band of Goshute Indians and the Related Transportation Facility in Tooele County, Utah*. NUREG-1714. Two volumes. Washington, D.C.: U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards. TIC: 253836.
182850	Swanson 2007	Swanson, D. 2007. Memorandum of Understanding Between the Office of Civilian Radioactive Waste Management and Nye County, Nevada. Letter from D. Swanson (Nye County) to J. Summerson (YMSCO), April 9, 2007, 0412075994, 07-099-DS (L), with enclosure. ACC: MOL.20070430.0246; MOL.20070430.0247.
185339	Vandeberg 2008	Vandeberg, M. 2008. “STB Application Documents.” Email from M. Vandeberg to N. Sullivan, March 12, 2008, with attachments. ACC: MOL.20080423.0056.

2

Proposed Action and No-Action Alternative

TABLE OF CONTENTS

Section | Page

LIST OF TABLES

LIST OF FIGURES

2. PROPOSED ACTION AND NO-ACTION ALTERNATIVE

Under the *Proposed Action*, the U.S. Department of Energy (DOE or the Department) would construct, operate, monitor, and eventually close a *geologic repository* for the *disposal* of *spent nuclear fuel* and *high-level radioactive waste* at Yucca Mountain. Since publication of the *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F; DIRS 155970-DOE 2002, all) (Yucca Mountain FEIS) in 2002, DOE has continued to develop the *repository* design and associated construction and operation plans. DOE has prepared this *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F-S1) (Repository SEIS) to evaluate the potential environmental *impacts* of the design, which includes plans for the repository's surface and *subsurface* facilities and transportation of spent nuclear fuel and high-level radioactive waste to the repository. DOE has submitted the Repository SEIS to the U.S. Nuclear Regulatory Commission (NRC) with its application for construction authorization for a geologic repository.

Section 2.1 discusses the Proposed Action. Section 2.2 incorporates by reference the *No-Action Alternative* presented in the Yucca Mountain FEIS, and Section 2.3 summarizes the findings of this Repository SEIS, which include the findings of the Rail Alignment EIS on the impacts of spent nuclear fuel and high-level radioactive waste transportation in Nevada, and compares the potential environmental impacts of the Proposed Action and the No-Action Alternative. Section 2.4 addresses the collection of information and the analyses DOE performed for this Repository SEIS. Section 2.5 identifies DOE's preferred *alternative*.

2.1 Proposed Action

This introduction provides an overview of the Proposed Action and refers the reader to the sections in this Repository SEIS that contain further detail. Figure 2-1 illustrates the components or activities associated with implementation of the Proposed Action.

Under the Proposed Action, DOE would construct, operate, monitor, and eventually close a geologic repository at Yucca Mountain for the disposal of up to 70,000 *metric tons of heavy metal* (MTHM) of commercial and *DOE spent nuclear fuel* and high-level *radioactive* waste. In its simplest terms, the repository would be a large subsurface excavation with a network of *drifts,* or tunnels, that DOE would use for *emplacement* of spent nuclear fuel and high-level radioactive waste. DOE would dispose of spent nuclear fuel and high-level radioactive waste in the repository using the inherent, natural *geologic* features of the mountain and *engineered* (manmade) *barriers* to help ensure the long-term *isolation* of these materials from the human environment. The NRC, through its licensing process, would regulate repository *construction*, *operations, monitoring*, and *closure*.

Under the Proposed Action, the Department would transport most spent nuclear fuel and high-level radioactive waste from 72 commercial and 4 DOE sites to the repository in NRC-certified *transportation casks* on trains dedicated only to those *shipments*. However, DOE would transport some shipments to the repository in transportation casks by truck over the nation's highways. Naval spent nuclear fuel would be transported to the repository in transportation casks on railcars in general freight service or *dedicated trains.*

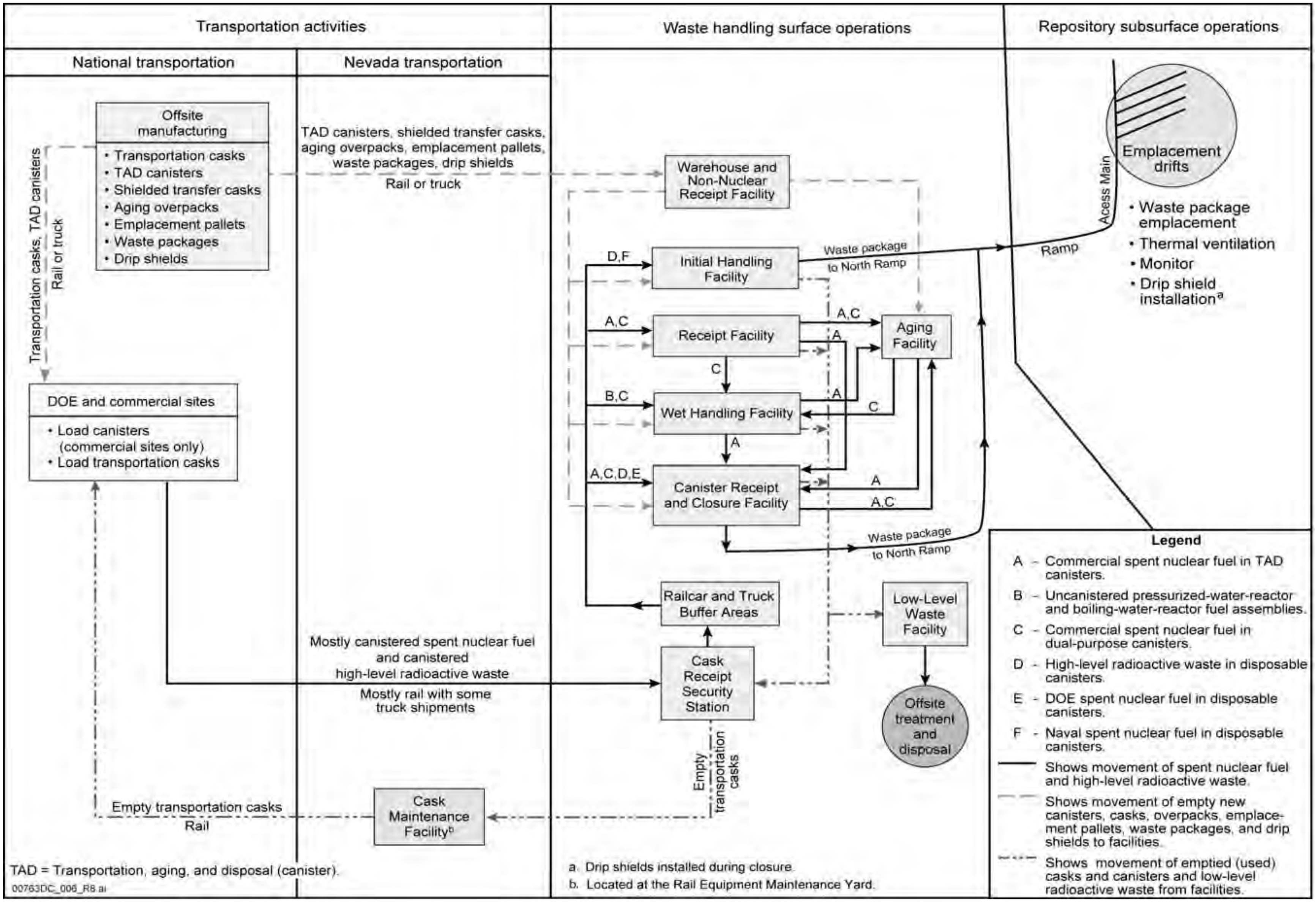


Figure 2-1. Overview flowchart for typical operations of the Proposed Action.

DEFINITION OF METRIC TONS OF HEAVY METAL

Quantities of spent nuclear fuel are traditionally expressed in terms of MTHM (typically uranium, but including plutonium and thorium), without the inclusion of other materials such as cladding (for example, the metallic tubes that contain the fuel) and structural materials. A metric ton is 1,000 kilograms (1.1 short tons or 2,200 pounds). Uranium and other metals in spent nuclear fuel are called heavy metals because they are extremely dense; that is, they have high weights per unit volume. One MTHM disposed of as spent nuclear fuel would fill a space approximately the size of the refrigerated storage area in a typical household refrigerator.

The Yucca Mountain FEIS described the equivalence methods by which MTHM is determined for high-level radioactive waste (pages A-36 to A-37). An MTHM equivalence is needed for high-level radioactive waste because its matrix is mostly silica or glass and almost all of its heavy metal has been removed. In this Repository SEIS, MTHM used in conjunction with high-level radioactive waste means MTHM equivalent, as explained in the Yucca Mountain FEIS.

High-level radioactive waste and DOE spent nuclear fuel would be placed in *disposable canisters* at the DOE sites and shipped to the repository. Although DOE has a small amount of spent nuclear fuel of commercial origin that it could ship to the repository uncanistered in a transportation cask, consistent with the analysis in the Yucca Mountain FEIS, this Repository SEIS assumes that it would transport and receive all DOE spent nuclear fuel and high-level radioactive waste in disposable canisters. As much as 90 percent of the *commercial spent nuclear fuel* would be placed in *transportation, aging, and disposal (TAD) canisters* at the commercial sites before shipment. The remaining commercial spent nuclear fuel (about 10 percent) would be transported to the repository in *dual-purpose canisters* (*canisters* suitable for storage and transportation), or as uncanistered spent nuclear fuel. Spent nuclear fuel shipped in dual-purpose canisters or as uncanistered spent nuclear fuel would be placed in TAD canisters at the repository prior to disposal.

At the repository, DOE would conduct waste handling activities, discussed below, to manage thermal output of the commercial spent nuclear fuel and to package the spent nuclear fuel into TAD canisters. The disposable canisters and TAD canisters would be placed into *waste packages* for disposal in the repository. A waste package is a container that consists of the *barrier* materials and internal components in which DOE would place the canisters that contained spent nuclear fuel and high-level radioactive waste. Section 2.1.1 discusses fuel packaging in TAD canisters and dual-purpose canisters more fully.

DOE would place approximately 11,000 waste packages, containing no more than a total of 70,000 MTHM, of spent nuclear fuel and high-level radioactive waste in the repository at Yucca Mountain. The *Proposed Action inventory,* or materials planned for disposal at the *Yucca Mountain Repository*, includes approximately:

- 63,000 MTHM of commercial spent nuclear fuel from boiling-water and *pressurized-water reactors*, which includes commercial high-level radioactive waste from the West Valley Demonstration Project;
- 2,333 MTHM of DOE spent nuclear fuel, which includes about 65 MTHM of naval spent nuclear fuel; and
- 4,667 MTHM of DOE high-level radioactive waste.

The Yucca Mountain FEIS evaluated the *cumulative impacts* of two additional inventories (Modules 1 and 2). Modules 1 and 2 include spent nuclear fuel and high-level radioactive waste in addition to the Proposed Action inventory, as well as other radioactive wastes generally considered unsuitable for near-surface disposal. Chapter 8 of this Repository SEIS contains updated inventories for Modules 1 and 2.

The handling and disposal of spent nuclear fuel and high-level radioactive waste would take place in an area known as the *geologic repository operations area*. The geologic repository operations area is defined at 10 CFR 63.2, as “a high-level radioactive waste facility that is part of a geologic repository, including both surface and subsurface areas, where waste handling activities are conducted.” The surface portion of the geologic repository operations area would include the facilities necessary to receive, package, and support emplacement of spent nuclear fuel and high-level radioactive waste in the repository. The subsurface portion of the geologic repository operations area would include the facilities necessary for emplacement. Section 2.1.2 discusses the geologic repository operations area facilities.

The design for implementation of the Proposed Action has multiple buildings that would enable a phased construction approach, allowing DOE to accept waste as soon as possible as well as being compatible with constrained funding. The primary surface waste handling facilities would include an *Initial Handling Facility*, three separate *Canister Receipt and Closure Facilities*, a *Wet Handling Facility*, and a *Receipt Facility*. In addition, there would be an *Aging Facility* with two *aging pads* for use in thermal management. These facilities would enable preparation for disposal of the various types of radioactive wastes after receipt at the geologic repository operations area. Section 2.1.2.1 discusses the waste handling surface facilities and operations more fully.

Once the spent nuclear fuel and high-level radioactive waste received at the repository were packaged in waste packages, the waste packages would be transferred to the subsurface portion of the geologic repository operations area for emplacement in dedicated tunnels (drifts). The waste packages would be aligned end-to-end in these drifts. Emplacement drifts would be excavated in a series of four panels (Section 2.1.2.2.1), phased to exceed the anticipated throughput rate of the surface waste handling facilities. In addition, the repository would have other underground excavations. These would include, for example, access mains to provide access from the surface to the emplacement drifts, and exhaust mains to direct ventilation air from the emplacement drifts to the surface. Gradually sloping ramps from the surface to the subsurface facilities would allow workers, equipment, and transport and emplacement vehicles access to and from repository operations. Section 2.1.2.2 discusses the subsurface facilities and operations.

Emplacement of the waste packages in the emplacement drifts would be managed according to the thermal energy or thermal output of the waste packages. In addition to being radioactive, spent nuclear fuel and high-level radioactive waste give off heat, which is referred to as thermal energy or thermal output. When these materials are placed in a confined space, such as an emplacement drift where heat cannot readily dissipate, the surrounding area would become hot. Under the Proposed Action, the thermal output of the waste packages would heat the rock surrounding the emplacement drifts to a temperature higher than the boiling point of water at the repository elevation, 96 degrees Celsius (°C) [205 degrees Fahrenheit (°F)]. This would cause the small amounts of water in the rock to turn into steam, which would move away from the drifts to a point where temperatures were below the boiling point of water and the steam could condense back to water. Because DOE wants to provide a path for the mobilized water to move downward past the emplacement drifts, the repository has been designed so there would be a middle region between the drifts (the *midpillar* region) that remained below the boiling point of water.

To accomplish this, DOE would manage the thermal output of the waste packages by selecting for emplacement only those packages that would keep the temperature in the midpillar region below the boiling point of water, as shown in Figure 2-2.

The evaluations of whether a waste package is too thermally hot for emplacement are based on a concept called thermal energy density, which is a measure of how heat is distributed over an area. By knowing the thermal characteristics of waste packages it had emplaced in an area of the repository, and the thermal characteristics of waste packages it had available for emplacement, DOE would select, from the available waste packages, those that would be appropriate for the next emplacement in the repository. DOE would make the selections based on calculations that evaluated the effect of the added thermal energy of the additional waste packages on maintaining the midpillar region below the boiling point of water. Management of an upper limit to the thermal energy density for emplacement would thus rely on selecting or blending of waste packages with specific thermal characteristics.

DOE's repository design includes other surface facilities to support waste handling and disposal. Section 2.1.2.3 describes the Central Control Center Facility, the Warehouse and Non-Nuclear Receipt Facility, the Heavy Equipment Maintenance Facility, the Low-Level Waste Facility, and the Emergency Diesel Generator Facility, as well as other support facilities. Section 2.1.2.4 describes utilities that would support the geologic repository operations area.

DOE would construct the surface and underground facilities and associated infrastructure, such as the onsite road and water distribution networks and emergency response facilities, in phases to accommodate the expected receipt rates of spent nuclear fuel and high-level radioactive waste. The Department would use two areas, the *South Portal development area* and the *North Construction Portal*, to support *underground facility* construction. Section 2.1.3 describes the South Portal development area and the North Construction Portal. Additional facilities outside the geologic repository operations area would support the project; Section 2.1.4 describes these facilities.

Under the Proposed Action, DOE would conduct a Performance Confirmation Program. *Performance confirmation* refers to a focused program of tests, experiments, and analyses DOE would conduct to monitor repository conditions, to assess the adequacy of geotechnical and design parameters, and to preserve the ability to perform waste retrieval, if necessary. The Performance Confirmation Program, would continue until *permanent closure* of the repository. Under the Proposed Action, DOE could retrieve emplaced waste packages for at least 50 years after the start of emplacement. Section 2.1.5 describes the Performance Confirmation Program.

When authorized by the NRC, closure of the repository would begin. DOE would install titanium *drip shields* over the waste packages. The drip shields would divert moisture that could drip from the drift walls, as well as condensed water vapor around the waste packages, to the drift floor, thereby increasing the life expectancy of the waste packages. In addition, drip shields would protect the waste packages from rockfalls. Closure would involve decontamination and dismantling of the surface handling facilities, backfilling of subsurface-to-surface openings, *decommissioning* and demolition of surface facilities, and restoration of the surface to its approximate condition before repository construction. In addition, closure would include erection of a network of monuments and markers around the site surface to warn future generations of the presence and nature of the buried radioactive waste. Section 2.1.6 discusses repository closure further.

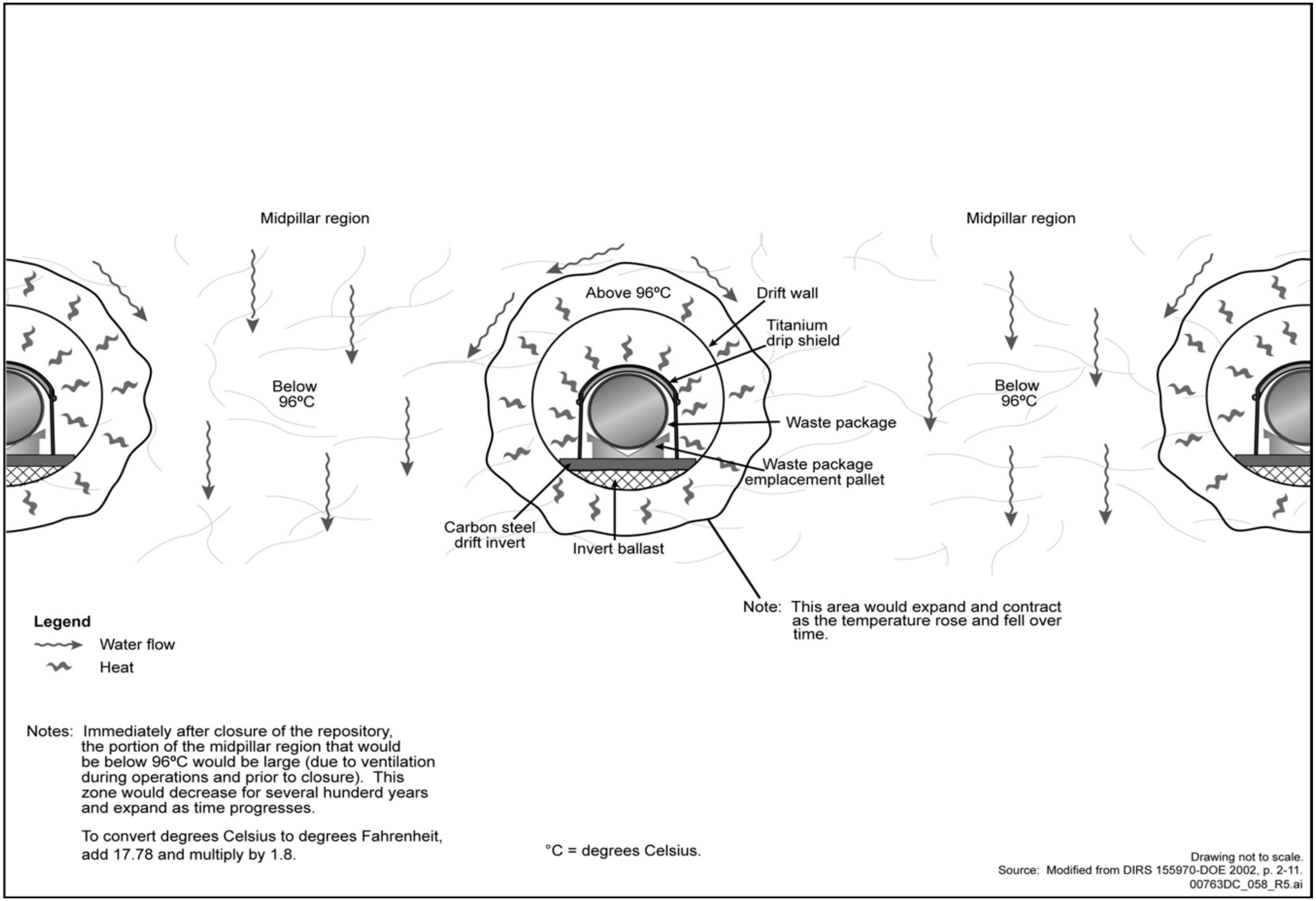


Figure 2-2. Management of waste package emplacement using thermal energy density (artist's concept).

After closure of the *subsurface facility*, the rock around the emplacement drifts would dry, which would minimize the amount of water that could contact the waste packages for hundreds of years. However, a portion of the rock between the drifts would remain at temperatures below boiling, which would promote drainage of water through the midpillar portions of the rock rather than into the emplacement drifts. Section 2.1.6 discusses repository closure further.

The Proposed Action includes construction and operation of a *railroad*, in an *alignment* in the State of Nevada, to connect the *Yucca Mountain site* to an existing *rail line* in Nevada. The Proposed Action also includes the construction and operation of several facilities that would be necessary for the operation of the railroad. The Rail Alignment EIS analyzes the construction and operation of the railroad; DOE summarizes and incorporates that analysis into this Repository SEIS, as discussed further in Section 2.1.7.

DOE has developed preliminary schedules for site preparation, construction, waste receipt, and routine emplacement operations. To the extent they relate to radiological health and safety or preservation of the common defense and security, these activities would not begin inside the geologic repository operations area until DOE received construction authorization from the NRC. Section 2.1.8 presents the schedules.

Best management practices are an integral part of the Proposed Action. DOE has defined best management practices for this Repository SEIS as the processes, techniques, procedures, or considerations it would employ to avoid or reduce the potential environmental impacts of its Proposed Action in a cost-effective manner while meeting the Yucca Mountain Repository project objectives. While best management practices are not regulatory requirements, they can overlap and support such requirements. Use of best management practices would not replace any local, state, or federal requirements. Best management practices are integral to the design, construction, and operation of the Yucca Mountain Repository, and the design for the repository incorporates them. Chapter 4 discusses resource-specific best management practices for the resource areas to which they apply. Chapter 9 discusses potential mitigation measures.

In summary, in this Repository SEIS DOE considers potential environmental impacts associated with the design for the repository, surface facilities, and transportation. The following subsections describe fuel packaging, geologic repository operations area facilities, construction support, and other facilities that would be necessary to implement the Proposed Action, as summarized above. In addition, they describe the Performance Confirmation Program, repository closure, and transportation activities associated with the Proposed Action.

2.1.1 FUEL PACKAGING

In the Yucca Mountain FEIS, DOE evaluated the receipt of commercial spent nuclear fuel under two packaging scenarios. These included the mostly canistered scenario, in which most commercial spent nuclear fuel would be received in dual-purpose canisters, and the mostly uncanistered scenario, in which most commercial spent nuclear fuel would be received uncanistered. In the mostly canistered scenario, the dual-purpose canisters would be opened at the repository and the spent nuclear fuel would be repackaged into waste packages. In the mostly uncanistered scenario, spent nuclear fuel would be transferred from transportation casks to waste packages. In both scenarios, DOE would handle the fuel at the repository in an uncanistered condition before loading it into waste packages for emplacement. In the

DEFINITIONS OF PACKAGING TERMS

Aging overpack:
A cask specifically designed for aging spent nuclear fuel at the repository. TAD canisters and dual-purpose canisters would be placed in aging overpacks for aging at the Aging Facility.

Disposable canister:
A metal vessel for commercial and DOE spent nuclear fuel assemblies (including naval spent nuclear fuel) or solidified high-level radioactive waste suitable for storage, shipping, and disposal. At the repository, DOE would remove the disposable canister from the transportation cask and place it in a waste package. There are a number of types of disposable canisters, including DOE standard canisters, multicanister overpacks, naval spent nuclear fuel canisters, and TAD canisters.

Dual-purpose canister:
A metal vessel suitable for storing (in a storage facility) and shipping (in a transportation cask) commercial spent nuclear fuel assemblies. At the repository, DOE would remove dual-purpose canisters from the transportation cask and open them. DOE would remove the spent nuclear fuel assemblies from the dual-purpose canister and place them in a TAD canister before placement in a waste package. The opened canister would be recycled or disposed of off the site as low-level radioactive waste.

Uncanistered spent nuclear fuel:
Commercial spent nuclear fuel assemblies not placed in a canister before placement into a transportation cask. At the repository, DOE would remove spent nuclear fuel assemblies from the transportation cask and place them in a TAD canister before placement in a waste package or aging overpack.

Shielded transfer cask:
A metal vessel used to transfer horizontal dual-purpose canisters from the Aging Facility to the Wet Handling Facility.

Transportation, aging, and disposal (TAD) canister:
A canister suitable for storage, shipping, aging, and disposal of commercial spent nuclear fuel. Commercial spent nuclear fuel would be placed into a TAD canister at the commercial reactor. At the repository, DOE would remove the TAD canister from the transportation cask and place it into a waste package or an aging overpack. The TAD canister is one of a number of types of disposable canisters.

Transportation cask:
A vessel that meets applicable regulatory requirements for transport of spent nuclear fuel or high-level radioactive waste via public transportation routes.

Waste package:
A container that consists of the corrosion-resistant outer container (Allow 22 outer cylinder) and structural inner container (stainless-steel inner cylinder) baskets, and shielding integral to the container. Waste packages would be ready for emplacement in the repository when the inner and outer lid welds were complete and the volume of the inner container had been evacuated and filled with helium gas to achieve an inert condition.

FEIS, all of the DOE materials (spent nuclear fuel and high-level radioactive waste) would be packaged in disposable canisters at the generator sites. These disposable canisters would not have to be opened at the repository and would be placed directly into waste packages for emplacement.

In this Repository SEIS, DOE would operate the repository with a *primarily canistered approach* in which the generator sites would package the majority (potentially as much as 90 percent) of commercial spent nuclear fuel in TAD canisters. DOE would use TAD canisters to transport, age, and dispose of commercial spent nuclear fuel at the repository, thereby eliminating the need to open the canister and handle that spent nuclear fuel at the repository. The remaining commercial spent nuclear fuel (about 10 percent) would arrive at the repository as uncanistered spent nuclear fuel or in dual-purpose canisters. The repository would receive DOE spent nuclear fuel, high-level radioactive waste, and naval spent nuclear fuel in disposable canisters. The Department could ship a small amount of DOE spent nuclear fuel of commercial origin to the repository as uncanistered spent nuclear fuel. At the repository, DOE would place uncanistered spent nuclear fuel directly into TAD canisters. *Aging* of the commercial spent nuclear fuel in TAD or dual-purpose canisters would, as necessary, manage thermal output. DOE would place both types of canisters (disposable and TAD) in waste packages before emplacement in the repository.

The TAD canister is a component of systems that the NRC (1) would certify for the transportation of spent nuclear fuel under 10 CFR Part 71 and would license for surface storage at the respective commercial sites under 10 CFR Part 72; and (2) would license for repository site transfer, aging, and geologic disposal under 10 CFR Part 63. Under this approach, the use of TAD canisters would minimize the handling of spent nuclear fuel assemblies because operators would seal commercial spent nuclear fuel in TAD canisters at generator sites. The TAD canister design would accommodate both *pressurized*- and *boiling-water-reactor* spent nuclear fuel. During transport, aging, and disposal, DOE would place a TAD canister inside another vessel that would provide other necessary functions (for example, radiological shielding, heat dissipation, structural strength, and *corrosion* resistance) as needed for each application. These vessels would include transportation casks, *shielded transfer casks*, *aging overpacks*, and waste packages.

DOE has adopted specifications to provide performance requirements for TAD canisters. The DOE performance specification (DIRS 185304-DOE 2008, all) contains detailed specifications for TAD canisters. Figure 2-3 is a schematic diagram of the TAD canister.

DOE’s expectation under the Proposed Action is that potentially as much as 90 percent of commercial spent nuclear fuel would be packaged in TAD canisters by the operators at the generator sites. However, DOE has conducted a sensitivity analysis, provided in Appendix A of this Repository SEIS, that considered the potential case that the operators could place only 75 percent of commercial spent nuclear fuel in TAD canisters at commercial sites, with DOE loading the remainder in TAD canisters at the repository.

2.1.2 FACILITIES IN THE GEOLOGIC REPOSITORY OPERATIONS AREA AND VICINITY

The facilities where DOE would handle spent nuclear fuel and high-level radioactive waste would be in the geologic repository operations area, which is shown in Figure 2-4. The surface portion of the geologic repository operations area would comprise the facilities necessary to receive age, package, and support emplacement of waste. Waste handling operations would be in a *restricted area* in the surface portion of the geologic repository operations area. DOE would locate the restricted area, defined in 10 CFR 63.2, to separate waste handling operations from other activities in the geologic repository operations area. During phased construction, physical barriers would encompass a *protected*

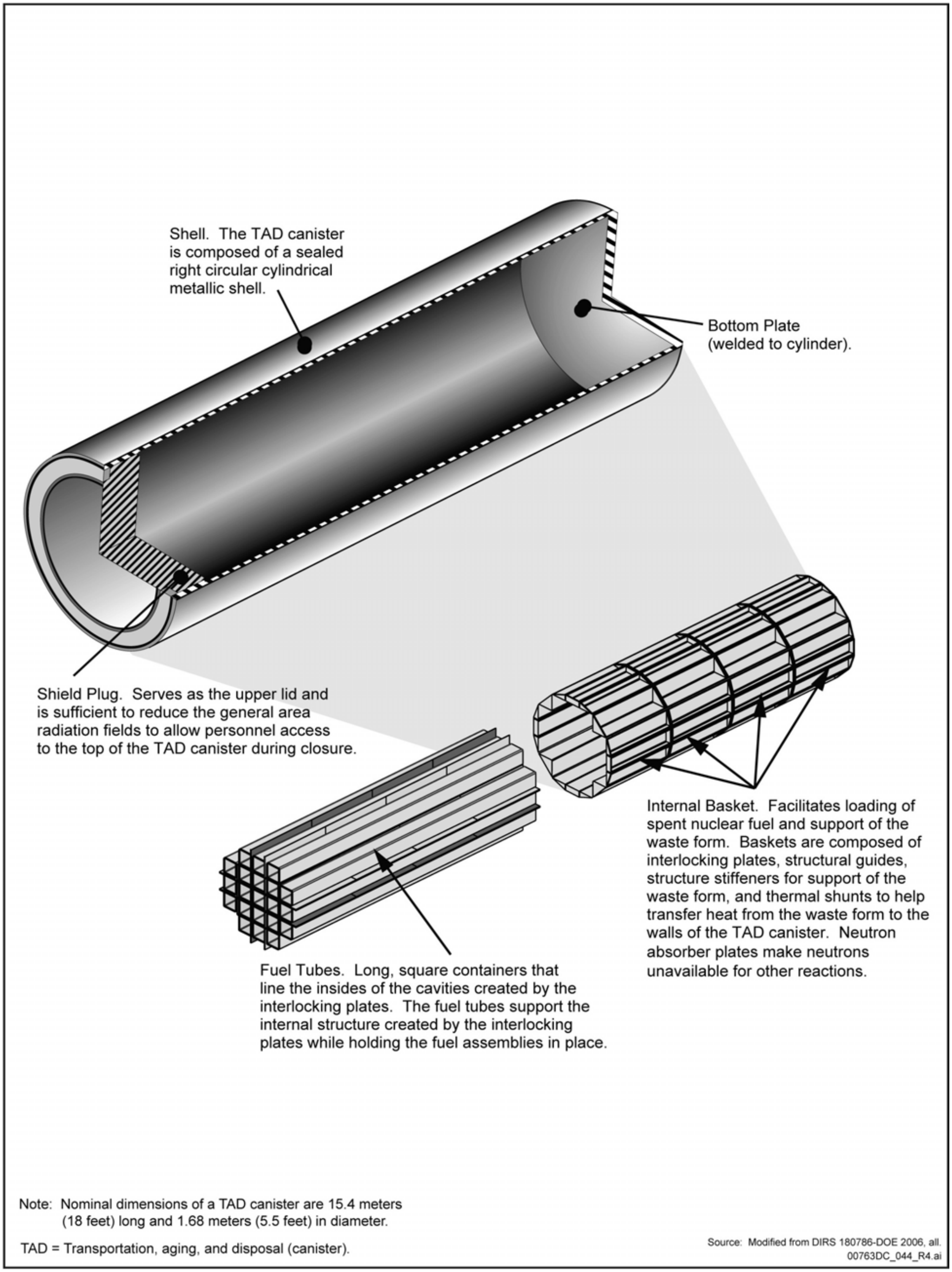


Figure 2-3. TAD canister schematic (artist's concept).

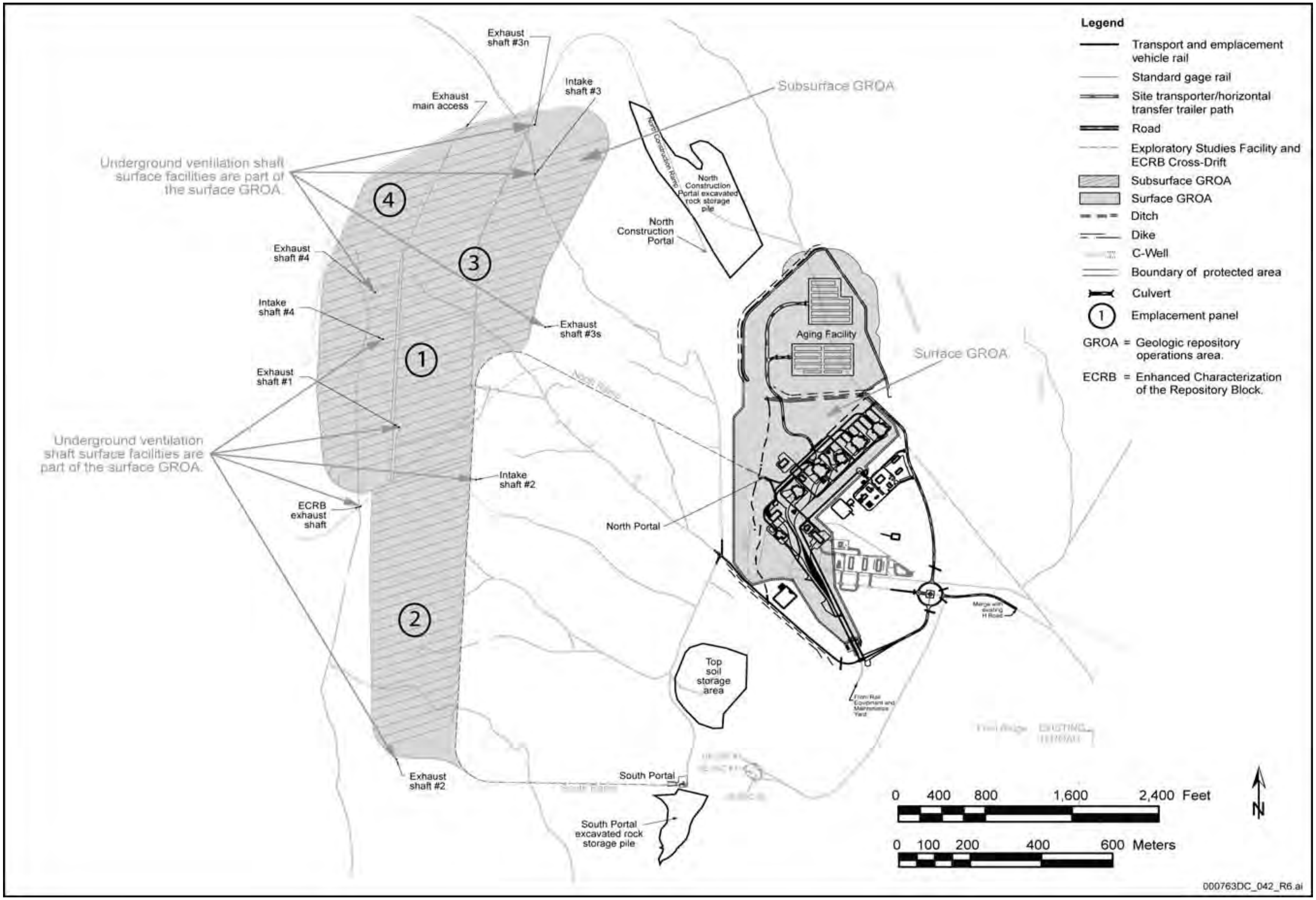


Figure 2-4. Geologic repository operations area.

area to ensure adequate safeguards and security for the spent nuclear fuel and high-level radioactive waste. The subsurface geologic repository operations area would consist of the features and facilities necessary to transport and emplace waste packages and provide ventilation to the emplaced waste packages. These subsurface features and facilities would include excavated drifts, rail lines, waste package emplacement pallets, engineered inverts, and support systems.

This Repository SEIS analyzes implementation of the Proposed Action according to four periods—construction analytical period, operations analytical period, monitoring analytical period, and closure analytical period, as listed in Table 2-1. DOE has defined these four *analytical periods* for use in this Repository SEIS to best evaluate potential *preclosure* environmental impacts that could be associated with the Proposed Action, as explained in further detail in Chapter 4. Various activities could occur in each analytical period, but the name of the analytical period implies the major activity that would occur. For instance, during the operations analytical period, construction would be occurring, but operations would be the major activity. Appendix A addresses the impacts of a potentially longer monitoring period. Table 2-1 also lists the corresponding *operational phases* DOE describes in its application for construction authorization. The four operational phases indicate when DOE expects specific facilities to be operational under the planned phased construction.

Section 2.1.2.1 describes the surface facilities and operations that DOE would use for waste handling. Section 2.1.2.2 describes the subsurface facilities and repository operations, including ventilation. Section 2.1.2.3 describes the balance of plant facilities, and Section 2.1.2.4 describes utilities for the geologic repository operations area and vicinity.

Table 2-1. Repository SEIS analytical periods and associated construction and activities.

Analytical period duration	Infrastructure improvements	Operational phases of surface facilities construction	Subsurface facility development (construction)	Other associated activities
Construction analytical period				
5 years The construction analytical period includes activities that would begin on receipt of the construction authorization from the NRC and that DOE would complete by the time it received spent nuclear fuel or high-level radioactive waste.	• Electrical power and distribution system • Roads and rail • Domestic water systems • Septic tank and leach field/wastewater treatment systems • Sewer and stormwater collection systems • Engineering and Safety Demonstration Facility • Hazardous Materials Collection Depot • Borrow pits • Explosives Storage Area • Offsite Training Facility • Housing for construction workers • Sample Management Facility • Marshalling yard and warehouse • South Portal development area	Phase 1 • Initial Handling Facility • Wet Handling Facility • Canister Receipt and Closure Facility 1 • Low-Level Waste Facility • Central Control Center Facility • Heavy Equipment Maintenance Facility • Aging Facility (pad 17R) • Aging Overpack Staging Facility • Warehouse and Non-Nuclear Receipt Facility • Two Fire Water Facilities • Cask Receipt Security Station • Central Security Station • Transporter Security Gate • Utilities Facility, cooling tower, and evaporation pond • Emergency and Standby Diesel Generator Facilities • Railcar buffer area • Truck buffer area • Helicopter pad	Subsurface facility development would begin with Panel 1, concurrent with surface construction.	• Developing initial ventilation system, which would include shafts, shaft pads, batch plants, and electrical utility transmission lines. • Beginning active ventilation of the repository.

Table 2-1. Repository SEIS analytical periods and associated construction and activities (continued).

Analytical period duration	Infrastructure improvements	Operational phases of surface facilities construction	Subsurface facility development (construction)	Other associated activities
Operations analytical period				
Up to 50 years The operations analytical period includes activities that would begin on receipt of spent nuclear fuel and high-level radioactive waste. The period would include receipt, handling, aging, emplacement, continued active ventilation of the repository, and monitoring of waste, as well as continued construction of surface and subsurface facilities.	• North Construction Portal.	Phase 2 • Receipt Facility • One Fire Water Facility • Administration Facility and two administration security stations • Fire, Rescue and Medical Facility • Warehouse/Central Receiving • Materials/Yard Storage • Vehicle Maintenance and Motor Pool • Diesel Fuel Oil Storage • Fueling stations • Craft shops • Equipment/Yard Storage Phase 3 • Canister Receipt and Closure Facility 2 • Aging Facility (pad 17P) Phase 4 • Canister Receipt and Closure Facility 3 • North Perimeter Security Station	Continued subsurface facility development with Panels 2, 3, and 4 until complete.	• Continuing development of ventilation system.

Table 2-1. Repository SEIS analytical periods and associated construction and activities (continued).

Analytical period duration	Infrastructure improvements	Operational phases of surface facilities construction	Subsurface facility development (construction)	Other associated activities
Monitoring analytical period				
50 years The monitoring analytical period includes activities that would begin with emplacement of the final waste package and continue for 50 years after the end of the operations analytical period.	No infrastructure improvements planned.	Possible surface facility construction to support waste retrieval, if necessary.	No subsurface facility development planned.	• Maintaining active ventilation of the repository for at least 50 years after emplacement of the last waste package. • Remotely inspecting waste packages. • Continuing monitoring of the waste. • Retrieving waste packages, if necessary.
Closure analytical period				
10 years The closure analytical period includes activities that would begin on receipt of a license amendment to close the repository and would last 10 years, concurrent with the last 10 years of the monitoring analytical period.	No infrastructure improvements planned.	No facility construction planned.	No subsurface facility development planned.	• Decontaminating and dismantling the surface handling facilities[a] • Emplacing the drip shields. • Removing concrete inverts from the main drifts. • Backfilling subsurface-to-surface openings. • Constructing monuments to mark the site. • Restoring the surface to its approximate condition before repository construction. • Continuing performance confirmation, as necessary.

a. The timeframe for decontaminating and dismantling the surface handling facilities is dependent on the determination that the surface facilities are no longer necessary to support spent nuclear fuel and high-level radioactive waste handling, processing, emplacement, or retrieval operations. This Repository SEIS assumes that this would occur during the closure analytical period.

DOE = U.S. Department of Energy.

NRC = U.S. Nuclear Regulatory Commission.

DEFINITIONS OF YUCCA MOUNTAIN SITE TERMS

Central operations area:
The central operations area is an area in which DOE would develop approximately 0.8 kilometer (0.5 mile) southeast of the geologic repository operations area for support operations, which would include upgrades and replacement of the subsurface infrastructure in the Exploratory Studies Facility.

Geologic repository operations area:
As defined at 10 CFR 63.2, the geologic repository operations area is "a high-level radioactive waste facility that is part of a geologic repository, including both surface and subsurface areas, where waste handling activities are conducted."

North Construction Portal:
Portal that would be used for construction of the subsurface facility.

North Portal:
An existing portal (current access to the Exploratory Studies Facility) that DOE would use initially for subsurface construction and to emplace waste packages in the subsurface facility.

North Ramp:
An existing, gently sloping incline that begins at the North Portal on the surface and extends through the subsurface to the edge of the subsurface facility. It would support waste package emplacement operations.

Protected area:
The protected area is an area encompassed by physical barriers and to which access would be controlled, ensuring adequate safeguards and security for the spent nuclear fuel and high-level radioactive waste. The protected area would expand as the additional waste handling facilities are completed.

Portal:
A portal is the opening to the subsurface facility that would provide access for construction, equipment, rock removal, or waste emplacement.

Restricted area:
The restricted area, as defined at 10 CFR 20.1003 and 10 CFR 63.2, is an area in which DOE would separate waste handling operations from other activities in the geologic repository operations area.

South Portal development area:
An existing portal and ramp that DOE would use for construction of the subsurface facility.

Subsurface facility (subsurface geologic repository operations area):
The structure, equipment and systems (such as ventilation), backfill materials if any, and openings that penetrate underground (for example, ramps, shafts, and boreholes).

Yucca Mountain Repository (repository):
As defined at 10 CFR 63.202, the Yucca Mountain Repository means the excavated portion of the facility constructed underground within the Yucca Mountain site.

2.1.2.1 Waste Handling Surface Facilities and Operations

Waste handling surface facilities would be in the protected area of the geologic repository operations area. Figure 2-5 shows the orientation and layout of the surface facilities in the geologic repository operations area. In Figure 2-5, the surface facilities are grouped according to the four operational phases that would occur under the planned phased construction. The repository would have initial operating capability at the completion of Phase 1 and full operating capability at the completion of Phase 2. The site layout addresses concurrent construction and operations in the geologic repository operations area.

DEFINITIONS OF DURATION TERMS

Repository SEIS analytical periods:

Four timeframes are defined for use in this Repository SEIS to best evaluate potential preclosure environmental impacts:

- **Construction analytical period: 5 years**—Begins upon receipt of the construction authorization from the NRC and ends prior to receipt of a license to receive and possess radiological materials. Activities would include site preparation, surface construction, and subsurface development.
- **Operations analytical period: 50 years**—Begins upon receipt of a license to receive and possess radiological materials and ends upon emplacement of the final waste package. Activities would include receipt, handling, aging, emplacement, and monitoring of waste, as well as continued construction of surface and subsurface facilities.
- **Monitoring analytical period: 50 years**—Begins upon emplacement of the final waste package. Activities would include maintaining active ventilation of the repository for as long as 50 years, remotely inspecting waste packages, and continuing investigations in support of predictions related to postclosure performance.
- **Closure analytical period: 10 years**—Overlaps the last 10 years of the monitoring period and includes activities that would begin upon receipt of a license amendment to close. Activities would include decommissioning and demolishing surface facilities, emplacing drip shields, backfilling subsurface-to-surface openings, restoring the surface to its approximate condition before repository construction, and constructing monuments to mark the site.

Operational phases:

Four phases used in DOE's application for construction authorization to indicate when specific facilities are expected to be operational under the planned phased construction. Operational phases are Phase 1, Phase 2, Phase 3, and Phase 4.

Preclosure:

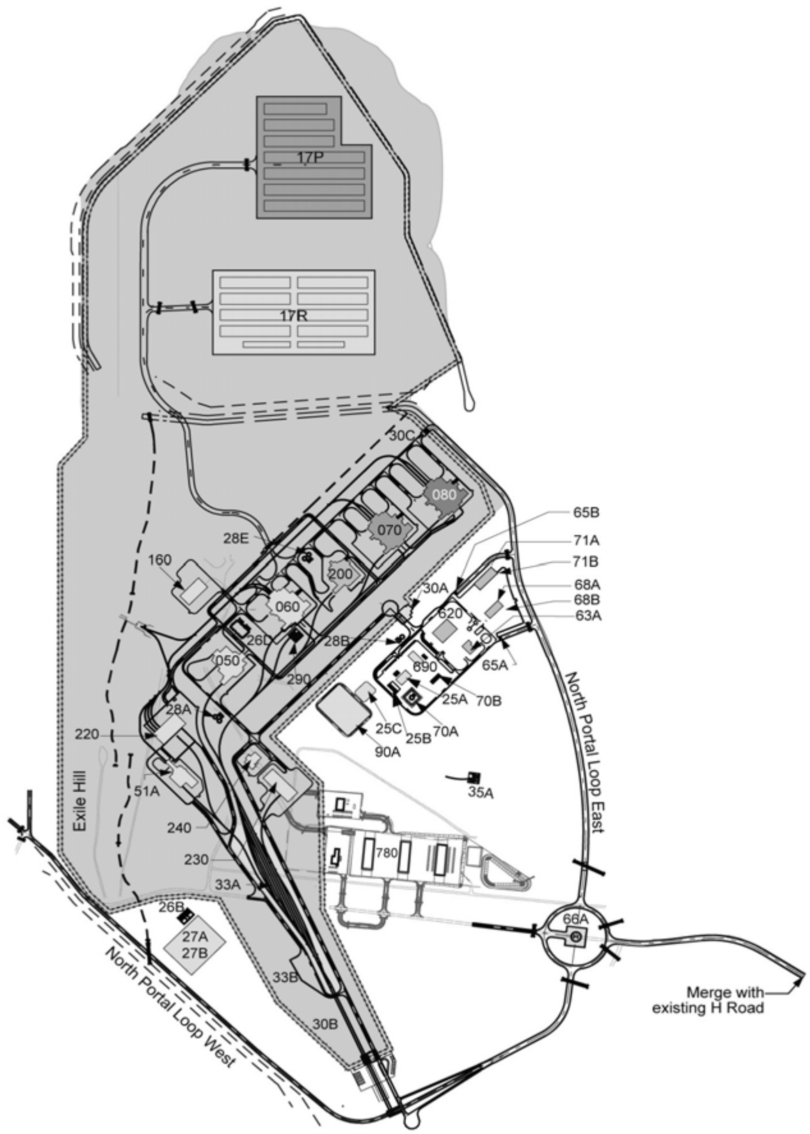
The timeframe from construction authorization to repository closure.

Postclosure:

The timeframe after permanent closure of the repository through the 1 million years analyzed in this Repository SEIS.

Repository-closure:

The point in time when activities associated with the closure analytical period, such as decommissioning and demolishing surface facilities and backfilling subsurface-to-surface openings, have been completed. Permanent closure of the repository would be complete; postclosure timeframe would begin.



LEGEND Initial Operating Capability			
Phase 1			
17R	Aging Pad R	33B	Truck Buffer Area
25A	Utilities Facility	35A	Septic Tank and Leach Field
25B	Cooling Tower	050	Wet Handling Facility
25C	Evaporation Pond	51A	Initial Handling Facility
26B	Standby Diesel Generator Facility	060	Canister Receipt and Closure Facility 1
26D	Emergency Diesel Generator Facility	66A	Helicopter Pad
27A	Switchyard (138 kilovolts)	90A	Stormwater Retention Pond
27B	13.8-kilovolt Switchgear Facility	160	Low-Level Waste Facility
28A	Fire Water Facility (Central)	220	Heavy Equipment Maintenance Facility
28B	Fire Water Facility (East)	230	Warehouse and Non-Nuclear Receipt Facility
30A	Central Security Station	240	Central Control Center Facility
30B	Cask Receipt Security Station	290	Aging Overpack Staging Facility
33A	Railcar Buffer Area	780	Lower Muck Yard
Full Operating Capability			
Phase 2			
28E	Fire Water Facility (North)	70B	Fueling Stations
63A	Fire, Rescue and Medical Facility	71A	Craft Shops
65A	Administration Security Station	71B	Equipment/Yard Storage
65B	Administration Security Station	200	Receipt Facility
68A	Warehouse/Central Receiving	620	Administration Facility
68B	Materials/Yard Storage	690	Vehicle Maintenance and Motor Pool
70A	Diesel Fuel Oil Storage		
Phase 3			
17P	Aging Pad P	070	Canister Receipt and Closure Facility 2
Phase 4			
30C	North Perimeter Security Station	080	Canister Receipt and Closure Facility 3

(shaded) Surface geologic repository operations area

Figure 2-5. Layout of the surface geologic repository operations area and vicinity.

DOE would use five types of surface facilities (eight buildings or areas) for waste handling—Initial Handling Facility, three Canister Receipt and Closure Facilities, the Wet Handling Facility, the Aging Facility, and the Receipt Facility—and would build them in phases. In addition, DOE would use a site transportation network to move transportation casks, shielded transfer casks, and aging overpacks between the waste handling facilities and eventually to move waste packages to the subsurface facility.

PRIMARY FUNCTIONS OF WASTE PREPARATION AND HANDLING FACILITIES

Aging Facility:
Provide two aging pads and associated equipment to age commercial spent nuclear fuel as necessary to meet waste package thermal limits.

Canister Receipt and Closure Facilities:
Receive DOE disposable canisters and TAD canisters, load canisters into waste packages, and close the waste packages.

Cask Receipt Security Station:
Perform initial waste receipt and inspection.

Initial Handling Facility:
Receive high-level radioactive waste and naval spent nuclear fuel canisters, load canisters into waste packages, and close the waste packages.

Receipt Facility:
Transfer TAD and dual-purpose canisters, as appropriate, to the Wet Handling Facility, a Canister Receipt and Closure Facility, or the Aging Facility.

Wet Handling Facility:
Handle uncanistered commercial spent nuclear fuel and open and unload dual-purpose canisters; essential purpose is loading TAD canisters.

DOE would conduct waste handling operations in these facilities with mostly remotely operated equipment. The Department would use thick, reinforced concrete shield walls, *shielded* canister transfer, and controlled access techniques to protect workers from *radiation exposure*. The design of the waste handling facilities and equipment would withstand the effects of ground motion from *earthquakes* and other *events.*

The Initial Handling Facility, Canister Receipt and Closure Facilities, Wet Handling Facility, Aging Facility, and Receipt Facility would have a digital control and management information system that would interface with, but have adequate isolation from, the safety components provided with mechanical handling equipment in each facility. In addition, the digital control and management information system would interface with the Central Control Center Facility to enable supervisory control and monitoring of facility operations by Central Control Center Facility operators.

Spent nuclear fuel and high-level radioactive waste would arrive at the repository in a variety of types and sizes, as follows. Figure 2-1 shows an overview of operations DOE would use to receive and handle the various waste forms, as described below.

The repository would receive the vast majority of commercial spent nuclear fuel in TAD canisters that were loaded, internally dried and filled by an inert gas to displace oxygen, and closed by the commercial nuclear utilities. Transportation casks arriving at the repository that contained commercial spent nuclear fuel in TAD canisters that required aging would be unloaded in the Receipt Facility. The TAD canisters would be placed in aging overpacks and moved to the Aging Facility for thermal management. Once the thermal heat output *decayed* to an acceptable level, DOE would move the aging overpacks to a Canister Receipt and Closure Facility for packaging of the TAD canisters in waste packages for subsequent subsurface emplacement. TAD canisters that did not require aging would be sent to a Canister Receipt and Closure Facility for packaging into waste packages for subsequent subsurface emplacement.

A small fraction of commercial spent nuclear fuel could arrive in transportation casks as uncanistered pressurized- and boiling-water-reactor fuel assemblies. DOE would move these transportation casks to the Wet Handling Facility for placement of the uncanistered spent nuclear fuel assemblies in TAD canisters. DOE would dry, close, and backfill these TAD canisters with helium gas to achieve an inert condition. If aging should be necessary, DOE would place the TAD canisters in aging overpacks and move them to the Aging Facility. Once the thermal heat output decayed to an acceptable level, DOE would move the aging overpacks to a Canister Receipt and Closure Facility for packaging of the TAD canisters in waste packages for subsequent subsurface emplacement. If aging was not necessary, the TAD canisters would be placed in aging overpacks and transported to a Canister Receipt and Closure Facility for packaging in waste packages for subsequent subsurface emplacement.

Commercial spent nuclear fuel could also arrive in sealed dual-purpose canisters. Dual-purpose canisters may be oriented either vertically or horizontally. DOE would unload transportation casks that contained commercial spent nuclear fuel in vertical dual-purpose canisters that required aging in the Receipt Facility. The dual-purpose canisters would be placed in aging overpacks and moved to the Aging Facility for thermal management. Transportation casks that contained horizontal dual-purpose canisters would be moved to a cask transfer trailer and from there to a horizontal aging module at the Aging Facility. Horizontal aging modules would be stationed at the Aging Facility and would be used specifically to age spent nuclear fuel in horizontal dual-purpose canisters. DOE would design the cask transfer trailers for docking at the portal of the horizontal aging module. A hydraulic ram system would be necessary to facilitate the transfer of canisters to the horizontal aging module. The hydraulic ram would be inserted through a portal in the appropriate end of the transportation cask and would be used to push the loaded canister into the horizontal aging module. Once the thermal heat output decayed to an acceptable level, DOE would move the aging overpacks that contained vertical dual-purpose canisters to the Wet Handling Facility for transfer of the spent nuclear fuel to TAD canisters. DOE would use the ram to withdraw the horizontally placed dual-purpose canister from the horizontal aging module and transfer it to a shielded transfer cask to enable moving the dual-purpose canister to the Wet Handling Facility. Dual-purpose canisters that arrived at the repository that did not require aging would be sent to the Wet Handling Facility where the spent nuclear fuel would be transferred to TAD canisters. The TAD canisters would then be placed in aging overpacks and moved to a Canister Receipt and Closure Facility for packaging in waste packages for subsequent subsurface emplacement.

High-level radioactive waste, naval spent nuclear fuel, and most DOE spent nuclear fuel would arrive at the repository in disposable canisters. These canisters would be loaded, backfilled with inert gas (except the canisters that contained high-level radioactive waste), sealed, and transported from waste generation and storage sites. Transportation casks that contained naval spent nuclear fuel in disposable canisters would be unloaded in the Initial Handling Facility. These canisters would be packaged separately into waste packages in the Initial Handling Facility for subsequent subsurface emplacement. Transportation casks that contained high-level radioactive waste in disposable canisters could be unloaded in either the Initial Handling Facility or a Canister Receipt and Closure Facility. In either facility, the canisters would be packaged in waste packages for subsequent subsurface emplacement. Transportation casks that contained DOE spent nuclear fuel in disposable canisters would be sent to a Canister Receipt and Closure Facility for unloading and transfer to a waste package for subsequent subsurface emplacement. In the Canister Receipt and Closure Facility, the high-level radioactive waste canisters and DOE spent nuclear fuel canisters could be codisposed in the waste packages. Depending on the waste package configuration, the codisposal would be as follows: five high-level radioactive waste canisters with one spent nuclear fuel canister, four high-level radioactive waste canisters with one spent nuclear fuel canister, or two high-level radioactive waste canisters with two spent nuclear fuel canisters.

Ultimately, the various waste forms would leave the waste handling facilities packaged uniformly in waste packages for repository emplacement.

2.1.2.1.1 *Cask Receipt Security Station*

The *Cask Receipt Security Station* would be at the south end of the surface geologic repository operations area (Figure 2-5, Facility 30B). The Cask Receipt Security Station would be the point of receipt for all transportation casks containing spent nuclear fuel and high-level radioactive waste. Shipments of spent nuclear fuel and high-level radioactive waste would arrive at the Cask Receipt Security Station on commercial railcars that carried rail transportation casks or on truck trailers that carried truck transportation casks. On arrival, the shipments would be inspected and custody of, or responsibility for, the transportation casks would be transferred from the transportation system to the repository. Casks, still on commercial railcars or truck trailers, would be moved from the Cask Receipt Security Station to a buffer area in the protected area of the geologic repository operations area to await processing in one of the waste handling facilities. Incoming empty waste packages, TAD canisters, and shielded transfer casks would also arrive at the Cask Receipt Security Station on railcars and truck trailers before their transfer to the Warehouse and Non-Nuclear Receipt Facility. Empty transportation casks would be held in the buffer area awaiting shipment off the site.

2.1.2.1.2 *Initial Handling Facility*

The Initial Handling Facility would be in the western part of the surface geologic repository operations area (Figure 2-5, Facility 51A). The Initial Handling Facility would receive rail and truck transportation casks that contained high-level radioactive waste canisters or naval spent nuclear fuel canisters; it would handle no other waste forms. This facility would have the capability to prepare truck and rail transportation casks for unloading: transfer disposable canisters to waste packages; and to close and seal the waste packages. The closing and sealing of the waste packages would include welding the inner lid closed, evacuating the waste package inner vessel and backfilling it with helium, and installing the waste package outer lid and welding it closed. The completed waste package would be positioned on an *emplacement pallet* such that a transport and emplacement vehicle could receive it, move it to the subsurface, and emplace it in the repository. Emplacement pallets would support the waste package in a horizontal position in the emplacement drift, as described further in Sections 2.1.2.2.2 and 2.1.2.2.3.

2.1.2.1.3 *Canister Receipt and Closure Facilities*

When the repository became fully operational, there would be three Canister Receipt and Closure Facilities of identical design for the packaging of canisters in waste packages. The three facilities would be in a row in the central part of the surface geologic repository operations area (Figure 2-5, Facilities 060, 070, and 080).

The Canister Receipt and Closure Facilities would have the ability to receive DOE disposable canisters and TAD canisters; to transfer them to waste packages; and to close and seal the waste packages. The closing and sealing of the waste packages would include welding the inner lid closed, evacuating the waste package inner vessel and backfilling it with helium, and installing the waste package outer lid and welding it closed. The completed waste package would be positioned on an emplacement pallet such that a transport and emplacement vehicle could receive it, move it to the subsurface, and emplace it in the repository. The facilities would also have the ability to transfer TAD and vertical dual-purpose canisters from transportation casks into aging overpacks on site transporters for transport to the Aging Facility.

Uncanistered spent nuclear fuel assemblies would not be accepted by the Canister Receipt and Closure Facilities, and canisters would not be opened inside the facility.

2.1.2.1.4 *Wet Handling Facility*

The Wet Handling Facility would be in the central part of the surface geologic repository operations area (Figure 2-5, Facility 050). This facility would provide support for cask preparation; receipt and opening of sealed dual-purpose canisters; transfer of commercial spent nuclear fuel into TAD canisters underwater; closure of TAD canisters; loading of TAD canisters into aging overpacks on site transporters for transport to the Aging Facility; and loading of TAD canisters into aging overpacks on site transporters for transfer to a Canister Receipt and Closure Facility. The Wet Handling Facility would have a 15.2-meter (50-foot)-deep pool. The pool would have a limited-capacity in-process spent nuclear fuel staging area. This would consist of storage racks with the capacity to hold approximately 80 pressurized-water-reactor spent nuclear fuel assemblies and 120 boiling-water reactor spent nuclear fuel assemblies.

The Wet Handling Facility would receive dual-purpose canisters in various ways, including (1) in aging overpacks from the Aging Facility, (2) in rail transportation casks, and (3) in horizontal shielded transfer casks from the Aging Facility. The facility also would receive uncanistered spent nuclear fuel assemblies in transportation casks transported from the rail or truck *buffer areas*.

The uncanistered spent nuclear fuel assemblies from the transportation casks and the spent nuclear fuel in the dual-purpose canisters would be repackaged into TAD canisters at the Wet Handling Facility. The transportation casks that contained uncanistered spent nuclear fuel assemblies would be moved to the facility's pool for lid removal and transfer of the uncanistered fuel assemblies to an empty TAD canister or to the pool staging rack. At this point, the spent nuclear fuel assemblies would be blended to ensure that the loaded TAD canister thermal limits would not be exceeded. Dual-purpose canisters would be opened outside the pool and then moved into the pool for transfer of the commercial spent nuclear fuel to TAD canisters or the pool staging rack.

Once the TAD canisters were loaded, dried, sealed, and backfilled with helium gas to achieve an inert condition, they would be transported to either the Aging Facility for thermal management or a Canister Receipt and Closure Facility for packaging in waste packages.

The facility also would contain a remediation area to facilitate the handling and limited repair of casks and TAD canisters. In addition, the facility would prepare the unloaded dual-purpose canisters for removal from the facility.

2.1.2.1.5 *Aging Facility*

The surface layout of the Aging Facility would include two aging pads to provide space for aging commercial spent nuclear fuel. The Aging Facility would be at the north end of the surface geologic repository operations area (Figure 2-5, Facilities 17P and 17R). The pads would enable aging of commercial spent nuclear fuel as necessary to meet waste package thermal limits. The principal components of the Aging Facility, in addition to the aging pads, would be the aging overpacks that contained either TAD canisters or dual-purpose canisters positioned on an aging pad and the overpack transfer component. The aging pads would accommodate up to 21,000 MTHM of commercial spent nuclear fuel. Aging overpacks would be either vertical aging overpacks for dual-purpose and TAD canisters or horizontal aging modules for horizontal dual-purpose canisters. Overpack transfer would involve equipment capable of moving aging overpacks containing TAD or dual-purpose canisters and transportation casks containing horizontal dual-purpose canisters between the handling facilities and the Aging Facility.

The Aging Facility would receive aging overpacks from the Receipt Facility, Wet Handling Facility, and Canister Receipt and Closure Facilities and would send aging overpacks to the Wet Handling Facility and Canister Receipt and Closure Facilities. The Aging Facility would also receive transportation casks that contained horizontal dual-purpose canisters from the Receipt Facility and later send them in shielded transfer casks to the Wet Handling Facility. Of the 2,500 aging spaces provided by the aging pads, about 100 would be for horizontal aging modules.

2.1.2.1.6 *Receipt Facility*

The Receipt Facility would be in the central part of the surface geologic repository operations area (Figure 2-5, Facility 200). This facility would transfer TAD and dual-purpose canisters that arrived on commercial railcars carrying rail transportation casks to the Wet Handling Facility, a Canister Receipt and Closure Facility, and the Aging Facility. TAD and dual-purpose canisters would be transferred to these facilities in aging overpacks, and horizontal dual-purpose canisters would be transferred to the Aging Facility in transportation casks. In addition, the Receipt Facility would prepare unloaded transportation casks for return to the national transportation system. Until the Receipt Facility became operational, a Canister Receipt and Closure Facility would provide the receipt function of the Receipt Facility.

2.1.2.1.7 *Site Transportation Network*

The site transportation network would consist of rail lines and roads that connected the waste handling facilities, buffer areas, Aging Facility, and emplacement *portal*. Onsite canister movement would be accomplished in shielded transfer casks, transportation casks, or aging overpacks by site transporters, site prime movers, cask tractors, and cask transfer trailers.

The site transporters would be hydraulically self-propelled and powered by a diesel engine or electric motor when operated outdoors and by an electric motor when used inside buildings. Each site transporter would include a cask restraint system to prevent uncontrolled cask movement during transport. The site transporters would be all-weather vehicles designed to operate in rain and snow over the temperature and humidity range of the site.

The site prime movers would be rail-based vehicles that would work in conjunction with buffer cars at each end to enable placement of rail cask cars in the waste handing building without the site prime mover entering the building.

The cask tractor would be the tow vehicle used to move horizontal dual-purpose canisters. The cask tractor would pull a cask transfer trailer carrying a transportation cask containing a horizontal dual-purpose canister from the Receipt Facility to the Aging Facility. Once aging was complete, the cask tractor would pull the cask transfer trailer carrying a horizontal shielded transfer cask containing a horizontal dual-purpose canister from the Aging Facility to the Wet Handling Facility. There would be two different cask transfer trailers to accommodate the different casks to be carried. Each cask transfer trailer would be a heavy industrial trailer with a support skid mounted on top.

2.1.2.1.8 *Waste Package Transport to the Subsurface Facility*

At the Initial Handling Facility and the Canister Receipt and Closure Facility, the completed waste packages would be positioned on an emplacement pallet such that a transport and emplacement vehicle could receive them, move them to the subsurface, and emplace them in the repository. A transport and emplacement vehicle would transport the waste package on an emplacement pallet from the Initial Handling Facility or Canister Receipt and Closure Facility to a subsurface emplacement drift through the *North Portal* and down the *North Ramp* to the appropriate emplacement drift. The waste package and its emplacement pallet would be transported as a single unit.

The transport and emplacement vehicle would be a specialized, shielded rail vehicle designed to move waste packages safely from the surface facilities into the subsurface facility for emplacement. The vehicle design would prevent uncontrolled movement that could lead to a breach of a waste package and withstand rockfall occurrences without jeopardizing the structural integrity of the waste package. To accommodate the high radiation environment of the emplacement drifts, the transport and emplacement vehicle would be controlled by an onboard, programmable logic controller and monitored by operators in the Central Control Center. Figure 2-6 shows the transport and emplacement vehicle.

2.1.2.2 Subsurface Facilities and Operations, Including Ventilation

DOE would excavate drifts (horizontal tunnels) in Yucca Mountain for waste emplacement. The subsurface facilities would consist of three access mains, which would be 7.6-meter (25-foot)-diameter tunnels that would provide access to smaller emplacement drifts. Emplacement drifts would be 5.5-meter (18-foot)-diameter tunnels. The design is based on an emplacement drift spacing of 81 meters (270 feet). The total repository emplacement area to accommodate 70,000 MTHM is about 6 square kilometers (1,500 acres).

Approximately 68 kilometers (42 miles) of emplacement drifts would be excavated in four panels. About 11,000 waste packages and their emplacement pallets would be placed in these drifts. DOE would use mechanical excavation methods such as electric-powered tunnel boring machines to excavate drifts (Figure 2-7), as well as road headers, drill and blast using explosives, and raise borers, depending on the application of the tunnel or *shaft*.

Ground support would protect workers by providing tunnel stability and preventing rockfall. Ground support would differ for the various types of underground openings. Ground support for emplacement drifts would consist of initial ground support and final ground support.

The initial ground support would provide worker safety until installation of the final ground support system. The initial ground support would consist of carbon-steel frictional rock bolts and wire mesh based on industry standard materials. The initial ground support would be installed in the drift crown only, immediately after excavation. The wire mesh would be removed before installation of the final

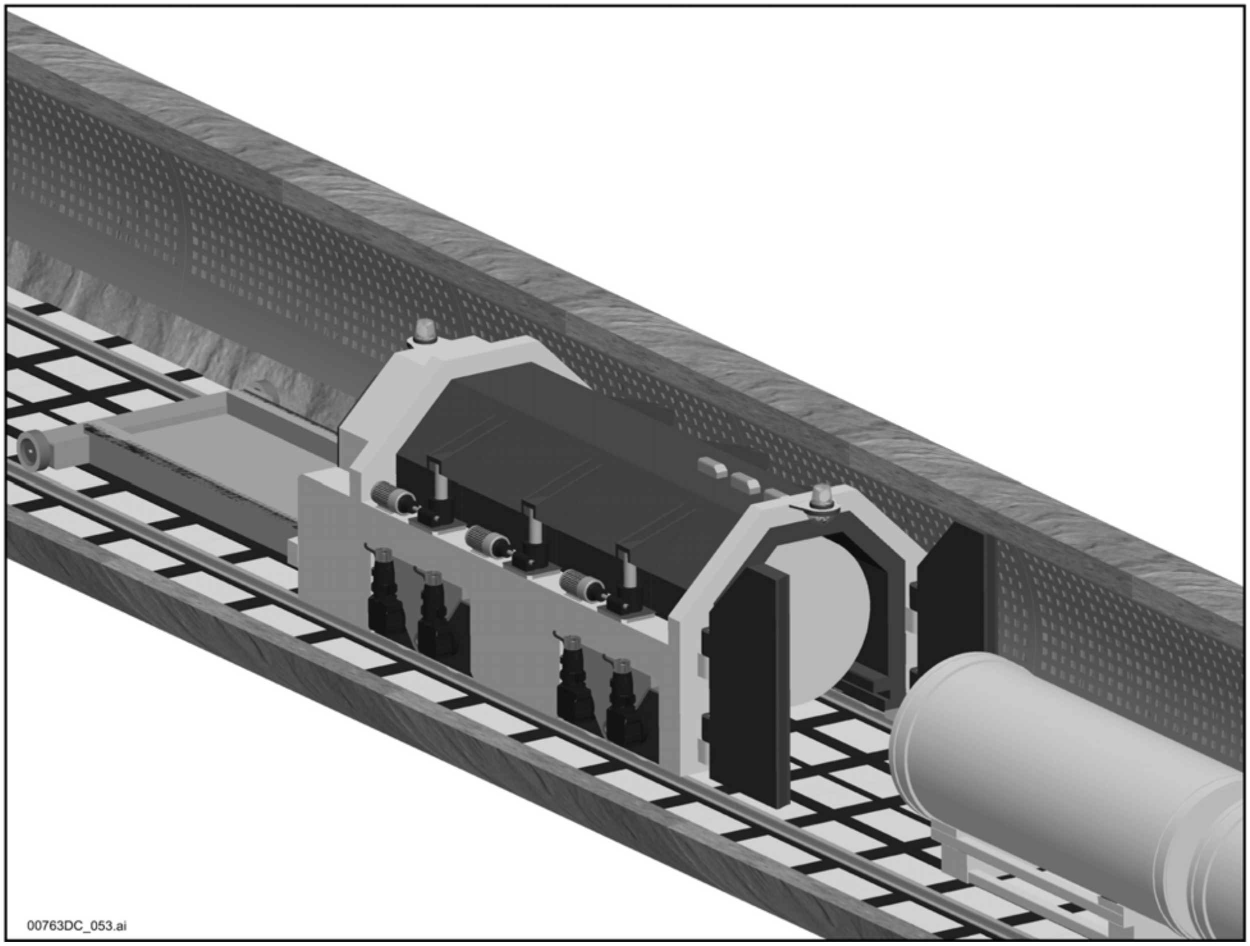


Figure 2-6. Transport and emplacement vehicle placing waste package in emplacement drift (artist's concept).

ground support, while the initial rock bolts would remain in place. The purpose of this initial ground support would be to protect personnel from loosened rock during the tunneling process, and to protect the geologic mapping personnel who could follow the tunnel boring machine in selected locations.

Final ground support for the emplacement drifts would be installed before the drifts were equipped with utilities and *invert* structures. Final ground support would consist of friction rock bolts, 3 meters (9.8 feet) long, spaced at 1.25-meter (4.1-foot)-intervals, and perforated metal sheets, 3 millimeters (0.12 inch) thick, installed in a 240-degree arc around the drift periphery along the entire drift length. Both the friction bolts and perforated metal sheets would be made of Stainless Steel Type 316 or equivalent. This material is corrosion-resistant, and DOE chose it based on the potential corrosion mechanisms in the repository environment during the preclosure analytical periods.

The ground support for the portals would consist of fully grouted rock bolts with fiber-reinforced shotcrete installed around the portal frontal and lateral faces. Due to the functions that the ramps provide as access ways for personnel and, in the case of the North Ramp, for waste package transportation, fully grouted rock bolts would be supplemented with a lining of shotcrete to enhance the ground support function in the three ramps.

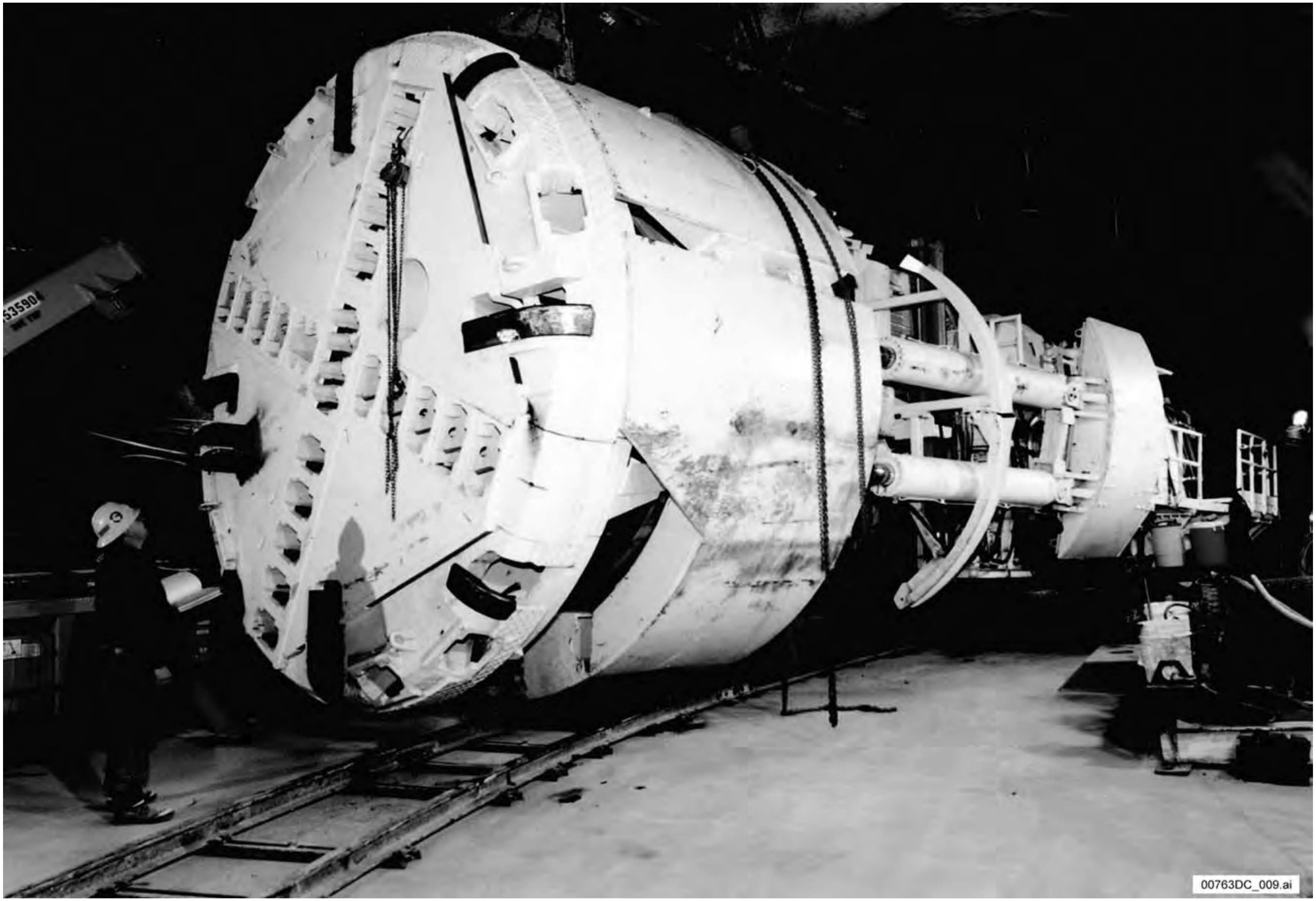


Figure 2-7. Tunnel boring machine.

Ground support design at intersections between the access main drifts and turnouts or between exhaust main drifts and emplacement drifts would consist of fully grouted rock bolts with fiber-reinforced shotcrete and lattice girders as necessary. Fully grouted rock bolts with welded wire mesh would be used for ground support in most of the nonemplacement openings, which would include access mains, exhaust mains, and turnouts.

Ventilation would be necessary for maintenance of airflow to the subsurface facilities during construction (development), emplacement, and monitoring. In addition, DOE would provide positive-pressure ventilation flow for the development of the repository and negative-pressure ventilation flow to the emplacement drifts. The configuration of the subsurface facility ventilation system would change over time as emplacement panels were added, until the repository was fully developed. The subsurface facility ventilation would consist of two operationally independent and separate systems: the development ventilation system and the emplacement ventilation system. Isolation barriers would physically separate the development side from the emplacement areas. These systems would enable concurrent development of emplacement drifts on one side of the isolation barriers and waste emplacement in operational emplacement drifts on the other side. The two systems would have independent airflow networks and fan systems that operated concurrently. The development ventilation system would be a supply system, with the primary purpose of ensuring the health and safety of subsurface personnel. The emplacement ventilation system would be an exhaust system with the primary purpose of attaining thermal goals in the repository. When the repository reached full emplacement, DOE would operate the entire subsurface facility with one subsurface ventilation system. That system would use all the intake and exhaust ventilation airways described in the design, and it would distribute air from the intake air zone into the emplacement drifts and remove heated air from the emplacement drifts to the heated air zone and out to the surface. The continuous forced ventilation to the emplacement drifts for an extended period after emplacement of waste packages would provide heat removal that is considered part of the bases for *postclosure* analyses.

The overall ventilation system would consist of three intake shafts and six exhaust shafts. The three ramps would act as additional ventilation intakes. Ventilation shafts are vertical openings, typically circular, excavated by mechanical means or by drill-and-blast techniques. The repository ventilation shafts would be either 4.9 meters (16 feet) or 7.9 meters (26 feet) in diameter. These nine shafts and three ramps would serve 108 emplacement drifts in the four repository waste *emplacement panels*.

The shafts would be near the crest of Yucca Mountain in an area that would have roads, shaft pads, and electrical utility transmission lines. The ventilation rate across each emplacement drift would be 15 cubic meters per second (approximately 32,000 cubic feet per minute). Figure 2-4 shows the main and emplacement panels and ventilation shafts.

2.1.2.2.1 *Subsurface Facility Emplacement Panels*

The subsurface facility would be divided into four waste emplacement panels that would be developed and made operational in sequence over a period of years, planned to coincide with the receipt of waste. Emplacement panels can best be described as groups of isolated tunnels set aside for waste disposal. Each panel would consist of multiple emplacement drifts in which DOE would dispose of the waste packages. Each panel would share common subsurface facilities for access, monitoring, and ventilation (Figure 2-4). The repository panels and their associated engineered barriers would function in conjunction with the *natural barriers* to provide waste containment and isolation during the preclosure and postclosure periods.

The emplacement panels would be excavated in rock formations that DOE has selected because of their attributes for waste containment and isolation. The excavations dedicated to waste emplacement would be equipped to (1) support waste emplacement and *retrieval* equipment, (2) contain a stable invert structure capable of holding the waste packages on their emplacement pallets and drip shields in stable positions, and (3) provide ground support systems capable of maintaining the safety and integrity of the excavations throughout the preclosure period.

As described below for Panel 1, construction would begin at a location in the existing *Exploratory Studies Facility* tunnel. DOE developed the Exploratory Studies Facility as the main test facility for collection of detailed geologic, hydrologic, and geophysical information on the welded volcanic *tuff* of the Topopah Spring unit identified as the host horizon for permanent spent nuclear fuel and high-level radioactive waste disposal. The Department began construction of the Exploratory Studies Facility in September 1994, using a 7.6-meter (25-foot)-diameter tunnel boring machine that excavated a 7.9-kilometer (4.9-mile), U-shaped tunnel into Yucca Mountain. The Exploratory Studies Facility has three main sections: (1) the North Ramp, which descends 2.8 kilometers (1.7 miles) into the mountain; (2) the main area of the facility, approximately 213 meters (700 feet) below the surface of the ramp entrance and running approximately 3.2 kilometers (2.0 miles) through the Topopah Spring unit of the mountain; and (3) the South Ramp, which ascends 2.2 kilometers (1.4 miles) back to the surface at the South Portal development area.

Panel 1

Construction would start with Panel 1 because this proposed location would be easily accessible from the North Portal. This panel would require the least amount of development work because of its small size and because it would use existing excavations for access. Panel 1 would be in the central section of the overall layout. Excavation and construction of six emplacement drifts would proceed from north to south. DOE would excavate one exhaust shaft during the same period. The Department would use three emplacement drifts for initial emplacement while development of the remaining drifts in the panel continued concurrently with that operation. The use of an observation drift in Panel 1 would support the Performance Confirmation Program at this time. DOE would construct isolation barriers to separate the initial emplacement area from the continuing construction in Panel 1. This panel would have six emplacement drifts.

Panel 2

After Panel 1 excavation was complete, DOE would excavate Panel 2. This panel would be accessed from the South Portal. Aside from Panel 1, Panel 2 would require the least amount of preparation for waste emplacement. Excavation and construction of emplacement drifts would proceed from north to south. This panel would have two exhaust shafts and one intake shaft and would have 27 emplacement drifts.

Panel 3

After Panel 2 excavation was complete, DOE would excavate Panels 3E and 3W. These panels, which would share a common access main, would be excavated alternately from south to north. Substantially more development would be necessary to prepare Panel 3 and associated drifts for emplacement in comparison with Panels 1 and 2. The North Construction Portal and North Construction Ramp, five ventilation shafts, and the excavation of access and exhaust mains would be constructed to support development activities for Panels 3E and 3W. The emplacement drifts for these two panels would be filled alternating from east to west, starting from the south and working north. Panels 3E and 3W would have a combined total of 45 emplacement drifts.

Panel 4

Panel 4 would be excavated in the western limit of the subsurface geologic repository operations area and accessed through the North Construction Portal. Panel 4 would be excavated concurrently with Panel 3. Construction activities would not be as extensive as those for Panels 3E and 3W. However, for reasons related to ventilation isolation, rock haulage, and construction access, waste emplacement in Panel 4 would occur last. The emplacement drifts in Panel 4 would be filled from the south to the north. This panel would have 30 emplacement drifts.

2.1.2.2.2 *Waste Emplacement in the Subsurface Facility*

Waste packages would be emplaced in dedicated emplacement drifts, supported on emplacement pallets, and aligned end-to-end on the drift floor inverts (Figure 2-8). Emplacement pallets would be fabricated from *Alloy 22* and Stainless Steel Type 316, which are corrosion-resistant and which DOE chose based on the potential corrosion mechanisms in the repository environment. The supports would have a V-shaped top surface to accept all waste package diameters. The waste package would not be mechanically attached to the pallet; it would rest on the V-shaped surfaces of the pallet. Because the ends of the waste package would extend past the ends of the emplacement pallet, the waste packages would be placed end-to-end, nominally 10 centimeters (4 inches) from each other, without interference from the pallets.

The emplacement pallet and waste package would be moved as one unit from a Canister Receipt and Closure Facility or the Initial Handling Facility to the emplacement drift. The emplacement pallet would support the waste package in the drift throughout the preclosure period. When the shielded transport and emplacement vehicle arrived at the assigned location in an emplacement drift and the emplacement access doors on the transport and emplacement vehicle opened, the emplacement pallet with its waste package would be lowered from the vehicle to its emplacement location in the drift.

2.1.2.2.3 *Engineered Barrier System*

The following components in the emplacement drifts would collectively comprise an Engineered Barrier System that would contribute to waste containment and isolation: (1) waste package, (2) emplacement pallet, (3) emplacement drift invert, (4) drip shield, and (5) emplacement drift. Figure 2-9 shows a cross section of a waste package, pallet, emplacement drift invert, and drip shield. The following sections summarize the details of these components.

Waste Package

The waste packages would consist of two concentric cylinders. The inner cylinder would be made of a modified Stainless Steel Type 316, and the outer cylinder would be made of corrosion-resistant, nickel-based Alloy 22. The Alloy 22 cylinder would provide long-term protection for the internal components of the waste package, including the stainless-steel inner cylinder, from corrosion and contact with water.

The Stainless Steel Type 316 cylinder would provide structural support for the thinner Alloy 22 cylinder. The basic waste package design would be the same for the various waste forms. However, the sizes and internal configurations would vary to accommodate the different waste forms.

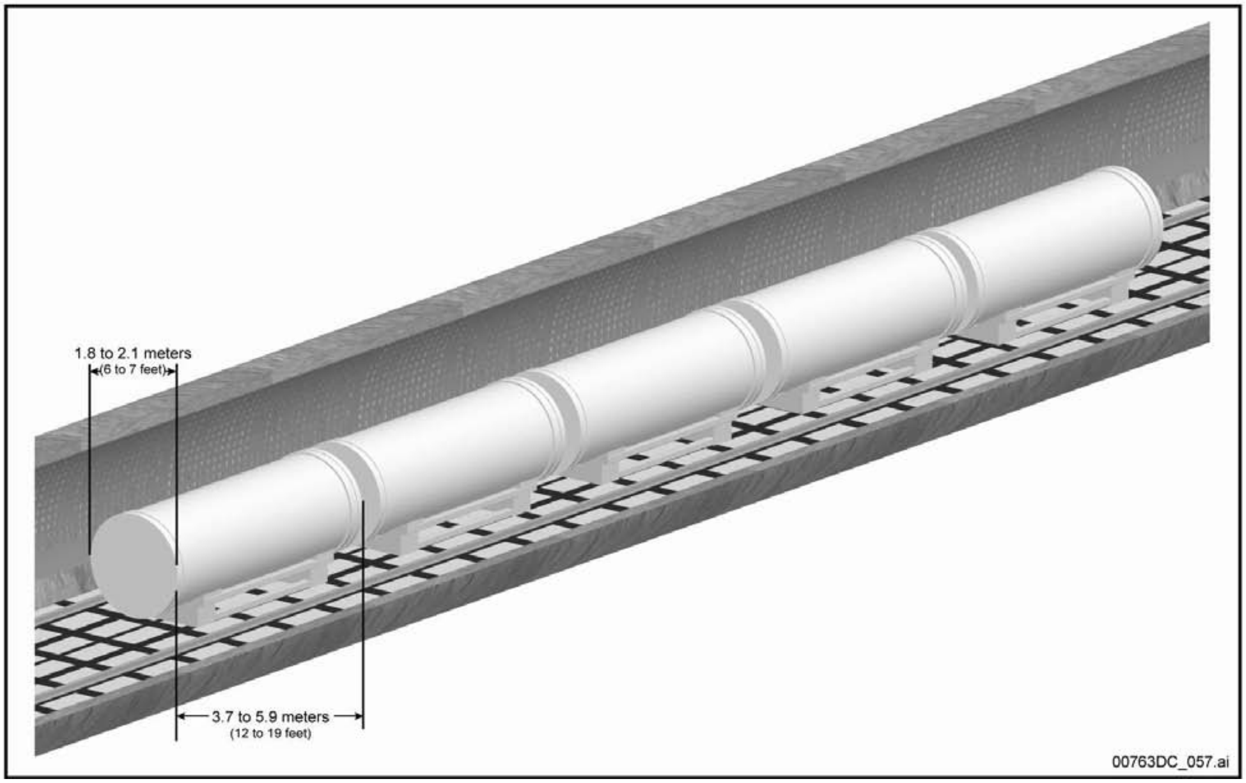


Figure 2-8. Emplacement pallets loaded with waste packages in an emplacement drift (artist's concept).

There would be minor changes to the waste package design from that described in the Yucca Mountain FEIS. Changes include (1) a new outer lid and closure weld techniques; (2) reduced stainless-steel inner lid thickness, including a spread ring closure for all waste packages except the DOE codisposal waste package, which would have a thicker inner lid that also served as a shield plug; (3) removal of the previously used trunnion collars so the waste package would be lifted only by the pallet; and (4) modification of the gap between the inner and outer vessel to better accommodate thermal expansion.

Corrosion tests on Alloy 22 have been and continue to be performed in a variety of thermal and chemical environments. Analyses indicate that Alloy 22 lasts considerably longer than 10,000 years, in the range of expected environments at the proposed repository (DIRS 166894-BSC 2004, all; DIRS 169766-BSC 2004, all; DIRS 170878-BSC 2004, all).

Emplacement Pallet

Emplacement pallets would support the waste packages in the drift. During preclosure and after closure, the emplacement pallet would prevent the waste package from coming into contact with the invert of the drift. The emplacement pallet would continue to fulfill its function of supporting the waste package during a *seismic* event and would maintain the waste package in position separate from other emplacement drift components during the postclosure period.

Emplacement Drift Invert

The emplacement drift invert would include structures and materials at the bottom of the emplacement drifts that supported the pallets and waste packages, drift rail system, and drip shields. The emplacement

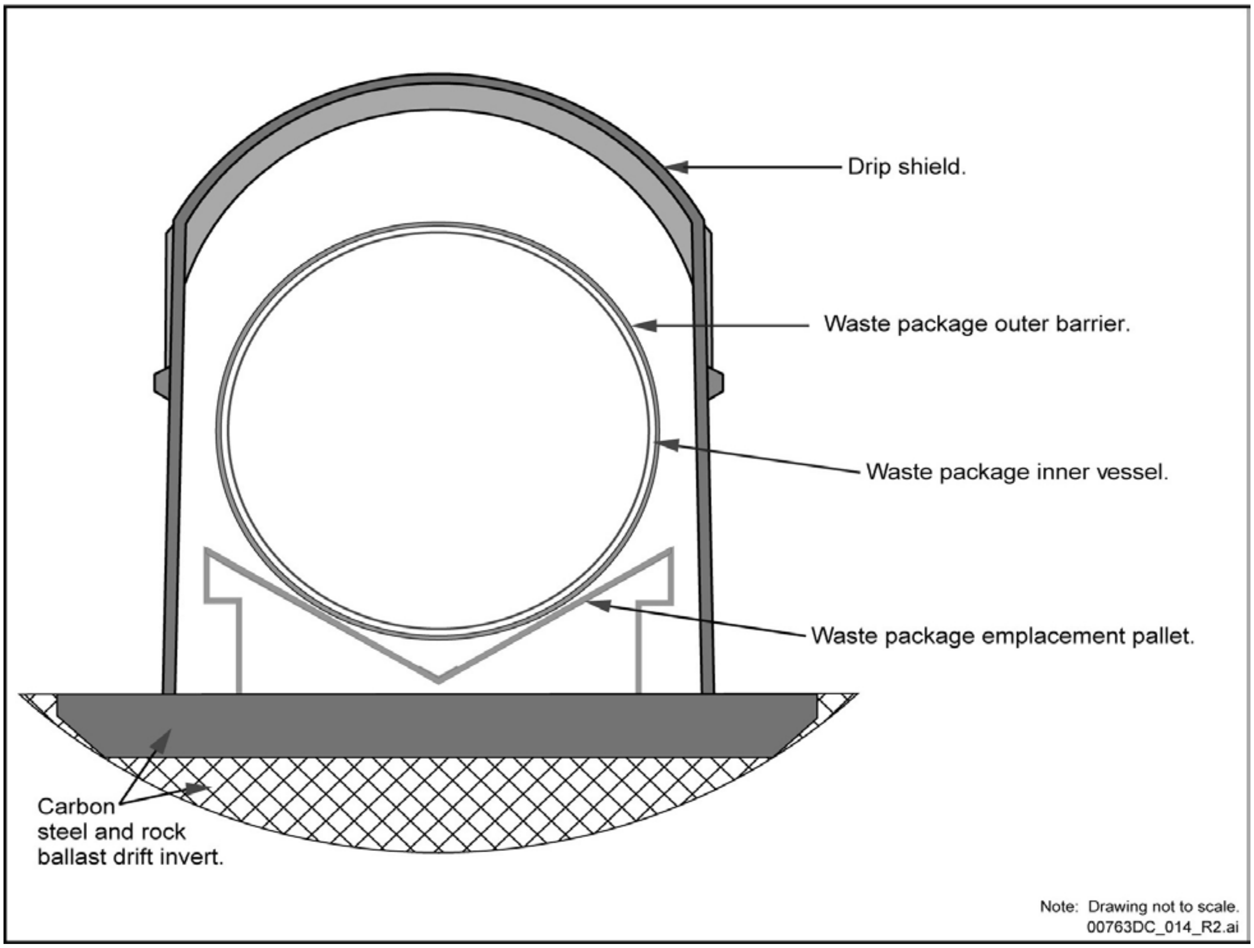


Figure 2-9. Cross section of a waste package, pallet, emplacement drift invert, and drip shield (artist's concept).

drift invert structure would consist of two components: the steel invert structure and the ballast fill. The steel invert structure would provide a platform to support the emplacement pallets, waste packages, and drip shields. The ballast would fill the voids between the drift rock and the invert steel frame, and the level of the ballast would be brought up to the top level of the steel. DOE has selected steel and crushed tuff (from the repository excavations) for the invert components based on their structural strength properties, compatibility with the emplacement drift environment, and expected longevity.

After repository closure, the crushed tuff in the invert would provide a layer of material below the waste packages that would (1) slow the movement of *radionuclides* into the host rock in the event of a waste package breach, and (2) provide support in the event of pallet failure after tens of thousands of years.

Drip Shield

A drip shield would protect each waste package in the repository. After the NRC approved a decision to close the repository, DOE would install titanium drip shields to protect waste packages from dripping water and rockfall. The drip shield would be fabricated from Titanium Grade 7 plates for the water diversion surfaces, Titanium Grade 29 for the structural members, and Alloy 22 for the bases. The Alloy 22 bases would be mechanically attached to the titanium drip shield side plates because the two materials cannot be welded together. The Alloy 22 bases would prevent direct contact between the titanium and the carbon-steel members in the invert, which could result in hydrogen embrittlement of the titanium. All the drip shields would be of a uniform size and would interlock with each other to form a continuous enclosure over all the waste packages.

There would be minor changes to the drip shield design from that proposed in the Yucca Mountain FEIS. The drip shields would be taller, increasing the distance from the waste package to the drip shield to minimize impacts from rockfall. Longitudinal stiffener beams would be added to provide greater strength for bending loads along the axial length of the drip shields, and the new design has simplified the handling and interlocking features.

Emplacement Drift

As described above, the repository would be divided into emplacement panels, each of which would contain a number of emplacement drifts. Panels would vary in size depending on physical and design constraints. The emplacement drift would be part of the Engineered Barrier System because it would provide a stable environment for waste emplacement and monitoring during preclosure. In addition, the emplacement drift would provide the environmental setting for waste packages and other engineered barrier components after repository closure.

2.1.2.3 Balance of Plant Facilities

The balance of plant facilities would be those that would not be directly involved in radioactive waste handling. These facilities would be in the surface geologic repository operations area (Figure 2-4) and would consist of the Central Control Center Facility, Warehouse and Non-Nuclear Receipt Facility, Heavy Equipment Maintenance Facility, Low-Level Waste Facility, Emergency Diesel Generator Facility, and other supporting facilities as discussed in the following sections.

2.1.2.3.1 *Central Control Center Facility*

The Central Control Center Facility would be in the central part of the surface geologic repository operations area (Figure 2-5, Facility 240) and would provide centralized communications and sitewide monitoring and control. The facility would provide space and layout for three major areas: the Central Control Center, an alarm station, and a central communications room. The Central Control Center would be the area from which the entire repository was monitored, selected infrastructure systems were controlled, and other systems were controlled on a supervisory level. The primary alarm station would include safeguards and security measures, support the material control and accounting program, and provide protective measures for personnel and property. The central communications room would provide the capability to communicate with offsite locations, including emergency response and other DOE facilities.

2.1.2.3.2 *Warehouse and Non-Nuclear Receipt Facility*

The Warehouse and Non-Nuclear Receipt Facility would be in the central part of the surface geologic repository operations area (Figure 2-5, Facility 230). The facility would be a nonradiological facility that would receive empty waste packages, empty TAD canisters, aging overpacks, and emplacement pallets from offsite manufacturers. It would have the capability for inspection, cleaning, and staging of these components for use by the Canister Receipt and Closure Facilities, the Receipt Facility, the Initial Handling Facility, and the Wet Handling Facility.

2.1.2.3.3 *Heavy Equipment Maintenance Facility*

The Heavy Equipment Maintenance Facility would be in the central part of the surface geologic repository operations area (Figure 2-5, Facility 220) and would provide the maintenance capability for the heavy-load handling equipment (such as the site transporter) used to transport and handle spent nuclear fuel and high-level radioactive waste in the geologic repository operations area.

The Heavy Equipment Maintenance Facility would have overhead cranes, tow vehicles, forklift trucks, a machine shop, a welding shop, and large maintenance bays for equipment parking and laydown space. In addition, this facility could receive, stage, handle, and manage waste package emplacement pallets. Transport and emplacement equipment would move to the Heavy Equipment Maintenance Facility for repair and routine maintenance.

DOE would use the Heavy Equipment Maintenance Facility to stage equipment and recover from unscheduled mobile equipment outages. Operations that involved tow vehicles, mobile cranes, heavy-lift equipment, and tractor-trailer operations could be planned and implemented from this facility.

2.1.2.3.4 *Low-Level Waste Facility*

The Low-Level Waste Facility would be in the western part of the surface geologic repository operations area (Figure 2-5, Facility 160). The facility design would include the collection, processing, and preparation for offsite shipment for the disposal of *low-level radioactive waste* streams generated during the handling of high-level radioactive waste and spent nuclear fuel. DOE would control and dispose of site-generated low-level radioactive waste in a DOE low-level waste disposal site, a site in an *Agreement State*, or an NRC-licensed site.

The Low-Level Waste Facility would contain storage for wastes in boxes, drums, filters, and high-integrity containers. Empty dual-purpose canisters would be stored in the facility for eventual disposal at an offsite low-level waste facility or offsite shipment for recycling.

Waste forms that DOE would handle at this facility include materials such as:

- Dry, solid low-level radioactive waste
  - Plastic, metal, paper, cloth, and rubber items
  - Wood
  - Concrete
  - Empty dual-purpose canisters
- Wet, solid low-level radioactive waste
  - Mechanical filters and material collected by the pool vacuum system
  - Mop heads, wet rags, sponges, and similar wet cleaning products used in contaminated areas
- Liquid low-level radioactive waste

- Equipment drains—including, but not limited to, heating, ventilation, and air conditioning systems condensate; mop water from contaminated areas; and emergency shower and eyewash water

- Decontamination wash water—such as water from decontamination of transportation casks and TAD canisters

- Floor drain system—collected fire suppression water from potentially contaminated areas

DOE would transport liquid waste to the Low-Level Waste Facility from the Initial Handling Facility, the Canister Receipt and Closure Facilities, and the Receipt Facility in tanker trucks or in containers (with shielding being provided as needed) on standard vehicular transport such as an open flatbed truck, or pumped liquid waste from the collection tanks at the Wet Handling Facility. The low-level liquid waste would be transferred to low-level liquid waste tanks outside the facility adjacent to one of the storage bays. Connections would be provided to mobile processing equipment, which would receive the liquid, process the liquid through appropriate cleanup media, and then return processed liquid to the process tanks. The media in the mobile processing equipment would be packaged and transported offsite.

2.1.2.3.5 *Emergency Diesel Generator Facility*

The Emergency Diesel Generator Facility would be in the central part of the surface geologic repository operations area (Figure 2-5, Facility 26D) and would provide power during the loss of normal electric power. During a power loss, the Emergency Diesel Generator Facility would provide 13.8-kilovolt power to maintain load demands in the waste handling surface facilities. Each of the two emergency diesel generators would operate independently. If normal power failed, the emergency diesel generator would start. The underground fuel-oil storage tanks for the emergency diesel generators would be adjacent to the Emergency Diesel Generator Facility.

2.1.2.3.6 *Other Balance of Plant Facilities*

This section discusses other balance of plant support facilities. DOE would develop a *central operations area* approximately 0.8 kilometer (0.5 mile) southeast of the geologic repository operations area for support operations, which would include upgrades and replacement of subsurface infrastructure in the Exploratory Studies Facility. DOE would construct new support buildings and install utilities (power, water, sewer, and communications). The support buildings would include the following:

- Administration Facility. This facility (Figure 2-5, Facility 620) would include area for offices, training, and computer operations.

- Fire, Rescue and Medical Facility. This multifunctional facility (Figure 2-5, Facility 63A) would provide space and layout for fire protection and firefighting services, underground rescue services, emergency and occupational medical services, and radiation protection. The Helicopter Pad (Figure 2-5, Facility 66A) would provide space for emergency medical evacuation.

- Craft Shops. Craft Shops (Figure 2-5, Facility 71A) would include primary shop services for maintenance and repair operations.

- Vehicle Maintenance and Motor Pool. The Vehicle Maintenance and Motor Pool would be near each other (Figure 2-5, Facility 690). The Vehicle Maintenance and Motor Pool would have space for refueling islands to supply diesel, gasoline, propane, and compressed natural gas to construction vehicles and separate facilities for vehicle maintenance and washing.

- Diesel Fuel Oil Storage and Fueling Station (Figure 2-5, Facilities 70A and 70B, respectively) would provide storage for fuel oil and would be the beginning point of the system that would distribute fuel oil throughout the geologic repository operations area, with the exception of fuel for the generators at the Emergency Diesel Generator Facility. The fuel-oil system would consist of tanks, pumps, instrumentation, and ancillary equipment. The main fuel-oil storage tank would provide fuel oil to the hot-water boilers, standby diesel generators, and diesel-driven fire water pumps.

- Warehouse/Central Receiving. This permanent facility (Figure 2-5, Facility 68A) would consist of storage space, a receiving and shipping dock, and general management functions. These facilities would provide space for material receiving, inspection, and storage; material isolation and control; industrial hazardous materials storage; and management of materials.

- Storage Areas. The materials and yard storage area (Figure 2-5, Facility 68B) would provide functional space for storing materials. The equipment yard/storage (Figure 2-5, Facility 71B) would provide functional space for storing equipment. The Aging Overpack Staging Facility (Figure 2-5, Facility 290) would be an outdoor storage area for empty aging overpacks and unloaded (noncontaminated) used aging overpacks not immediately needed by the waste handling facilities, delivered for staging by a site transporter. The railcar buffer area and truck buffer area (Figure 2-5, Facilities 33A and 33B, respectively) would provide space for staging railcars and trucks, respectively.

Other balance of plant facilities would be the Fire Water Facilities and security stations. There would be three Fire Water Facilities in the surface geologic repository operations area and vicinity when the repository was fully operational (Figure 2-5, Facilities 28A, 28B, and 28E). The facilities would provide space for fire water storage tanks, pumping equipment and systems, and support equipment.

DOE would establish security stations at personnel access points to the geologic repository operations area. These would include a Central Security Station, a Cask Receipt Security Station, and a North Perimeter Security Station (Figure 2-5, Facilities 30A, 30B, and 30C, respectively). The Central Security Station would provide space for security functions to control physical access to the geologic repository operations area and would establish the primary interface between the protected area and the other areas of the Yucca Mountain site for personnel and vehicle traffic. The Central Security Station would provide security operational functions (such as portal monitors, personnel access control, and vehicle access), as well as internal functions required by or for the security group. The Cask Receipt Security Station would provide facilities for physical inspections (security and radiological) of outgoing casks and incoming cask shipments by either rail or truck. In addition, the Cask Receipt Security Station would function as the point of custody transfer for the receipt of cask shipments. This facility would not support personnel access or egress under normal operating conditions. The North Perimeter Security Station would function only as an exit facility from the protected area.

2.1.2.4 Utilities

The proposed utilities for the Yucca Mountain site would include electricity, water supply, wastewater and stormwater systems, Utilities Facility and cooling tower, and communications. The following sections discuss each utility.

2.1.2.4.1 *Electrical Power and Distribution*

A new site electrical power system would receive and distribute power to the facilities in the geologic repository operations area and in the vicinity. The electrical power distribution system would include a high-voltage switchyard, a 13.8-kilovolt switchgear facility, an Emergency Diesel Generator Facility with two diesel generators, and a Standby Diesel Generator Facility with four standby diesel generators (Figure 2-5, Facilities 27A, 27B, 26D, and 26B, respectively). The switchyard would provide interface between offsite and onsite electrical power systems.

The Department proposes to install two 138-kilovolt transmission lines (with a capability of 230 kilovolts if necessary) from the existing Lathrop Wells switch station that would terminate at the main substation at the central operations area (Figure 2-10). The transmission lines, which would follow utility corridors parallel to the site access road, could be installed sequentially. As an option, one line could follow a utility corridor parallel to the site access road while another line could follow a separate utility corridor. Routing decisions are not expected to affect the overall impacts of such actions. For safety purposes, one of these transmission lines could be installed to support current site activity. For analytical purposes, installation of the transmission lines were evaluated during the construction analytical period.

From the main substation at the switchyard in the central operations area, the distribution system would branch to several primary electrical distribution points. From the substation at the central operations area, DOE would install two 13.8-kilovolt distribution lines: an approximately 1.6-kilometer (1-mile) replacement line to power the existing Exploratory Studies Facility equipment and a 3.2-kilometer (2-mile) line to a substation at the South Portal to provide power to operate exhaust fans that currently function intermittently on generator power.

2.1.2.4.2 *Water Supply*

The Proposed Action would require both potable and raw, or nonpotable, water systems. The function of the raw water system would be to provide raw water to the North Portal, the North Construction Portal area, and the South Portal. Potable water would be provided to facilities for drinking and for safety fixtures use, such as for emergency showers and eyewashes. Nonpotable water would be provided through the distribution piping as utility water in the nonradiological facilities for washdown and housekeeping. In addition, nonpotable water would be used in the closed-loop hot water and chilled water systems and for decontamination. Deionized water would be provided for makeup water lost from the pool in the Wet Handling Facility.

DOE would upgrade existing site sources of raw water, which would include rework of the C-Wells, piping supply systems, water storage tanks, a booster pump station and booster tanks, a fire water tank, chlorination system, arsenic treatment system, a potable water storage tank, service connections to the water system on the North Portal pad, and controls to meet national standards, such as those of the American Water Works Association and National Fire Protection Association. Water storage tanks would

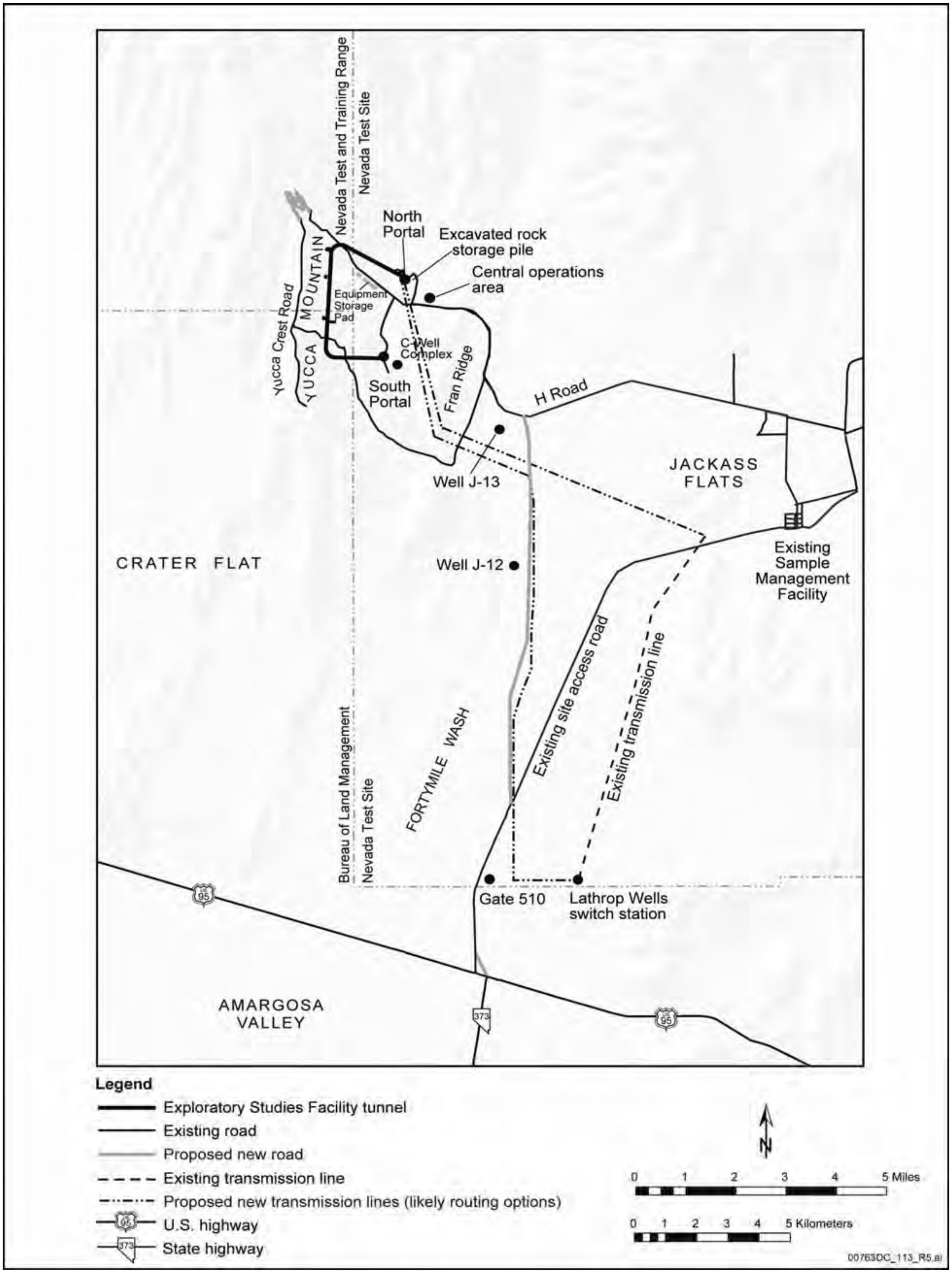


Figure 2-10. Location of features in the vicinity of the Yucca Mountain site.

be installed in the surface geologic repository operations area or in the immediate vicinity. Water would be pumped from existing C-Wells and J-Wells (Figure 2-10). A new well at Gate 510 would provide domestic and fire protection water for the Gate 510 security station, off U.S. Highway 95 at the southern entrance of the *land withdrawal area*.

2.1.2.4.3 *Wastewater and Stormwater Systems*

The *sanitary waste* system would consist of septic tanks and leach fields in the central operations area (Figure 2-5, Facility 35A). As an option, DOE has included an evaluation of the potential benefits and impacts of implementation of a wastewater treatment system in Appendix A of this Repository SEIS.

A stormwater collection system would be installed to collect stormwater from roadways, graded areas, and roof surfaces from the waste handling facilities in the vicinity of the North Portal pad and to route this water to a lined *retention pond* near the Utilities Facility (Figure 2-5, Facility 90A). A retention pond is designed to hold a specific amount of water indefinitely.

Three stormwater *detention pond*s in the vicinity of the surface geologic repository operations area would collect stormwater runoff. A detention pond is a low-lying area that is designed to hold a set amount of water temporarily while slowly draining to another location. Such ponds exist for flood control when large amounts of rain could cause flash flooding if not dealt with properly. The detention ponds would be near the Helicopter Pad and the Cask Receipt Security Station.

During construction and development, DOE would collect excess water from dust suppression applications as well as water from tunnel boring operations and water from concrete mixing and cleanup, and pump it to lined *evaporation ponds* at the South Portal development area and the North Construction Portal. An evaporation pond is a containment pond (with an impermeable lining of clay or synthetic material) to hold liquid wastes and to concentrate the waste through evaporation. Another evaporation pond (Figure 2-5; Facility 25C) would be near the Utilities Facility for collection of blowdown from the cooling tower and liquids from regeneration of water softeners. A fourth evaporation pond would be in the central operations area and would receive process water from two oil-water separators as well as superchlorinated water generated from maintenance of the drinking water system.

2.1.2.4.4 *Utilities Facility and Cooling Tower*

The Utilities Facility (Figure 2-5, Facilities 25A, 25B, and 25C) would include a cooling tower and evaporation pond (described above). The Utilities Facility would house the support systems, equipment, and controls, such as those necessary for the heating, ventilation, and air conditioning; central chilled water and hot water heating subsystems; and other services to support process operations, such as chillers, heaters, and deionized water. DOE would design systems in the building that would interface with radiological operations or facilities with features to prevent radiological cross-contamination of the Utilities Facility.

2.1.2.4.5 *Communications Systems*

Expansion and upgrades to the communications systems would include connectivity between the Yucca Mountain site, the Las Vegas Data Center, the DOE Office of Civilian Radioactive Waste Management, management and operating contractor facilities, and Nye County emergency response facilities. This connectivity would consist of dual fiber-optic lines, cellular telephone towers, microwave systems to Las

Vegas, radio systems, telephone switch systems, dual satellite links, federally approved encryption equipment, and a network operations building.

2.1.3 CONSTRUCTION SUPPORT FACILITIES

For analytical purposes, DOE has included activities to repair, replace, or improve certain facilities, structures, roads, and utilities (collectively referred to as *infrastructure*) for the Yucca Mountain Project to enhance safety at the project and to enable DOE to continue ongoing operations, scientific testing, and routine maintenance safely as part of the Proposed Action. The Department assumed these activities would occur during the construction analytical period. The activities would include demolition or relocation of the existing facilities at the North Portal, excavation of fill material down to the original ground contours, and placement and compaction of engineered *backfill* in the area of waste handling facilities construction. Three concrete batch plants would be in the area. Two plants would have a capacity of 190 cubic meters (250 cubic yards) per hour, and one plant would have a capacity of 115 cubic meters (150 cubic yards) per hour. Aggregate and material storage bins would be collocated with the concrete batch plants.

In addition, the excavated rock currently stored near the North Portal would be removed and either used during construction or moved to an excavated rock storage pile at the South Portal development area. Approximately 600,000 cubic meters (800,000 cubic yards) of fill and excavated rock currently are in the area that would become the surface geologic repository operations area. Improvements would include work at an area previously used for equipment and material storage, about 2.4 kilometers (1.5 miles) southeast of the North Portal. Site preparation of this area would include bringing the site to the appropriate grade, installing underground utilities, improving the entrance, upgrading or constructing access roads and a parking area, and constructing a detention pond.

Development of the Yucca Mountain subsurface facilities would be achieved primarily through the use of two ramps and portals, known as the North Construction Ramp and Portal, at the north end of the repository, and the South Portal development area (which includes a ramp and portal) at the south end of the repository. Figure 2-4 shows the locations of the North Construction Portal and the South Portal. The North Portal would provide access for construction of Panel 1 until receipt of a license to receive and possess radioactive materials.

The North Construction Portal and North Construction Ramp would remain available throughout development of the subsurface after emplacement began and would allow access for the construction of emplacement panels in the north half of the subsurface facility. In addition, the North Construction Portal and North Construction Ramp would accommodate construction ventilation ducting, ancillary ventilation equipment, and rock removal equipment such as a conveyor. Similar to the North Construction Portal, the South Portal development area would accommodate construction support facilities. In addition, the South Portal development area would support the excavation and construction of the repository and occupy about 0.08 square kilometer (20 acres).

Both the North Construction Portal and the South Portal development area would contain:

- Staging facilities for personnel, materials, and equipment.
- Concrete batch plants.

- Equipment maintenance facilities that included wash racks and a change house.

- Excavated rock storage areas. Two separate locations are designated for the storage of excavated rock. Excavated rock initially would be removed from the South Portal and placed in a storage area near the South Portal development area. The remainder of the excavated rock would be removed from the North Construction Portal and placed in a rock storage area north of the Aging Facility and east of the North Construction Portal. The area covered by both excavated rock storage areas would be approximately 0.8 square kilometer (200 acres).

- Utilities services, including electricity, water, and wastewater disposal to a septic tank and leach field.

2.1.4 OTHER PROJECT FACILITIES

This section discusses other project facilities that would support construction, operations, monitoring, and eventual closure of the repository. With the exception of onsite roads, these facilities would be outside the geologic repository operations area.

2.1.4.1 Roads

DOE would construct, improve, or replace paved roads and graded dirt construction and haul roads in the land withdrawal area. In addition, DOE would build (1) a new 13.7-kilometer (8.5-mile)-long, four-lane, paved access road from a point 3.7 kilometers (2.3 miles) north of Gate 510 on the existing access road of the Nevada Test Site to a point about 0.8 kilometer (0.5 mile) east of *Fortymile Wash*, where it would connect to an existing road (H Road), (2) a new 2.1-kilometer (1.3-mile)-long, two-lane, paved road to the crest of Yucca Mountain, and (3) a new 4-kilometer (2.5-mile)-long road leading to Fran Ridge. In total, DOE would construct about 40 kilometers (25 miles) of paved roads (new and replacement roads) within the *Yucca Mountain site boundary* (Figure 2-10).

In addition, DOE would construct a four-lane access road that would extend from U.S. Highway 95 to the existing access road at Gate 510. This access road could be constructed with the use of a phased approach, with initial construction of two lanes, and later widening of the road. A suitable intersection at U.S. Highway 95 also would be constructed.

2.1.4.2 Engineering and Safety Demonstration Facility

The Department would construct an Engineering and Safety Demonstration Facility in the land withdrawal area, approximately 3.2 kilometers (2.0 miles) southeast of the South Portal, at Fran Ridge. Its primary mission would be to provide data for health and safety, engineering, construction, and operations, and as a location for public outreach. The Engineering and Safety Demonstration Facility would demonstrate the following:

- The feasibility of certain features of the design and operation of a repository (for example, emplacement of ground support, waste packages, drip shields, and demonstration of dust and noise control and monitoring techniques);

- Repository constructability (for example, excavation of turnouts and drill-and-blast performance) in different types of rock, excavation of emplacement drifts by different techniques, installation of drip shields, and installation of high-density ballast for emplacement invert; and

- Remote systems (for example, a transport and emplacement vehicle for emplacement and retrieval of waste packages).

The Engineering and Safety Demonstration Facility would require construction of a 3.7-kilometer (2.3-mile)-long, 7.6-meter (25-foot)-diameter tunnel beneath Fran Ridge. The tunnel would be excavated by drilling, blasting, and mechanical techniques. About 150,000 cubic meters (200,000 cubic yards) of rock would be excavated and stored near the South Portal development area.

2.1.4.3 Offsite Training Facility

DOE would construct a training facility near the Yucca Mountain site to support the project prototype testing and the operator training and qualification programs. The facility would not be in the land withdrawal area. DOE has assumed a location near Gate 510 for the environmental impact analysis in this Repository SEIS.

2.1.4.4 Temporary Accommodations

Temporary accommodations for construction workers could be required to support expedited construction of the repository. They would include housing for construction workers; a utility zone dedicated to power supply, temporary trash storage, wastewater, and potable water treatment; eating facilities; laundry facilities; and office space. The temporary accommodations would be prepared by clearing, hauling of gravel fill, leveling, and compaction. Roads and parking areas would be created with gravel fill. Lighting would be installed for security and parking. Utility services would be provided by commercial sources. The accommodations could be expanded as necessary for additional personnel. They would be removed when no longer needed. For a conservative analysis, DOE has assumed a location near Gate 510 for the environmental impact analysis in this Repository SEIS. However, DOE could use the temporary accommodations for railroad construction workers planned for the Crater Flat area as part of the proposal in the Rail Alignment EIS. Depending on the need for housing, the Department could use the rail construction camp either in lieu of temporary accommodations at the southern boundary or in addition to those accommodations.

2.1.4.5 Sample Management Facility

DOE would construct a proposed Sample Management Facility to consolidate, upgrade, and improve storage and warehousing for scientific samples and materials. The facility could be inside the land withdrawal area, but for a more conservative analysis, DOE assumed it would be outside the land withdrawal area near Gate 510. This facility would house a variety of samples collected from studies, including rock cores. The building area would be about 3,900 square meters (42,000 square feet), surrounded by a 3,300-square-meter (36,000-square-foot) fenced area.

2.1.4.6 Surface Facilities for Performance Confirmation Activities

DOE would build surface facilities to support performance confirmation activities. These facilities would be used for administrative functions, test equipment repair and calibration, remote-operated vehicle maintenance, and data acquisition and communications.

2.1.4.7 Marshalling Yard and Warehouse

This proposed facility would consolidate material shipment and receipt into one 0.2-square-kilometer (50-acre) facility outside the land withdrawal area to enable offsite receipt, transfer, and staging of materials for construction activities at the Yucca Mountain site. Material would be hauled to the site on a just-in-time basis. The marshalling yard would require some fencing, offices, warehousing, open laydown, and shops. Some prefabrication, assembly, and other light industrial activities could be performed at this location. DOE has assumed a location near Gate 510 for environmental impact analysis in this Repository SEIS.

2.1.4.8 Borrow Pits

DOE would create borrow pits for the source of aggregate and fill material for building and subsurface and surface facilities. The Department assumed the location of the borrow pits would be in the analyzed land withdrawal area, along the main access road to the geologic repository operations area. Land disturbance would be approximately 0.4 square kilometer (100 acres).

2.1.4.9 Explosives Storage Area

DOE would store explosives in accordance with programs developed under 10 CFR Part 851, considering requirements similar to those of the Bureau of Alcohol, Tobacco and Firearms regulations (27 CFR Part 555) and Occupational Safety and Health Administration Standards (29 CFR 1910.109). DOE would build a permanent Class I magazine for the storage of high explosives. A magazine is a building or structure, other than an explosives manufacturing building, for the storage of explosives. A Class I magazine would be necessary because DOE would probably store more than 22.7 kilograms (50 pounds) of explosives at any one time. The regulations at 29 CFR 1910.109 specify requirements for a Class I magazine, including but not limited to distance from other magazines, posting with signs, construction material type, and ventilation. DOE assumed the location of the explosive storage area would be in the analyzed land withdrawal area, near the South Portal, south of the top soil storage area.

2.1.4.10 Solid Waste Landfill

DOE would construct a State-permitted *solid waste* landfill on the Yucca Mountain site for disposal of *industrial waste*, including construction and demolition debris and sanitary waste. DOE assumed the location of the sanitary landfill would be in the analyzed land withdrawal area, along the main access road to the geologic repository operations area.

2.1.5 PERFORMANCE CONFIRMATION PROGRAM

Performance confirmation refers to the program of tests, experiments, and analyses DOE would conduct to evaluate the adequacy of the information used to demonstrate compliance with the performance objectives at 10 CFR Part 63, Subpart F. Specifically, the Performance Confirmation Program must provide data that indicate, where practicable, (1) actual encountered subsurface conditions and changes in those conditions during construction and waste emplacement operations were within the limits assumed in the licensing review, and (2) natural and engineered systems and components necessary for repository operation and that DOE designed or assumed to operate as barriers after permanent closure are functioning as intended and anticipated.

The Yucca Mountain Performance Confirmation Program began during *site characterization* and would continue until permanent closure of the repository, in accordance with 10 CFR 63.131(b). The Performance Confirmation Program would include elements of site testing, repository testing, repository support facilities construction, and waste package testing. If the NRC granted the license for construction authorization, the activities would focus on monitoring and data collection for performance parameters important to the terms and conditions of the license.

The Performance Confirmation Program would consist of a focused program of tests, experiment, and analyses that DOE would use to monitor repository conditions, to assess the adequacy of geotechnical and design parameters, and to preserve the ability to perform waste retrieval of any or all waste packages, if necessary, before closure of the repository in accordance with 10 CFR 63.111(e). Retrieval, as defined at 10 CFR 63.2, would be the act of permanent removal of radioactive waste from the subsurface location at which DOE had emplaced the waste for disposal. Chapter 4, Section 4.2 of this Repository SEIS discusses implementation of a retrieval contingency and the associated environmental impacts.

DOE would build a performance confirmation observation drift about 10 meters (33 feet) below one of the emplacement drifts in the first panel. DOE would drill *boreholes* from the performance confirmation observation drift that would approach the rock mass near the emplacement drift; instruments in these boreholes would gather data on the thermal, mechanical, hydrological, and chemical characteristics of the rock after waste emplacement. DOE would acquire performance confirmation data from instruments in the performance confirmation drift or along the perimeter mains through remote inspections in emplacement drifts and monitoring of ventilation exhaust and water quality in wells.

DOE would use thermally accelerated drifts to obtain confirmatory data about anticipated postclosure conditions in the repository during the preclosure period. The Department would use drifts that were unventilated, and therefore thermally accelerated, to emulate conditions most typical of the postclosure repository. The intent would be to develop thermal environments in emplacement drifts in which DOE could monitor or observe representative postclosure coupled thermal, hydrologic, mechanical, chemical, microbial, and radiological processes and effects. Planned activities in thermally accelerated drifts would monitor in-drift conditions, expose engineered barrier material samples to potential corrosion mechanisms in representative *in situ* environments, monitor drift degradation, and test near-field coupled *processes*. The conceptual design includes at least one thermally accelerated drift at the repository horizon and an observation and instrumentation drift at a lower elevation.

DOE would use the Performance Confirmation Program data to evaluate system performance and predict system response. If the data indicated actual conditions differed from the predictions, DOE would notify the NRC and undertake remedial actions to address any such condition. The repository design includes features to implement the Performance Confirmation Program.

2.1.6 CLOSURE ANALYTICAL PERIOD

Regulations at 10 CFR 63.51(a)(1) and (2) require submittal of a license amendment to the NRC for closure of the repository. Before closure, DOE would submit an application to the NRC seeking permission to close the repository. The application would provide an update of the assessment of repository performance for the period after closure, as well as a description of the program for postclosure monitoring to control or prevent activities that could impair the long-term isolation of waste. The Postclosure Monitoring Program, as required by Section 801(c) of the *Energy Policy Act of 1992* and as required by the NRC (10 CFR Part 63), would include the monitoring activities DOE would conduct around the repository after it closed the facility. The details of this program would be delineated during processing of the license amendment for closure. Deferring the delineation of this program to the closure phase would allow identification of appropriate technology, which could include technology that might not be currently available.

The closure analytical period would last 10 years. Closure of the repository would include the installation of drip shields, removal and salvage of equipment and materials, and backfilling of subsurface-to-surface openings. Backfilling would require fill material from the excavated rock storage area or another source, and processing (screening, crushing, and possibly washing) the material to obtain the required characteristics. Fill material would be transported on the surface in trucks and subsurface in open gondola railcars. A fill placement system would place the material in the subsurface ramps.

Surface facilities would be decontaminated, if required, and dismantled. Equipment and materials would be salvaged, recycled, or reused, if possible. Reclamation would include restoration of the site to as near its preconstruction condition as practicable, which would include the recontouring of disturbed surface areas, surface backfill, soil buildup and reconditioning, site revegetation, site watercourse configuration, and erosion control, as appropriate.

In compliance with 10 CFR Part 63, DOE would erect a network of permanent monuments and markers around the site to warn future generations of the presence and nature of the buried waste, and detailed public records would identify the location and layout of the repository and the nature and hazard of the waste it contains. The Federal Government would maintain *institutional control* of the site. Active and passive security systems and monitoring would prevent deliberate or inadvertent *human intrusion* and any other human activity that could adversely affect the repository.

2.1.7 TRANSPORTATION ACTIVITIES

Under the Proposed Action, DOE would transport spent nuclear fuel and high-level radioactive waste from commercial and DOE sites to the repository. The Naval Nuclear Propulsion Program would transport *naval spent nuclear fuel* from the Idaho National Laboratory to the repository. Section 2.1.7.1 discusses loading activities of these materials at generator sites. Sections 2.1.7.2 and 2.1.7.3 discuss transportation of the materials to the Yucca Mountain site, across the nation and in Nevada, respectively. Chapter 6 and Appendix G of this Repository SEIS provide further discussion of transportation activities and resultant environmental impacts.

2.1.7.1 Loading Activities at Commercial and DOE Sites

The Proposed Action in this Repository SEIS includes the shipping of empty casks and TAD canisters to commercial and DOE sites, as well as loading of spent nuclear fuel and high-level radioactive waste at commercial and DOE sites for transportation to Yucca Mountain. Loading activities would involve preparing the spent nuclear fuel or high-level radioactive waste for shipment including loading the commercial spent nuclear fuel into TAD canisters and loading high-level radioactive waste and DOE spent nuclear fuel into disposable canisters, the subsequent loading of canisters and a small amount of DOE uncanistered spent nuclear fuel assemblies into transportation casks, and placing the transportation casks on a railcar or truck. This Repository SEIS assumes that at the time of shipment, the spent nuclear fuel and high-level radioactive waste would be in a form that met approved acceptance and disposal criteria for the repository.

2.1.7.2 National Transportation

Under the Proposed Action evaluated in this Repository SEIS, DOE would transport spent nuclear fuel and high-level radioactive waste from 76 sites across the country to the repository by mostly rail. The Department would transport some spent nuclear fuel and high-level radioactive waste by truck. Figures 2-11 and 2-12 show the representative national rail and truck routes, respectively, evaluated in this Repository SEIS. For this Repository SEIS, DOE has updated the routes to reflect the current highway and rail routes in the United States and to add routes that support the Mina rail *corridor* that DOE considers in the Rail Alignment EIS. Representative routes are routes that were analyzed but might not be the routes actually used for shipment to the repository. Rail routes are based on maximizing the use of mainline track and minimizing the overall distance and number of interchanges between railroads.

Important elements of DOE's national transportation plan that have evolved since publication of the Yucca Mountain FEIS include the following:

DOE has established the policy to use dedicated trains for shipments of commercial and DOE spent nuclear fuel and high-level radioactive waste. This policy would not apply to shipments of naval spent nuclear fuel. Shipments of commercial and DOE spent nuclear fuel and high-level radioactive waste would consist of from one to five casks that contained spent nuclear fuel or high-level radioactive waste per train. For shipments of naval spent nuclear fuel, this analysis assumed regular freight service and from 1 to 12 casks that contained spent nuclear fuel per train. In both cases, two *buffer cars*, two to three locomotives, and one to two *escort cars* would be present. A buffer car would be a railcar at the front of a cask train between the locomotive and the first cask car and at the back of the train between the last cask car and the escort car. An escort car would be a railcar in which escort personnel would travel on trains that carried spent nuclear fuel or high-level radioactive waste.

- Trucks that carried transportation casks probably would be overweight rather than legal weight. In the Yucca Mountain FEIS, DOE estimated that the trucks carrying truck casks would have gross vehicle weights less than 36,000 kilograms (80,000 pounds) and would be, therefore, legal weight (23 CFR 658.17). DOE has since determined that trucks carrying truck casks would be more likely to have gross vehicle weights in the range of 36,000 kilograms to 52,000 kilograms (115,000 pounds). These *overweight trucks* would be subject to the additional permitting requirements in each state through which they traveled.

- This Repository SEIS evaluates transportation of spent nuclear fuel and high-level radioactive waste from 72 commercial sites and 4 DOE sites, for a total of 76 locations (one less than in the Yucca Mountain FEIS because DOE will ship spent nuclear fuel currently stored at Fort St. Vrain, Colorado, to the Idaho National Laboratory for packaging and then to the repository). This Repository SEIS analyzes the shipment of approximately 9,500 rail casks and 2,700 truck casks of spent nuclear fuel and high-level radioactive waste. The Yucca Mountain FEIS analyzed approximately 9,600 rail casks and 1,100 truck casks under the mostly rail shipping scenario. The estimated number of truck and rail casks changed primarily due to the use of TAD canisters and revised information on interface capabilities and cask handling capabilities at U.S. nuclear facilities.

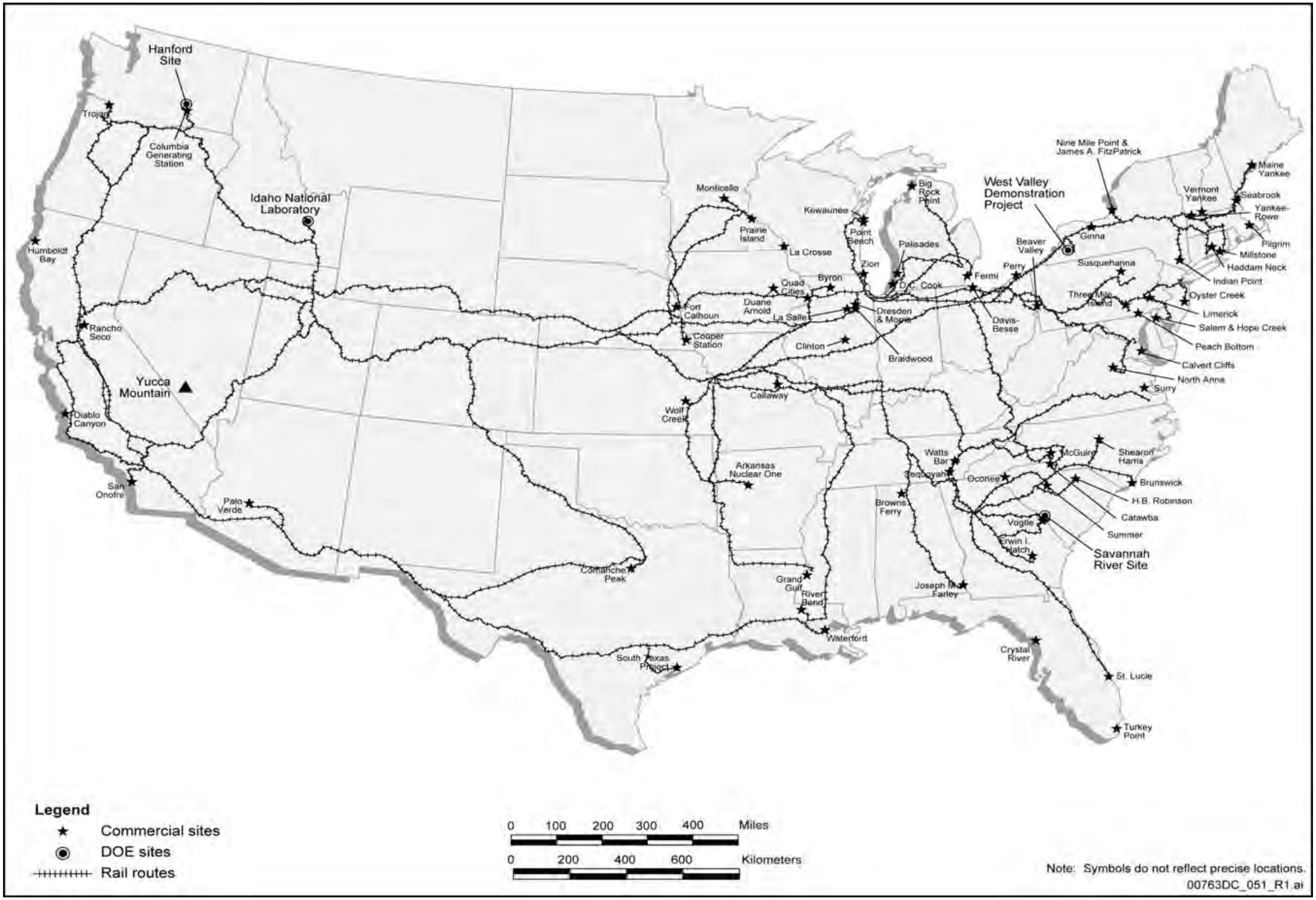


Figure 2-11. Representative national rail routes considered in the analysis for this Repository SEIS.

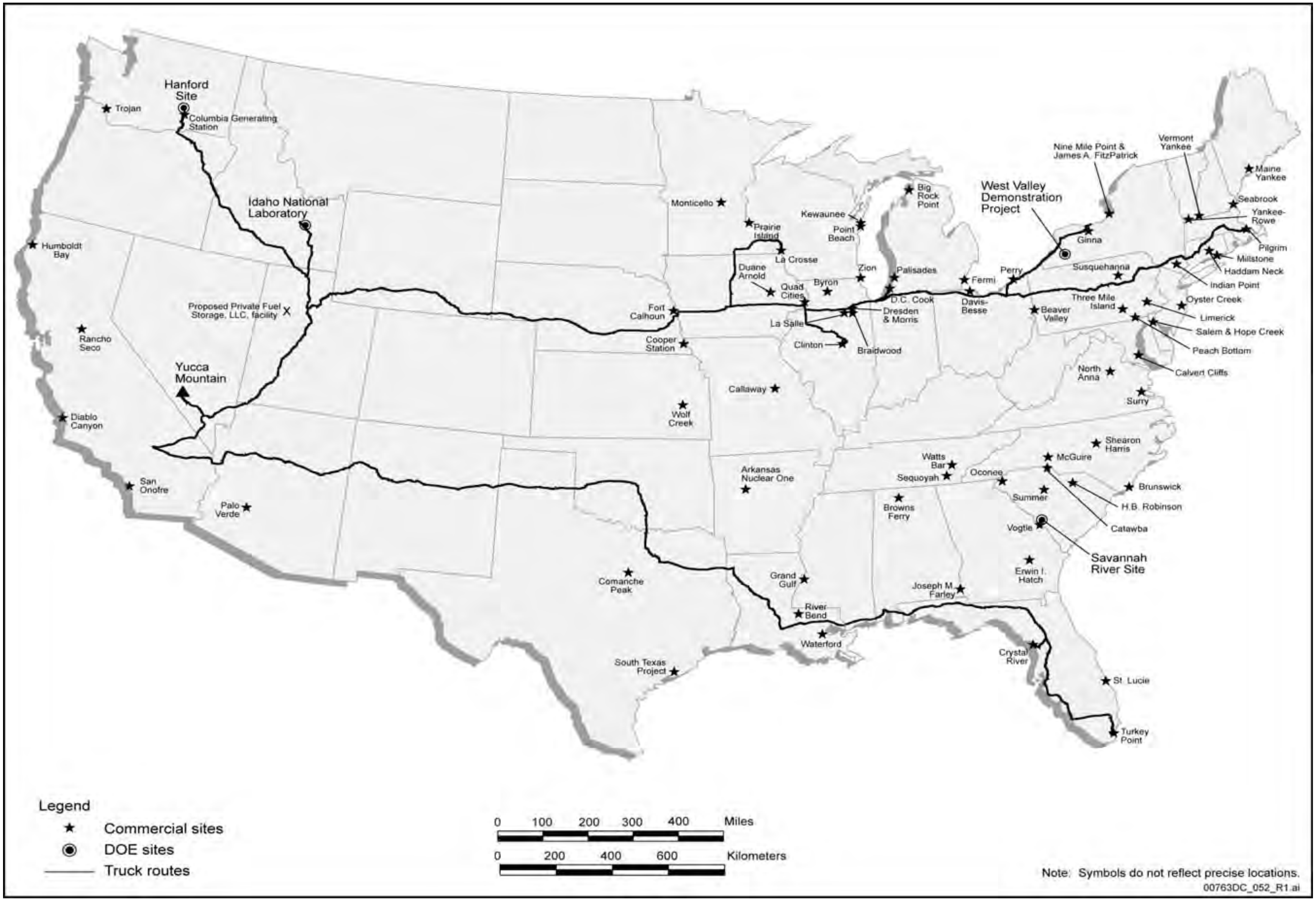


Figure 2-12. Representative national truck routes considered in the analysis for this Repository SEIS.

- Based on interim compensatory measures now required by the NRC and that DOE would follow, at least two security escorts would be present in all areas (urban, suburban, and rural) during the shipment of spent nuclear fuel and high-level radioactive waste.

2.1.7.3 Nevada Transportation

Concurrent with this Repository SEIS, DOE has prepared the Nevada Rail Corridor SEIS and Rail Alignment EIS to make further decisions on transportation in the State of Nevada. In the Nevada Rail Corridor SEIS, DOE considers the feasibility and environmental impact of using the Mina rail corridor, which it had excluded from consideration in the Yucca Mountain FEIS, as explained in the Foreword of this Repository SEIS. In addition, DOE updates environmental information for three other *rail corridors* it considered in the Yucca Mountain FEIS, specifically the Carlin, Jean, and Valley Modified rail corridors. DOE examines both the Caliente and Mina rail corridors at the alignment level in the Rail Alignment EIS. DOE had selected the Caliente rail corridor in which to examine potential alignments for construction and operation of a railroad in its April 8, 2004, *Record of Decision* (69 FR 18557).

To serve as a supplement to the Yucca Mountain FEIS, this Repository SEIS includes the impacts of transportation of spent nuclear fuel and high-level radioactive waste to the repository, with the rail shipments occurring in either the Caliente or Mina rail corridor (Figure 2-13). This SEIS summarizes and incorporates Chapter 3, Sections 3.2 and 3.3, and Chapters 4, 5, and 8 the Rail Alignment EIS. The Foreword of this document describes the incorporation of the results of the Rail Alignment EIS impact analysis.

Under the Proposed Action in the Rail Alignment EIS, DOE analyzes specific potential impacts of constructing and operating a railroad along common segments and alternative segments in the Caliente and Mina rail corridors to determine an alignment in which to construct and operate a railroad for shipments of spent nuclear fuel and high-level radioactive waste from an existing rail line in Nevada to a geologic repository at Yucca Mountain. To aggregate potential impacts associated with transportation of spent nuclear fuel and high-level radioactive waste to the repository, this Repository SEIS summarizes and incorporates by reference those portions of the Rail Alignment EIS addressing the impacts associated with construction and operation of a railroad in Nevada, including cumulative impacts. This Repository SEIS provides direction to those portions of the Rail Alignment EIS that do not deal directly with the aggregation of impacts that would be associated with the SEIS Proposed Action. The following sections summarize the Proposed Action DOE examines in the Rail Alignment EIS.

2.1.7.3.1 *Summary of the Proposed Action in the Rail Alignment EIS*

In the Rail Alignment EIS, DOE analyzes a Proposed Action and a No-Action Alternative. The Proposed Action is to determine an alignment (in a corridor) and construct, operate, and potentially abandon a railroad in Nevada to transport spent nuclear fuel, high-level radioactive waste, and other Yucca Mountain Project materials to a repository at Yucca Mountain. There are two implementing alternatives under the Proposed Action—the Caliente Implementing Alternative, under which the Department would construct the proposed railroad in the Caliente rail corridor, and the Mina Implementing Alternative, under which the Department would construct the proposed railroad in the Mina rail corridor. The Caliente Implementing Alternative is the DOE preferred alternative. The Mina Implementing Alternative is nonpreferred.

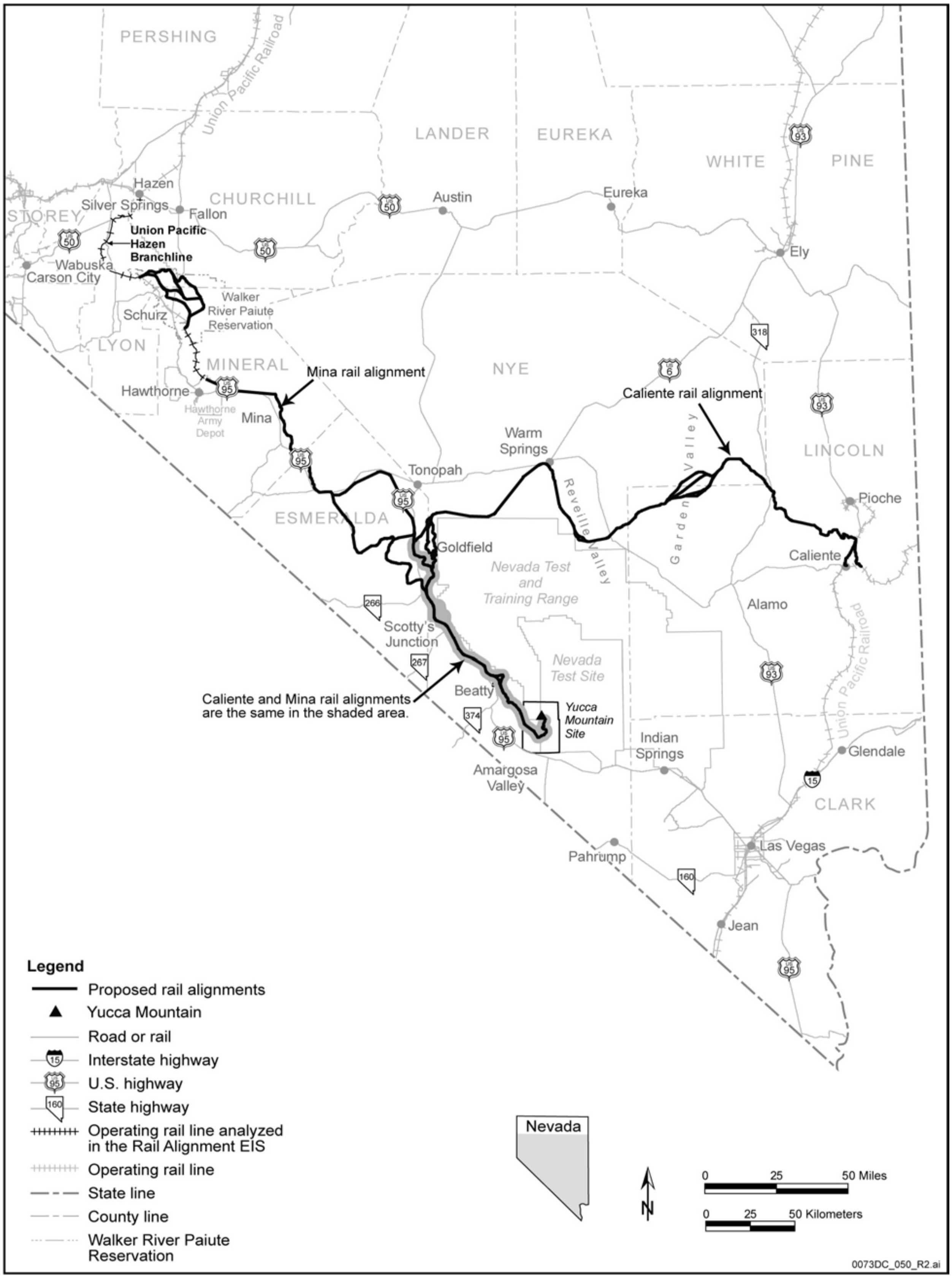


Figure 2-13. Caliente and Mina rail alignments.

In the Rail Alignment EIS, DOE considers a series of *common segments* and a range of *alternative segments* during development of the Proposed Action. The identified alternative rail segments are a subset of the Proposed Action and are not standalone alternatives. The Rail Alignment EIS compares and contrasts the alternative segments and identifies the preferred alternative segments. In addition, the Rail Alignment EIS identifies segments that DOE has eliminated from detailed analysis.

Under the Rail Alignment Proposed Action, the proposed railroad would be dedicated to DOE transport of spent nuclear fuel, high-level radioactive waste, and other Yucca Mountain Project materials. However, for each implementing alternative in the Rail Alignment EIS, DOE analyzed a Shared-Use Option under which the Department would allow commercial shippers to use the railroad for general freight shipments. General freight would include stone and other nonmetallic minerals, petrochemicals, nonradioactive waste materials, or other commodities that private companies would ship or receive.

DOE would use the railroad primarily to ship approximately 9,500 casks containing spent nuclear fuel and high-level radioactive waste from either the Caliente or Hawthorne area (the towns where construction of the new railroad would begin in the Caliente or Mina rail corridor, respectively) to the repository over a 50-year *operations analytical period*. DOE also would ship approximately 29,000 railcars of other materials, which would include repository construction materials, materials necessary for day-to-day operations of the railroad and the repository, and waste materials for disposal, such as scrap metal and solid waste.

The Rail Alignment Proposed Action includes the construction and operation of several facilities that would be necessary for the operation of the railroad. These facilities would include the Staging Yard, the Interchange Yard (Caliente Implementing Alternative), the Maintenance-of-Way Facilities, the Rail Equipment Maintenance Yard, the Cask Maintenance Facility, the Nevada Railroad Control Center, and the National Transportation Operations Center. DOE would construct these facilities at the same time it constructed the railroad and would coordinate facility construction with railroad construction.

Under the No-Action Alternative in the Rail Alignment EIS, DOE would not implement the Proposed Action in the Caliente or Mina rail corridor. DOE would relinquish the public lands withdrawn from surface entry and mineral entry for the purpose of evaluating the lands for the potential construction, operation, and maintenance of a railroad. These lands would then become available for surface and mineral entry. In the event that DOE did not select a *rail alignment* in the Caliente or Mina rail corridor, the future course it would pursue to meet its obligation under the NWPA is highly uncertain. DOE recognizes that it could pursue other possibilities, including evaluating the three other rail corridors to determine an alignment for the construction and operation of a rail line to transport spent nuclear fuel and high-level radioactive waste to the repository at Yucca Mountain; the Department analyzed these possibilities in the Yucca Mountain FEIS. Further consideration of these possibilities could require additional reviews, as appropriate, under the *National Environmental Policy Act*.

2.1.7.3.2 *Rail Equipment Maintenance Yard and the Repository Interface*

The railroad would approach Yucca Mountain from the northwest, terminating at the Rail Equipment Maintenance Yard (Figure 2-14). The geologic repository operations area would be on the north end of the Rail Equipment Maintenance Yard, another 2.2 kilometers (1 mile) northeast. The interface would consist of a double-track spur that led into the surface geologic repository operations area for delivery of casks and supplies to the repository.

This area would include a Satellite Maintenance-of-Way Facility, a locomotive repair facility, a car repair shop, and an escort car service facility, and it could serve as the location of the Nevada Railroad Control Center and the National Transportation Operations Center.

The Rail Equipment Maintenance Yard would include a shop for washing, inspection, and repair of locomotives and railcars; communications equipment; and housing for train crews and escort personnel (in the same building as the Nevada Railroad Control Center and National Transportation Operations Center if they were at the Rail Equipment Maintenance Yard). The facility would be on a 0.41-square-kilometer (100-acre) site.

2.1.7.3.3 *Cask Maintenance Facility*

The primary purpose of the Cask Maintenance Facility would be to process transportation casks and to ensure that all casks were road-ready and configured with the correct equipment. The basic functions of the facility would be those necessary to ensure compliance with an NRC-issued Certificate of Compliance. The Cask Maintenance Facility would be at the Rail Equipment Maintenance Yard, which would enable the facility to service the casks before their return to the commercial or DOE sites. The Cask Maintenance Facility would require about 0.08 square kilometers (20 acres).

2.1.8 PRELIMINARY SCHEDULE FOR PROPOSED ACTION IMPLEMENTATION

Consistent with 10 CFR 63.21(b)(2) and in compliance with NWPA Section 114(e)(1), DOE has developed preliminary schedules for site preparation, construction, waste receipt, and routine emplacement operations. The schedules address the development of infrastructure inside and outside the geologic repository operations area, including site preparation and construction activities. To the extent they relate to radiological health and safety or preservation of the common defense and security, these activities would not begin inside the geologic repository operations area until DOE received construction authorization from the NRC.

The primary assumptions DOE used in developing the schedules for design, construction, testing, and initial operation are:

- No site preparation or construction activities related to radiological health and safety or preservation of the common defense and security would begin in the geologic repository operations area until after DOE received construction authorization from the NRC,
- DOE would accomplish construction and operation of surface facilities by a phased approach, and
- DOE would accomplish underground panel construction by a phased approach.

The schedules in this section include a conceptual schedule for construction, testing, and initial operation (startup) of the railroad. It would take a minimum of 4 years to construct the proposed railroad under either implementing alternative. Assumptions that DOE used in developing the schedule for the railroad include:

- Construction of the rail roadbed would begin simultaneously at multiple points along the rail alignment;

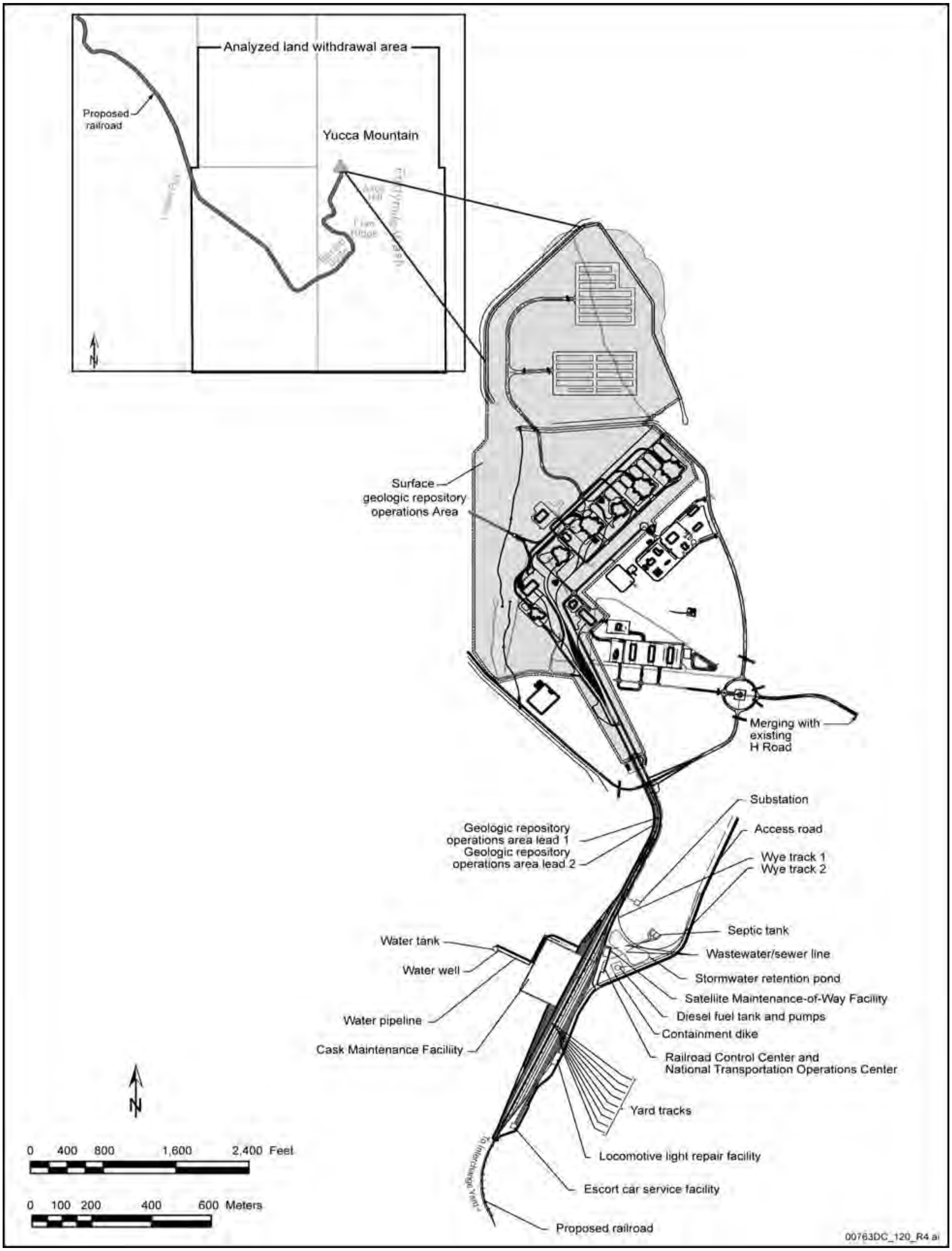


Figure 2-14. Interface of the surface geologic repository operations area with the proposed Rail Equipment Maintenance Yard and the railroad.

- Each time a section of the track was completed and the signals and communications systems installed and tested, integrated testing would begin using train equipment to validate that all components were operating as designed; and

- Although construction would take a minimum of about 4 years, the Rail Alignment EIS accounts for the possibility that it could take longer (up to 10 years) because annual funding levels might not be sufficient to complete construction in 4 years. The construction sequence under a 10-year schedule would be largely the same as that for the 4-year schedule, but under the 10-year schedule construction of the rail roadbed would occur sequentially, starting at the beginning of the rail alignment and moving toward Yucca Mountain.

2.1.8.1 Initial Operating Capability

Figure 2-14a shows the schedule for the Proposed Action construction, startup, and initial operating capability. The objective of Phase 1, or the initial operating capability, would be to develop the capability to start operations, including the development of assets necessary to achieve a reasonable ramp-up of operations during the first several years of waste receipt.

The Initial Handling Facility, the first Canister Receipt and Closure Facility (Canister Receipt and Closure Facility 1), the first aging pad at the Aging Facility, the Wet Handling Facility, and components of subsurface Panel 1 would provide the initial operating capability, Phase 1 construction. Some of the infrastructure DOE would develop outside the geologic repository operations area would include the railroad, communication system improvements, and electric transmission lines. It would take a minimum of 4 years to construct the proposed railroad under either implementing alternative.

Table 2-1 lists other infrastructure and supporting facilities that DOE would construct during Phase 1.

2.1.8.2 Full Operating Capability

Figure 2-14b shows the schedule for the remainder of the Proposed Action construction and startup to full operating capability, which encompasses Phases 2, 3, and 4. The objective of these operating phases would be to develop full operating capability for receiving and emplacing the 70,000 MTHM currently authorized by law for the repository.

To increase throughput capabilities, the full operating capability would include additional high-throughput handling facilities similar to those developed for the initial operating capability. In Phase 2, the Receipt Facility would complement the three handling facilities operable from Phase 1. DOE would complete the Canister Receipt and Closure Facility 2 and the second aging pad ath the Aging Facility in Phase 3, and Canister Receipt and Closure Facility 3 in Phase 4 to complete the full operating capability. The Department would complete the remainder of subsurface Panels 1 and 2 during Phase 2, with the ongoing construction of Panels 3 and 4 throughout Phases 2, 3, and 4.

Table 2-1 lists other infrastructure and supporting facilities that DOE would construct during Phases 2, 3, and 4.

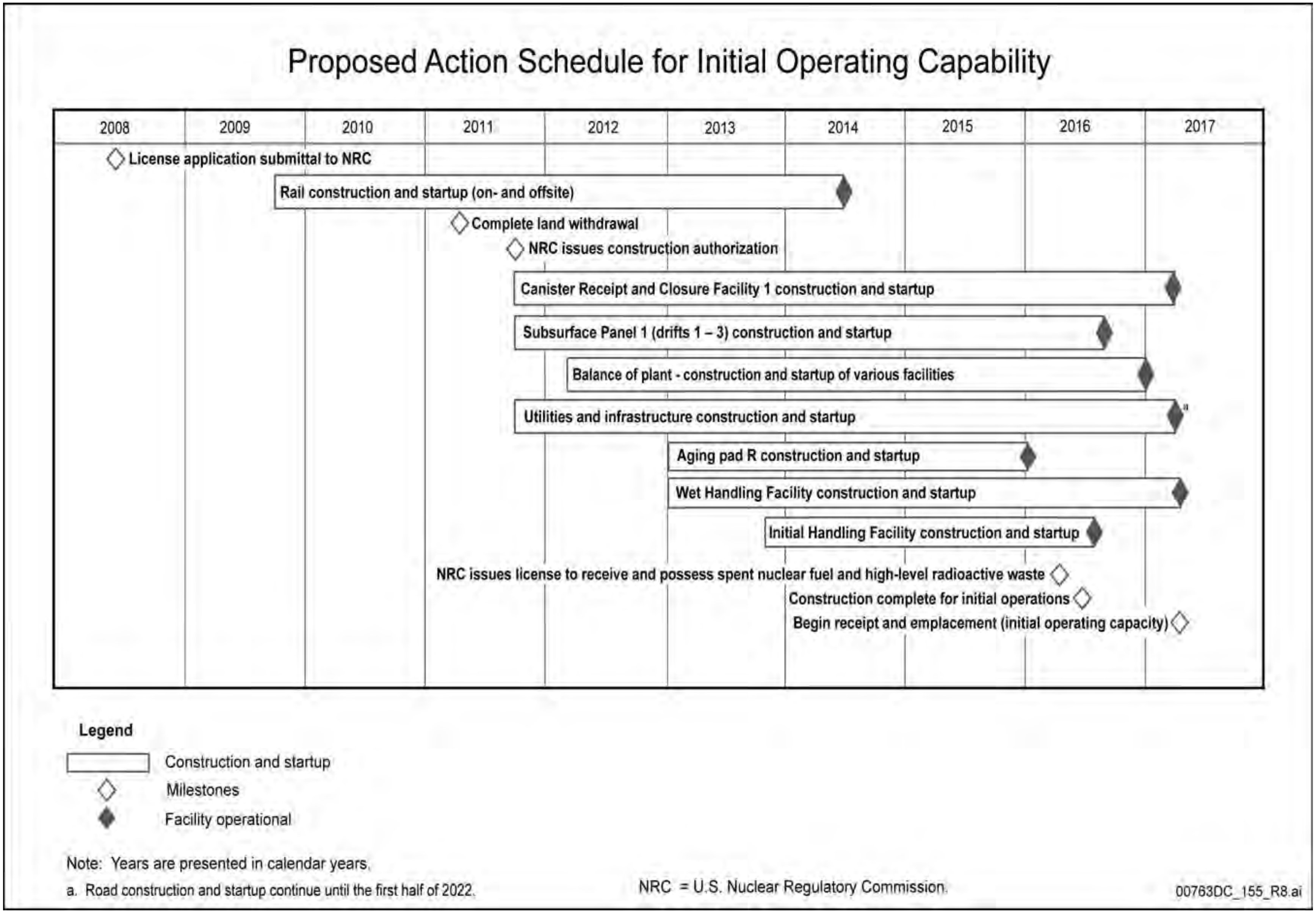


Figure 2-14a. Schedule for the Proposed Action construction, startup, and initial operating capability – Phase 1.

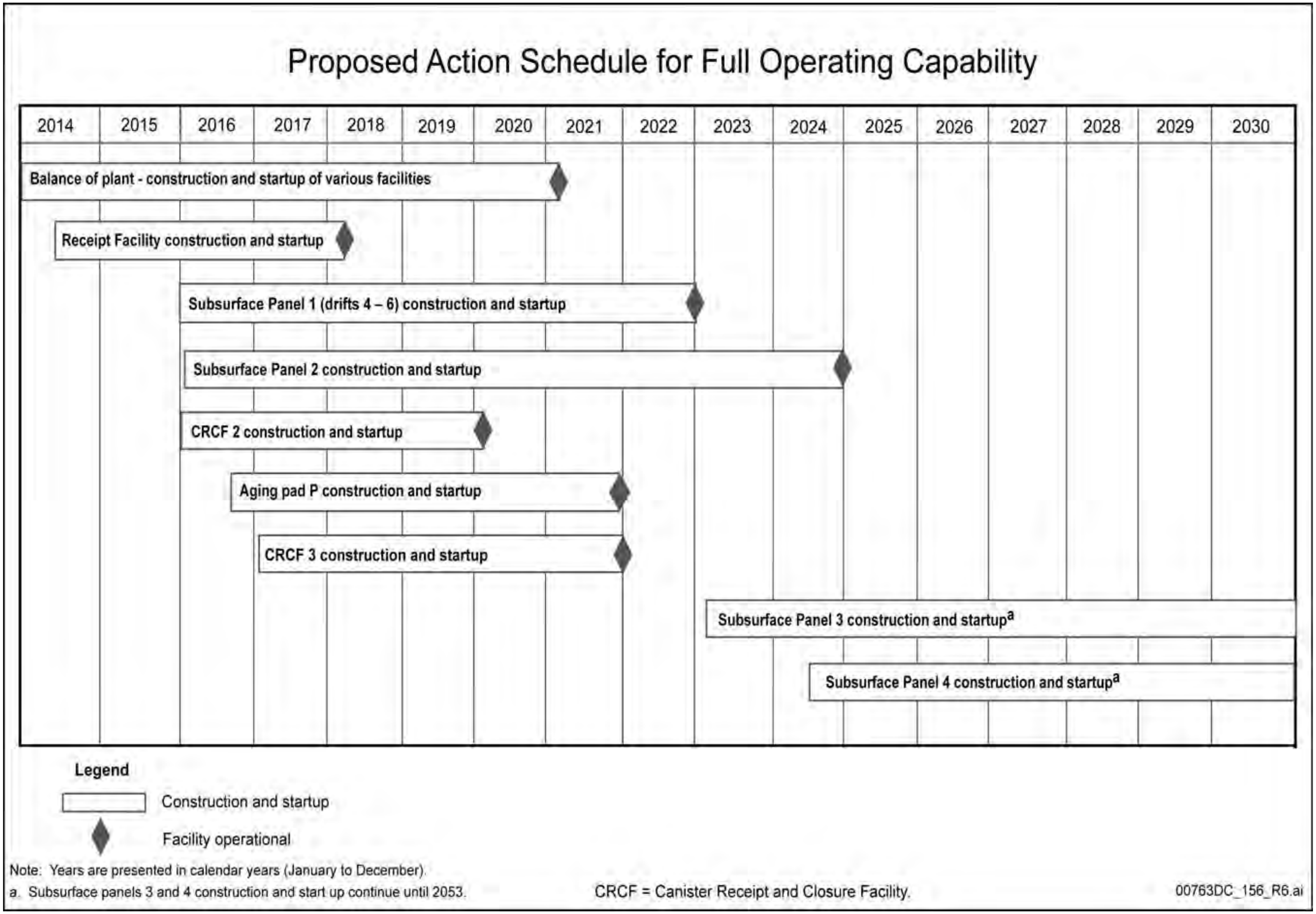


Figure 2-14b. Schedule for the Proposed Action construction and startup to full operating capability – Phases 2, 3, and 4.

2.2 No-Action Alternative

This section summarizes and incorporates by reference Section 2.2 of the Yucca Mountain FEIS.

The No-Action Alternative provides a basis for comparison with the Proposed Action. Under the No-Action Alternative, DOE would curtail activities at Yucca Mountain and undertake site reclamation. Commercial nuclear power utilities and DOE would continue to manage the 76 identified generator sites under one of the following two scenarios. Under No-Action Scenario 1, long-term storage of the spent nuclear fuel and high-level radioactive waste would occur at the current storage sites with effective institutional control for at least 10,000 years. Under institutional control, these facilities would be maintained to ensure that workers and the public were protected in accordance with current federal regulations. The storage facilities would be evaluated for life-extension or replaced every 100 years under Scenario 1. Under No-Action Scenario 2, long-term storage of the spent nuclear fuel and high-level radioactive waste would occur at the current storage sites with no effective institutional control after about 100 years. Beyond that time, the scenario assumes no institutional control. Therefore, after about 100 years and up to 10,000 years, the analysis assumed that the spent nuclear fuel and high-level radioactive waste storage facilities at commercial and DOE sites would begin to deteriorate and that the radioactive materials in them could eventually escape to the environment.

DOE used a regional approach that divided the continental United States into five regions to analyze the No-Action Alternative. In the Yucca Mountain FEIS, DOE recognized that the future course Congress, DOE, and the commercial utilities would take, if Yucca Mountain was not approved, is uncertain. A number of possibilities could be pursued, including continued storage at existing sites or at one or more centralized locations, study and selection of another location for a geologic repository, the development of new technologies, or reconsideration of alternatives to geologic disposal. The Yucca Mountain FEIS listed representative studies on centralized or regionalized interim storage and summarized relevant environmental considerations. However, because of these uncertainties, DOE decided to illustrate the range of potential environmental impacts by analyzing the aforementioned two scenarios.

While the No-Action Alternative has not changed, DOE has recognized the State of Nevada’s concerns about the No-Action Alternative expressed during scoping meetings by reconsidering the validity of the No-Action Alternative’s analytical scenarios in this Repository SEIS. DOE has elaborated on the uncertainties, and thus unpredictability, of future actions in the event the Proposed Action for Yucca Mountain is not approved. This discussion is found in Chapter 7 of this Repository SEIS.

2.3 Summary of Findings and Comparison of the Proposed Action and the No-Action Alternative

This section summarizes the potential impacts of the Proposed Action and the No-Action Alternative. For the Proposed Action, this summary includes preclosure impacts and postclosure impacts for the proposed repository as well as those from transportation both nationally and in the State of Nevada. Preclosure impacts are those that would occur during the construction, operations, monitoring, and eventual closure of the proposed repository; postclosure impacts are those that would occur after permanent repository closure, for which DOE analyzed impacts for the first 10,000 years and the post-10,000-year period (up to 1 million years). This section updates the information in the Yucca Mountain FEIS and incorporates relevant new information or new environmental considerations.

DOE has characterized potential impacts in this Repository SEIS as direct or indirect. A *direct impact* is an effect that would result solely from the Proposed Action without intermediate steps or processes. Examples include *habitat* destruction, soil disturbance, air emissions, and water use. An *indirect impact* is an effect that would be related to but removed from the Proposed Action by an intermediate step or process. Examples include surface-water quality changes from soil erosion at construction sites, reductions in productivity from changes in soil temperature, and job growth due to repository employment.

DOE has quantified impacts where possible; in addition, the Department has provided qualitative assessments with these descriptors:

- Small. Environmental effects would not be detectable or would be so minor that they would not destabilize or noticeably alter any important attribute of the resource.
- Moderate. Environmental effects would noticeably alter but not destabilize important attributes.
- Large. Environmental effects would be clearly noticeable and would destabilize important attributes.

This summary and comparison of the Proposed Action and No-Action Alternative impacts is based on the impact analyses in the following chapters of this Repository SEIS:

- Chapter 4 describes potential preclosure environmental impacts during construction, operations, monitoring, and closure of the repository and includes those from the manufacture of waste packages, TAD canisters, and transportation casks.
- Chapter 5 describes the potential postclosure environmental impacts from the disposal of spent nuclear fuel and high-level radioactive waste in the repository.
- Chapter 6 describes the potential impacts of the transportation of spent nuclear fuel, high-level radioactive waste, other materials, and personnel to and from the repository. It includes the impacts of construction and operation of a railroad in Nevada, which DOE presents in more detail in the Rail Alignment EIS.
- Chapter 7 describes the potential impacts of the No-Action Alternative.
- Chapter 8 describes potential cumulative impacts in relation to other activities in the regions of influence.

Section 2.3.1 summarizes the potential preclosure and postclosure impacts of the proposed repository. Section 2.3.2 summarizes the potential impacts of national and Nevada transportation. Section 2.3.3 summarizes the potential impacts of the No-Action Alternative. Section 2.3.4 combines, and adds together where possible, the impacts from the repository and transportation analyses to present the total estimated impacts of the Proposed Action. It identifies where the regions of influence overlap for this Repository SEIS and the Rail Alignment EIS and describes impacts in those overlap areas.

2.3.1 POTENTIAL PRECLOSURE AND POSTCLOSURE IMPACTS ASSOCIATED WITH THE REPOSITORY

For preclosure impacts, DOE assessed potential impacts during the construction, operations, monitoring, and closure analytical periods for 13 resource areas and included impacts from the two connected actions, manufacturing repository components and airspace restrictions (Chapter 4). The analysis led to the following conclusions:

- For most resource areas, preclosure impacts would be small. Preclosure impacts to groundwater would range from small to moderate, and preclosure impacts to socioeconomics and materials use related to offsite manufacturing of repository components would be moderate.

- The potential health and safety impacts indicate that the repository could be constructed and operated without significant impacts to workers or the public.

For postclosure impacts, DOE assessed the potential impacts from the release of radiological and nonradiological hazardous materials over much longer periods (the first 10,000 years and the post-10,000-year period) after the permanent closure of the repository (Chapter 5). The Department based these projections on the best available scientific techniques and focused the assessment of postclosure impacts on human health, biological resources, and surface- and groundwater resources. The analysis led to the following conclusions:

- There could be very low levels of *contamination* in the groundwater in the *Amargosa Desert* for a long period.

- The proposed repository would release radionuclides over a long period. The analysis demonstrated that the postclosure performance of the proposed repository over the first 10,000 years would result in mean and median annual individual *doses* that would not exceed 0.24 *millirem* and 0.13 millirem, respectively, to a *reasonably maximally exposed individual* (RMEI) hypothetically located 18 kilometers (11 miles) from the repository. The analysis of the post-10,000-year period resulted in a mean and median annual individual dose that would not exceed 2.0 millirem and 0.96 millirem, respectively, to the RMEI at the same location. There would be no significant adverse health effects to individuals from these projected doses.

Table 2-2 summarizes preclosure and postclosure impacts associated with the repository. The table identifies the sections of this Repository SEIS that contain more information about the impacts.

Table 2-2. Potential preclosure and postclosure impacts associated with the repository.

Resource area	Preclosure impacts	Postclosure impacts
Land use and ownership	Small; about 9 km^2 (2,200 acres) of disturbed land; 600 km^2 (150,000 acres) of land withdrawn from public use. (Section 4.1.1)	Small; potential for limited access into the area; reclamation of disturbed land would restore preconstruction conditions; the only surface features remaining would be markers. (Section 5.0)
Air quality	Small; concentrations well below regulatory limits (less than 3 percent) for all criteria pollutants except particulate matter. Maximum concentrations of PM_{10} would be 40 percent of limit at land withdrawal area boundary. Maximum annual releases of carbon dioxide, a greenhouse gas from the burning of fossil fuels and the manufacture of concrete would be about 69,000 metric tons (76,000 tons). This would be less than 0.15 percent of the 2004 State of Nevada total carbon dioxide emissions. (Sections 4.1.2.5 and 4.1.2.6)	Small; population doses from release of gaseous radionuclides would be on the order of 1×10^{-8} person-rem in the 84-km (52-mile) radius around the repository. (Section 5.6)
Hydrology		
Surface water	Small; land disturbance would result in minor changes to runoff and infiltration rates; minimal potential for contaminants to be released and reach surface water; only ephemeral drainage channels would be affected. Facilities would be above flood zones, or constructed dikes and diversion channels would keep floodwaters away; floodplain assessment concluded impacts would be small. (Section 4.1.3.1)	Small; potential sources for surface-water contamination would no longer be present. (Section 5.0)
Groundwater	Small to moderate; minimal potential to change recharge rates and for contaminants to be released and reach groundwater; peak water demand (460 acre-feet per year)[a] below the lowest estimate of the groundwater basin's perennial yield (580 acre-feet); after construction, water demand would decrease to 330 acre-feet per year or less. Groundwater would be withdrawn from existing wells and possibly a new well to support Gate 510 facilities. (Section 4.1.3.2)	Estimated releases over the first 10,000 years would result in a mean and median annual individual dose that would not exceed 0.24 millirem and 0.13 millirem, respectively, to an RMEI hypothetically located 18 kilometers (11 miles) from the repository. The analysis of the post-10,000-year period resulted in a mean and median annual individual dose that would not exceed 2.0 millirem and 0.96 millirem, respectively, to the RMEI at the same location. Expected uptakes from nonradioactive hazardous chemicals would all be less than the oral reference doses for any of these substances. (Section 5.5)
Biological resources and soils	Small; loss of up to 9 km^2 (2,200 acres) of desert soil, habitat, and vegetation, but no loss of rare or unique habitat or vegetation; adverse impacts to individual threatened desert tortoises and loss of a small amount of low-density tortoise habitat, but no adverse impacts to the species as a whole; reasonable and prudent measures would minimize impacts; no adverse impacts to wetlands. (Section 4.1.4)	Small; slight increase in surface soil temperature directly over repository, lasting from approximately 200 to 10,000 years, could result in a temporary shift in plant and animal communities in the affected area; impacts to individual threatened desert tortoises would decrease as activity level at repository decreased; no temperature-driven change in desert tortoise sex ratio would be likely; sediment load in ephemeral water courses could temporarily increase coincident with changes to soil and vegetation characteristics. (Section 5.10)

Table 2-2. Potential preclosure and postclosure impacts associated with the repository (continued).

Resource area	Preclosure impacts	Postclosure impacts
Cultural resources	Small; minimal ground disturbances and activities that could destroy or modify the integrity of archaeological or cultural resource sites through avoidance of sites and mitigation. Mitigation of indirect impacts that could result from easier physical access to the land withdrawal area, such as unauthorized excavation and collection of artifacts, by training, monitoring and establishing long-term management of sites. Opposing American Indian viewpoint exists. (Section 4.1.5)	Small; potential for limited access into the area; opposing American Indian viewpoint. (Section 5.0)
Socioeconomics		
New jobs (percent of workforce in affected counties)	Construction: Small impacts in region; peaks are 0.05 percent above baseline in Clark County and 1.5 percent above baseline in Nye County. Operations: Small impacts in region; peaks are 0.06 percent above baseline in Clark County and 2.0 percent above baseline in Nye County. (Section 4.1.6)	Small; very few workers. (Section 5.0)
Peak real disposable personal income	Construction: Small impacts in region; peaks are $41.7 million (0.05-percent increase) in Clark County and $17.1 million (1.16-percent increase) in Nye County. Operations: Small impacts in region; peaks are $58.3 million (0.05-percent increase) in Clark County and $27.7 million (1.15-percent increase) in Nye County. (Section 4.1.6)	Small; very few workers. (Section 5.0)
Peak incremental Gross Regional Product	Construction: Small impacts in region; peaks are $58.9 million (0.05-percent increase) in Clark County and $22.7 million (1.42-percent increase) in Nye County. Operations: Small impact in region; peaks are $98.7 million (0.05-percent increase) in Clark County and $68.9 million (2.65-percent increase) in Nye County. (Section 4.1.6)	Small; very few workers. (Section 5.0)
Occupational and public health and safety		
Public, Radiological		
MEI (probability of an LCF)	0.00032 (Section 4.1.7)	1.4×10^{-7} (Section 5.5)
Population (LCFs)	8.0 (Section 4.1.7)	Not calculated.

Table 2-2. Potential preclosure and postclosure impacts associated with the repository (continued).

Resource area	Preclosure impacts	Postclosure impacts
Occupational and public health and safety (continued)		
Public, Nonradiological		
Fatalities due to emissions	Small; exposures well below regulatory limits. (Section 4.1.7)	Small; exposures well below regulatory limits. (Section 5.0)
Workers (involved and noninvolved)		
Radiological (LCFs)	3.5 (Section 4.1.7)	Small; very few workers. (Section 5.0)
Nonradiological fatalities (includes commuting traffic fatalities)	38 (Section 4.1.7)	Small, very few workers. (Section 5.0)
Accidents, Radiological		
Public MEI (probability of an LCF)	2.6×10^{-11} to 2.1×10^{-5} (Section 4.1.8)	Less than 1×10^{-7} probability.
Public Population (LCFs)	9.0×10^{-7} to 1.9×10^{-2} (Section 4.1.8)	Less than 1×10^{-7} probability.
Workers	5.8×10^{-4} to 3.5 rem (3.5×10^{-7} to 2.1×10^{-3} LCF) (Section 4.1.8)	Less than 1×10^{-7} probability.
Noise and vibration	Small; impacts to public would be small due to large distances to residences; workers exposed to elevated noise levels—controls and protection would be used as necessary. (Section 4.1.9)	Small; minimal activities, therefore, minimal noise or ground vibration. (Section 5.0)
Aesthetics	Small; the presence of exhaust ventilation stacks on the crest of Yucca Mountain would be an aesthetic aggravation to American Indians. If the Federal Aviation Administration required beacons atop the stacks, they could be visible for several kilometers, especially west of Yucca Mountain. (Section 4.1.10)	Small; the only constructed surface features remaining would be markers. (Section 5.0)
Utilities, energy, materials, and site services	Small; use of materials would be small in comparison with amounts used in the region; electric power delivery system to the Yucca Mountain site would need enhancement. (Section 4.1.11)	Small; minimal use of materials or energy. (Section 5.0)

Table 2-2. Potential preclosure and postclosure impacts associated with the repository (continued).

Resource area	Preclosure impacts	Postclosure impacts
Waste and hazardous materials	Construction/demolition debris – 476,000 cubic meters (620,000 cubic yards) Industrial wastewater – 1.2 million cubic meters (320 million gallons) Sanitary sewage – 2.0 million cubic meters (530 million gallons) Sanitary/industrial waste – 100,000 cubic meters (130,000 cubic yards) Hazardous waste – 8,900 cubic meters (12,000 cubic yards) Low-level radioactive waste – 74,000 cubic meters (97,000 cubic yards) None of the projected volumes of waste would exceed regional capacities for disposal or management. (Section 4.1.12)	Small; minimal waste generated or hazardous materials used. (Section 5.0)
Environmental justice	No identified disproportionately high and adverse potential impact to any populations; no identified subsections of the population, including minority or low-income populations that would receive disproportionate impacts. DOE acknowledges the opposing American Indian viewpoint. (Section 4.1.13)	Small; no disproportionately high and adverse impacts to minorities or low-income populations; DOE acknowledges the opposing American Indian viewpoint. (Section 5.0)
Airspace restrictions	Small; if necessary, DOE would obtain exclusive control of a lightly used 48-km^2 (19-square-mile) airspace and implement specific restrictions to the Nevada Test Site restricted airspace; airspace restrictions could be lifted once operations were complete. (Section 4.1.15)	Not applicable.
Manufacturing repository components		
Air quality	Small; annual pollutant emissions from component manufacturing would be 0.4 percent or less of the regional emissions for a typical manufacturing location. (Section 4.1.14)	Not applicable.
Occupational and public health and safety	Small; 1,700 reportable occupational injuries and illnesses and 0.61 fatality over entire manufacturing campaign. (Section 4.1.14)	Small.
Socioeconomics	Moderate; the area of a typical manufacturing site could see increases of up to 4.7 percent in the average annual output; up to 2.6 percent in the average annual income; and up to 0.63 percent in the average annual employment. (Section 4.1.14)	Not applicable.

Table 2-2. Potential preclosure and postclosure impacts associated with the repository (continued).

Resource area	Preclosure impacts	Postclosure impacts
Manufacturing repository components (continued)		
Materials use	Moderate; annual use of nickel in component manufacturing would be 3.6 percent of U.S. imports in 2007 when there was no significant domestic production, but almost as much was recovered from nickel scrap as was imported. Annual use of palladium would be 59 percent of U.S. production in 2007, but when imports are included, annual use would be reduced to 6.8 percent of the palladium used in the United States in 2007. Annual use of titanium would be 22 percent of U.S. imports in 2007 when there was limited domestic production, but increased domestic production is forecast for the future. (Section 4.1.14)	Not applicable.
Waste generation	Small; a typical manufacturing facility would generate as much as 7.5 metric tons (8.3 tons) of liquid waste and 1 metric ton (1.1 tons) of solid waste per year. (Section 4.1.14)	Small.
Environmental justice	Disproportionately high and adverse impacts to minority or low-income populations would be unlikely from the manufacturing activities. (Section 4.1.14)	Not applicable.

a. To convert acre-feet to cubic meters, multiply by 1,233.49. This table lists acre-feet because of common statutory and public use of this unit of measure for groundwater resources.

km = kilometer.
km^2 = square kilometer.
LCF = Latent cancer fatality.
MEI = Maximally exposed individual.
PM_{10} = Particulate matter with an aerodynamic diameter of 10 micrometers or less.
RMEI = Reasonably maximally exposed individual.

2.3.2 POTENTIAL IMPACTS OF NATIONAL AND NEVADA TRANSPORTATION

DOE analyzes the impacts from national and Nevada transportation in Chapter 6 of this Repository SEIS and in the Rail Alignment EIS, respectively. Table 2-3 summarizes the range of transportation impacts both nationally and in Nevada under the mostly rail scenario and with the use of dedicated trains.

The impact analysis for national transportation addressed health and safety impacts from the movement of spent nuclear fuel and high-level radioactive waste from the 72 commercial and 4 DOE sites across the nation to the Yucca Mountain site. It includes the impacts of the loading of these materials at the generator sites and their transportation on U.S. railroads and highways.

As Chapter 6 discusses in more detail, shipments of spent nuclear fuel and high-level radioactive waste would represent a very small fraction of the annual traffic levels on the nation's railroads and highways (0.0002 percent for trucks, 0.006 percent for railcars, and about 0.1 percent for trains). The analysis of national transportation led to the following conclusions:

- The environmental impacts from shipments to land use and ownership; *hydrology*; biological resources and soils; cultural resources; socioeconomics; noise and vibration; aesthetics; utilities, energy, and materials; and waste management would be small in comparison with the impacts of other nationwide transportation activities.

- The radiological health impacts to the public and workers for national transportation activities would be small.

- The transportation *accident* that is reasonably foreseeable and that would have the highest (or maximum) consequences (the maximum reasonably foreseeable accident) would have an estimated frequency of about 8×10^{-6} per year. This accident would involve a long-duration, high-temperature fire that would engulf a cask. If the accident occurred in an urban area, the estimated population radiation dose would be about 16,000 *person-rem*. In the exposed population, this would result in an estimated 9 *latent cancer fatalities*. If the accident occurred in a rural area, the estimated population radiation dose would be about 21 person-rem, and the estimated *probability* of a single latent *cancer* fatality in the exposed population would be 0.012 (1 chance in 80).

- For sabotage events involving penetration of a spent nuclear fuel rail cask with a high-energy-density device, DOE estimated that there would be 19 latent cancer fatalities in the exposed population if the sabotage event occurred in an urban area. If the sabotage event took place in a rural area, DOE estimated that the probability of a single latent cancer fatality in the exposed population would be 0.029 (1 chance in 30).

For rail transportation in Nevada, Table 2-3 summarizes the impacts from both the Caliente and Mina Implementing Alternatives to show the differences between impacts of the two alignments. The impacts are from the summary tables in Chapter 2 of the Rail Alignment EIS. Potential impacts under the Shared-Use Option would be generally the same as impacts under the Proposed Action without shared use, unless otherwise noted. The impacts from construction and operation of a railroad in Nevada would be linear in nature and would occur over a range from 452 to 541 kilometers (281 to 336 miles).

Table 2-3 illustrates that the Mina Implementing Alternative would be environmentally preferable in comparison with the Caliente Implementing Alternative. In general, the Mina Implementing Alternative would have fewer impacts to private land use, less surface disturbance, lower *wetlands* impacts, and lower *air quality* impacts than the Caliente Implementing Alternative. However, the Mina Implementing Alternative remains the nonpreferred alternative due to the objection of the Walker River Paiute Tribe to the transportation of spent nuclear fuel and high-level radioactive waste through its Reservation.

Table 2-3. Potential impacts from national and Nevada transportation.

Resource area	National transportation	Nevada transportation[a]	
		Caliente Implementing Alternative	Mina Implementing Alternative
Corridor length		Total length (all new construction): 528 to 541 km (328 to 336 miles).	Total length: 452 to 502 km (281 to 312 miles).
Land use and ownership	Small (Section 6.3)[b]	Total surface disturbance: 55 to 61 km^2 (14,000 to 15,000 acres); would result in topsoil loss and increased potential for erosion.	Total surface disturbance: 40 to 48 km^2 (9,900 to 12,000 acres) would result in topsoil loss and increased potential for erosion.
		Loss of prime farmland soils: 1.2 to 1.8 km^2 (300 to 440 acres). Less than 0.1 percent of prime farmland soils in Lincoln and Nye counties.	Loss of prime farmland soils: 0.011 to 0.015 km^2 (2.6 to 3.6 acres). Less than 3 percent of the prime farmland soils of the Walker River Paiute Reservation.
		Land use change on public lands for operations right-of-way.	Land use change on public lands and on Walker River Paiute Reservation for operations right-of-way.
		Private parcels the rail line would cross: 7 to 66. Area of affected private land: 0.49 to 1.25 km^2 (120 to 310 acres).	Private parcels the rail line would cross: 1 to 39. Area of affected private land: 0.21 to 0.81 km^2 (52 to 199 acres).
		Private land needed for facilities: 0.65 to 0.89 km^2 (159 to 219 acres)	
		Active grazing allotments the rail line would cross: 23 to 25. Animal unit months lost: 999 to 1,034. [An animal unit equates to approximately 360 kilograms (800 pounds) of forage and is a measure of the forage needed to support one cow, one cow/calf pair, one horse, or five sheep for 1 month.]	Active grazing allotments the rail line would cross: 6 to 9. Animal unit months lost: 179 to 199.
		Sections with unpatented mining claims that would be crossed: 37 to 42.	Sections with unpatented mining claims that would be crossed: 43 to 50.
Air quality	Small (Section 6.3)[b]	Rail line construction would not result in exceedances of the NAAQS in Esmeralda, Lincoln, or Nye counties with the possible exception of 24-hour PM_{10} in Nye County near a potential quarry.	Rail line construction would not result in exceedances of the NAAQS in Churchill, Lyon, Esmeralda, or Nye counties. In Mineral County the potential exists for exceedances of the NAAQS for PM_{10} and $PM_{2.5}$.
		Rail line operations would add less than about 20 percent to the 2002 countywide burden of all criteria air pollutants for Lincoln County, less than 6 percent for Esmeralda County, and less than 40 percent for Nye County. Rail line operations would not lead to an exceedance of air quality standards. Construction and operation of a proposed quarry in Lincoln County would not result in exceedances of the NAAQS.	Rail line operations would add less than 35 percent to the 2002 countywide burden of all criteria air pollutants for both Esmeralda and Nye counties and less than about 1 percent to the 2002 countywide burden of all criteria air pollutants for Churchill and Lyon counties. Rail line operations would lead to an exceedance of air quality standards.

Table 2-3. Potential impacts from national and Nevada transportation (continued).

Resource area	National transportation	Nevada transportation[a] Caliente Implementing Alternative	Nevada transportation[a] Mina Implementing Alternative
Air quality (continued)		Construction and operation of a proposed quarry in Nye County could result in exceeding 24-hour PM_{10} limit, but measures required by the Surface Disturbance Permit would greatly reduce PM_{10} emissions, making an exceedance of the NAAQS unlikely. Churchill County. Not applicable. Lyon County. Not applicable. Mineral County. Not applicable.	Operation of a proposed quarry in Esmeralda County near Hawthorne could result in exceeding the 24-hour PM_{10} standards. Construction of the Staging Yard at Hawthorne in Mineral County could result in exceeding 24-hour PM_{10} and $PM_{2.5}$ standards and annual PM_{10} standards. Rail line construction near Mina could result in exceeding the 24-hour PM_{10} standard. Rail line construction near Schurz could result in exceeding 24-hour PM_{10} and $PM_{2.5}$ standards and annual PM_{10} standards. Operating restrictions in the required Surface Disturbance Permit would likely reduce PM_{10} and $PM_{2.5}$ emissions making exceedances of the NAAQS unlikely. Lincoln County. Not applicable.
Hydrology			
Surface water	Small (Section 6.3)[b]	Up to approximately 0.225 km^2 (56 acres) of wetlands could be filled.	Not more than 28 m^2 (0.007 acres) of wetlands would be filled.
Groundwater	Small (Section 6.3)[b]	Physical impacts to existing groundwater resource features such as existing wells or springs resulting from railroad construction and operation would be small. Groundwater withdrawals during construction would not be expected to impact groundwater resources or users except in a few specific locations. However, mitigation measures such as reducing the pumping rate or relocating some of the proposed wells would minimize these impacts. The impact of proposed groundwater withdrawals on groundwater quality would be small to negligible. The proposed withdrawals would not conflict with water quality standards protecting groundwater resources.	Physical impacts to existing groundwater resource features such as existing wells or springs from railroad construction and operations would be small. Groundwater withdrawals during would not be expected to impact groundwater resources or users except in a few specific locations. However, in such instances, mitigation measures such as reducing the pumping rate or relocating some of the proposed wells would minimize these impacts. The impact of proposed groundwater withdrawals on groundwater quality would be small to negligible. The proposed withdrawals would not conflict with water quality standards for groundwater resources.
Biological resources	Small (Section 6.3)[b]	Short-term impact to 0.014 to 0.28 km^2 (3.4 to 69 acres) wetland/riparian habitat. Long-term impacts to 0.011 to 0.18 km^2 (2.7 to 45 acres) wetland/riparian habitat.	Short-term impact to 0.013 to 0.035 km^2 (3.19 to 8.7 acres) wetland/riparian habitat. Long-term impacts to 0 to 0.0015 km^2 (0 to 0.37 acre) wetland/riparian habitat.

Table 2-3. Potential impacts from national and Nevada transportation (continued).

Resource area	National transportation	Nevada transportation[a] Caliente Implementing Alternative	Mina Implementing Alternative
Biological resources (continued)		Impacts would vary by alternative segment, be localized, and could include: • Short-term moderate impact on riparian and wetland vegetation • Small to moderate impacts on raptor nesting sites • Short-term moderate impacts to desert big horn sheep	Impacts would vary by alternative segment, be localized, and could include: • Short-term moderate impact on riparian and wetland vegetation • Small to moderate impacts on raptor nesting sites • Short-term moderate impacts to desert big horn sheep • Small to moderate long-term impacts to Inter-Mountain Basins Mixed Salt Desert Scrub and Inter-Mountain Basins Greasewood Flat land cover types • Small short-term and long-term impacts to Western snowy plover • Moderate impact to winterfat communities • Long-term moderate impacts to Inter-Mountain Basins Mixed Salt Desert Scrub and Inter-Mountain Basins Big Sagebrush Shrubland land cover types
Cultural resources	Small (Section 6.3)[b]	Numerous archaeological sites identified along segments of alignments subject to sample inventory. Construction could result in impacts to the early Mormon colonization cultural landscape, Pioche-Hiko silver mining community route, 1849 Emigrant Trail campsites, American Indian trail systems, and more than 50 sites eligible for the *National Register of Historical Places* identified along segments of alignments subjected to sample inventory. Indirect effects to a National Register-eligible rock art site are likely from two quarry sites. No direct impacts to known paleontological resources.	Numerous archaeological sites, including more than 60 National Register-eligible sites, identified along segments of alignments subject to sample inventory. Potential direct and indirect impacts to sites eligible for the *National Register of Historical Places* and to other sites that might be identified during the complete survey. No direct impacts to known paleontological resources.
Socioeconomics			
New jobs (percent of workforce in affected counties)	Small (Section 6.3)[b]	Construction: Ranges from 0.1-percent increase in Clark County to 5.6-percent increase in Lincoln County. Operation: Ranges from less than 0.1-percent increase in Clark County to 3.9-percent increase in Lincoln County.	Construction: Ranges from 0.02-percent increase in Lyon County to 14-percent increase in Esmeralda County. Operation: Ranges from 0.01-percent increase in Lyon County to 14-percent increase in Esmeralda County.
Peak real disposable personal income	Small (Section 6.3)[b]	Construction: Ranges from 0.2-percent increase in Clark County to 7.6-percent increase in Esmeralda County. Operation: Ranges from less than 0.1-percent increase in Clark County to 4.7-percent increase in Lincoln County.	Construction: Ranges from 0.03-percent increase in Lyon County to 27-percent increase in Esmeralda County. Operation: Ranges from 0.01-percent increase in Lyon County to 10-percent increase in Esmeralda County.

Table 2-3. Potential impacts from national and Nevada transportation (continued).

Resource area	National transportation	Nevada transportation[a]	
		Caliente Implementing Alternative	Mina Implementing Alternative
Socioeconomics (continued)			
Peak incremental Gross Regional Product	Small (Section 6.3)[b]	Construction: Ranges from 0.2-percent increase in Clark County to 28-percent increase in Lincoln County. Operation: Ranges from less than 0.1-percent increase in Clark County to 5.2-percent increase in Lincoln County.	Construction: Ranges from 0.04-percent increase in Lyon County to 57-percent increase in Esmeralda County. Operation: Ranges from less than 0.01-percent increase in Lyon County to 24-percent increase in Esmeralda County.
Occupational and public health and safety[d]			
Public, Radiological			
MEI (probability of an LCF)	1.3×10^{-4}	4.7×10^{-6}	4.7×10^{-6}
Population (LCFs)	0.73 to 0.79	6.3×10^{-5} to 1.5×10^{-4}	8.2×10^{-4} to 8.6×10^{-4}
Workers (involved and noninvolved)			
MEI (probability of an LCF)[c]	0.015	0.015	0.015
Radiological (LCFs)	9.9 to 10	0.78	0.77 to 0.79
Nonradiological fatalities (includes commuting traffic and vehicle emissions fatalities)	63 to 65	21	22
Maximum reasonably foreseeable transportation accident (LCFs)	0.012 (rural area) to 9.4 (urban area)	0.0012 (rural area) to 0.46 (suburban area) (no urban areas exist along the Caliente Implementing Alternative)	0.0089 (rural area) to 1.2 (suburban area) (no urban areas exist along the Mina Implementing Alternative)
Noise and vibration	Small (Section 6.3)[b]	Noise from construction activities in Caliente would exceed Federal Transit Administration guidelines. Noise from rail construction would be temporary. Noise from operations would create adverse impacts at three noise-sensitive receptors in Caliente. There would be no adverse vibration impacts from construction trains or from operational train activity.	Noise from construction would cause temporary adverse impacts at two locations. Noise from operations would create adverse noise impacts at eight noise-sensitive receptors in Silver Springs and one noise-sensitive receptor in Wabuska. There would be no vibration impacts from construction trains or from operational train activity.
Aesthetics	Small (Section 6.3)[b]	Small to large impact along rail alignment (depending on segment) from operations and the installation of linear track, signals, communications towers, power poles connecting to the grid, access roads, Staging Yard, and quarries.	Small to large impact along rail alignment (depending on segment) from operations and the installation of linear track, signals, communications towers, power poles connecting to the grid, access roads, Staging Yard, and quarries.

Table 2-3. Potential impacts from national and Nevada transportation (continued).

Resource area	National transportation	Nevada transportation[a]	
		Caliente Implementing Alternative	Mina Implementing Alternative
Utilities, energy, materials, and site services	Small (Section 6.3)[b]	Utility interfaces: Potential for short-term interruption of service during construction. No permanent or long-term loss of service or prevention of future service area expansions.	Utility interfaces: Potential for short-term interruption of service during construction. No permanent or long-term loss of service or prevention of future service area expansions.
		Public water systems: Most water would be supplied by new wells; small effect on public water systems from population increase attributable to construction and operation employees.	Public water systems: Most water would be supplied by new wells; small effect on public water systems from population increase attributable to construction and operation employees.
		Wastewater systems: Dedicated wastewater treatment systems would be at construction camps and operations facilities; small impact on public systems from population increase attributable to construction and operation employees.	Wastewater systems: Dedicated wastewater treatment systems would be at construction camps and operations facilities; small impact on public systems from population increase attributable to construction and operation employees.
		Fossil fuels: Fossil-fuel demand would be approximately 6.5 percent of statewide use during construction and less than 0.25 percent of statewide use during operation. Demand could be met by existing regional supply systems and suppliers. For the Shared-Use Option, demand would be less than 0.3 percent of statewide use during operation. Demand could be met by existing regional supply systems and suppliers.	Fossil fuels: Fossil-fuel demand would be approximately 6 percent of statewide use during construction and less than 0.25 percent of statewide use during operation. Demand could be met by existing regional supply systems and suppliers. For the Shared-Use Option, demand would be less than 0.3 percent of statewide use during operation. Demand could be met by existing regional supply systems and suppliers.
		Materials: Material requirements such as steel, concrete, and ballast would generally be very small in relation to supply capacity.	Materials: Material requirements such as steel, concrete, and ballast would generally be very small in relation to supply capacity.
Hazardous materials and waste	Small (Section 6.3)[b]	Small (Apex Landfill) to moderate (smaller landfills) impacts from nonhazardous waste (solid and industrial and special waste) disposal.	Small (Apex Landfill) to moderate (smaller landfills) impacts from nonhazardous waste (solid and industrial and special waste) disposal.
		Small impacts from use of hazardous materials.	Small impacts from use of hazardous materials.
		Small impacts from hazardous waste disposal.	Small impacts from hazardous waste disposal.
		Small impacts from low-level radioactive waste disposal for wastes that would be generated at the Cask Maintenance Facility.	Small impacts from low-level radioactive waste disposal for wastes that would be generated at the Cask Maintenance Facility.
Environmental justice	Small (Section 6.3)[b]	Constructing and operating the proposed rail line along the Caliente rail alignment would not result in disproportionately high and adverse impacts to minority or low-income populations.	Constructing and operating the proposed rail line along the Mina rail alignment would not result in disproportionately high and adverse impacts to minority or low-income populations.

Table 2-3. Potential impacts from national and Nevada transportation (continued).

Resource area	National transportation	Nevada transportation[a]	
		Caliente Implementing Alternative	Mina Implementing Alternative

a. Short-term impacts for the Rail Alignment EIS would occur during the construction phase (4 to 10 years). Long-term impacts would occur throughout and beyond the life of the railroad operations phase (up to 50 years).

b. With the exception of occupational and public health and safety impacts, because shipments of spent nuclear fuel and high-level radioactive waste would comprise only small fractions of total national highway and rail traffic, the environmental impacts of the shipments on land use and ownership; hydrology; biological resources and soils; cultural resources; socioeconomics; noise and vibration; aesthetics; utilities, energy, and materials; and waste management would be small in comparison with the impacts of other nationwide transportation activities.

c. Based on a worker who would receive the administrative dose limit of 500 millirem per year (DIRS 156764-DOE 1999, p. 2-3).

d. Impacts are composed of the industrial safety and transportation impacts from Chapter 4 of the Rail Alignment EIS and Chapters 4 and 6 of this Repository SEIS. Included in the impacts are radiation-related latent cancer fatalities, nonradiological industrial accident fatalities, vehicle emission fatalities, and traffic fatalities, as appropriate. Impacts may occur nationally or in Nevada. Impacts may include workers or members of the public.

CO = Carbon monoxide.
km = kilometer.
km^2 = square kilometer.
LCF = Latent cancer fatality.
MEI = Maximally exposed individual.
NAAQS = National Ambient Air Quality Standards.
NO_x = Nitrous oxides.
$PM_{2.5}$ = Particulate matter with an aerodynamic diameter of 2.5 micrometers or less.
PM_{10} = Particulate matter with an aerodynamic diameter of 10 micrometers or less.
SO_2 = Sulfur dioxide.
VOC = Volatile organic compounds.

2.3.3 POTENTIAL IMPACTS OF THE NO-ACTION ALTERNATIVE

Table 2-4 summarizes the potential impacts of the No-Action Alternative from Chapter 7 of this Repository SEIS. Because there would be no construction or operation of a railroad under the No-Action Alternative for the Rail Alignment EIS, there would be no impacts. Therefore, this section does not further discuss the No-Action Alternative for the Rail Alignment EIS.

For the No-Action Alternative for the Proposed Action, short-term actions would include termination of activities and reclamation at the Yucca Mountain site as well as continued management and storage of spent nuclear fuel and high-level radioactive waste at the commercial and DOE sites across the United States. The information in Table 2-4 shows that the short-term (up to 100 years) environmental impacts for the No-Action Alternative would generally be small.

Under No-Action Alternative Scenario 1, DOE would continue to manage spent nuclear fuel and high-level radioactive waste at the DOE sites, and commercial utilities would continue to manage their spent nuclear fuel at their sites, on a long-term basis to isolate the material from human access with institutional control. Under Scenario 2, DOE assumed there would be no effective institutional control after 100 years. The spent nuclear fuel and high-level radioactive waste storage facilities would begin to deteriorate, and radioactive materials could escape to the environment and contaminate the local atmosphere, soils, surface water, and groundwater, thereby representing a considerable human health *risk*, as Table 2-4 indicates.

The analysis led to the following conclusions:

- For Scenario 2, from 0.04 to 0.4 square kilometer (10 to 100 acres) of land at each generator site could become contaminated to the extent that the land would not be usable for long periods. There would be no such impacts for Scenario 1.

- For Scenario 2, there could be low levels of contamination in the surface watershed and high concentrations of *contaminants* in the groundwater downstream of the commercial and DOE sites for long periods. There would be no such impacts for Scenario 1.

- For Scenario 2, estimated long-term radiological impacts to the public would be high (1,000 latent cancer fatalities over 10,000 years) in comparison with the first 10,000 years for the Proposed Action.

- For Scenario 1, estimated long-term (10,000 years) fatalities would be about 1,100, primarily to the workforce at the storage sites.

- For both scenarios, the risks in relation to sabotage and diversion of fissionable materials at the commercial and DOE sites would be much greater than they would be if the materials were in a deep geologic repository.

Table 2-4. Potential impacts from the No-Action Alternative.

Resource area	Repository	Commercial and DOE sites: Short-term 100 years	Commercial and DOE sites: Long-term (100 to 10,000 years) Scenario 1	Commercial and DOE sites: Long-term (100 to 10,000 years) Scenario 2
Land use and ownership	DOE would require no new land to support decommissioning and reclamation. Decommissioning and reclamation would include removal or shutdown of existing surface and subsurface facilities and restoration of disturbed lands, including soil stabilization and revegetation of disturbed areas.	Small; storage would continue at existing sites.	Small; storage would continue at existing sites.	Large; potential contamination of 0.04 to 0.4 km^2 (10 to 100 acres) around each of the existing commercial and DOE sites.
Air quality	Dismantling and removal of existing structures, recontouring, and revegetation would generate fugitive dust that would be below the regulatory limit.	Small; releases and exposures well below regulatory limits.	Small; releases and exposures well below regulatory limits.	Small; degraded facilities would preclude large atmospheric releases.
Hydrology				
Surface water	Recontouring of terrain to restore the natural drainage and managing potential surface-water contaminant sources would minimize surface-water impacts.	Small; minor changes to runoff and infiltration rates.	Small; runoff during storage and reconstruction would be controlled in stormwater holding ponds; active monitoring would ensure quick response to leaks or releases; commercial and DOE sites for storage probably would be outside flood zones.	Large; potential for radiological releases and contamination of drainage basins downstream of commercial and DOE sites (concentrations potentially exceeding current regulatory limits).
Groundwater	DOE would use a small amount of groundwater during the decommissioning and reclamation.	Small, use would be small in comparison with other site use.	Small; use would be small in comparison with other site use.	Large; potential for radiological contamination of groundwater around the commercial and DOE sites.
Biological resources and soils	Reclamation would result in the restoration of 1.4 km^2 (346 acres) of habitat. Site reclamation would include soil stabilization and revegetation of disturbed areas. Some animal species could take advantage of abandoned tunnels for shelter. Decommissioning and reclamation could produce adverse impacts to the threatened desert tortoise.	Small; storage would continue at existing sites.	Small; storage would continue at existing sites.	Large; potential adverse impacts at each of the sites from subsurface contamination of 0.04 to 0.4 km^2 (10 to 100 acres).

Table 2-4. Potential impacts from the No-Action Alternative (continued).

		Commercial and DOE sites		
		Short-term	Long-term (100 to 10,000 years)	
Resource area	Repository	100 years	Scenario 1	Scenario 2
Cultural resources	Leaving roads in place after decommissioning could have an adverse impact on cultural resources by increasing public access to the site. Preserving the integrity of important archeological sites and resources important to American Indians could be difficult.	Small; storage would continue at existing sites; limited potential of disturbing sites.	Small; storage would continue at existing sites; limited potential of disturbing sites.	Small; no construction or operation activities; therefore, no impacts.
Socioeconomics	Loss of approximately 4,700 jobs (1,800-person workforce for decommissioning and reclamation, 1,400 engineering and technical personnel in locations other than the repository site, and 1,500 indirect jobs) in the socioeconomic region of influence. Nye County collects most of the federal monies associated with the repository project. The No-Action Alternative would result in the loss of payments-in-lieu-of-taxes to Nye County.	Small; population and employment changes would be small compared with totals in the regions.	Small; population and employment changes would be small compared with totals in the regions.	No workers; therefore, no impacts.
Occupational and public health and safety				
Public – Radiological MEI (probability of an LCF)	None.	0.0000052[a]	0.0000016[a]	(b)
Public – Population (LCFs)	0.001	0.49[a]	3.1[a]	1,000[c]
Public – Nonradiological (fatalities due to emissions)	Small; exposures well below regulatory limits or guidelines.	Small; exposures well below regulatory limits or guidelines.	Small; exposures well below regulatory limits or guidelines.	Moderate to large; substantial increases in releases of hazardous substances and exposures to the public.
Workers – Radiological (LCFs)	0.09	24[a]	15[a]	No workers; therefore, no impacts.
Workers – Nonradiological fatalities (includes commuting traffic fatalities)	Less than 0.15	9	1,080	No workers; therefore, no impacts.

Table 2-4. Potential impacts from the No-Action Alternative (continued).

Resource area	Repository	Commercial and DOE sites: Short-term 100 years	Commercial and DOE sites: Long-term (100 to 10,000 years) Scenario 1	Commercial and DOE sites: Long-term (100 to 10,000 years) Scenario 2
Accidents				
Public – Radiological MEI (probability of an LCF)	None.	None.	None.	Not applicable.
Public – Population (LCFs)	None.	None.	None.	4 to 16[d]
Workers	Accident impacts would be limited to those from traffic and typical industrial hazards during construction or excavation activities. These were estimated at 94 total recordable cases and 45 lost workday cases.	Large; for some unlikely accident scenarios workers probably would be severely injured or killed; however, DOE or NRC would manage facilities safely during continued storage operations.	Large; for some unlikely accident scenarios workers would probably be severely injured or killed.	No workers; therefore, no impacts.
Traffic and transportation	Less than 0.15 traffic fatality would be likely during decommissioning and reclamation.	Small; local traffic only.	Small; local traffic only.	No activities, therefore no traffic.
Noise and vibration	Noise levels would be no greater than the current baseline noise environment at the Yucca Mountain site.	Small; transient and not excessive, less than 85 dBA.	Small; transient and not excessive, less than 85 dBA.	No activities, therefore, no noise.
Aesthetics	Site decommissioning and reclamation would improve the scenic value of the site, which DOE would return as close as possible to its predisturbance state.	Small; storage would continue at existing sites; expansion as needed.	Small; storage would continue at existing sites; expansion as needed.	Small; aesthetic value would decrease as facilities degraded.
Utilities, energy, materials, and site services	Decommissioning would consume electricity, diesel fuel, and gasoline. The amounts of use would not adversely affect the utility, energy, or material resources of the region.	Small; materials and energy use would be small in comparison with total regional use.	Small; materials and energy use would be small in comparison with total regional use.	No use of materials or energy; therefore, no impacts.
Waste management	Decommissioning would generate some waste that would require disposal in existing Nevada Test Site or regional landfills. DOE would minimize waste by salvaging most equipment and many materials.	Small; waste generated and materials used would be small in comparison with total regional generation and use.	Small; waste generated and materials used would be small in comparison with total regional generation and use.	No generation of waste or use of hazardous materials; therefore, no impacts.

Table 2-4. Potential impacts from the No-Action Alternative (continued).

		Commercial and DOE sites		
		Short-term	Long-term (100 to 10,000 years)	
Resource area	Repository	100 years	Scenario 1	Scenario 2
Environmental justice	The No-Action Alternative at the repository location would not result in disproportionately high and adverse impacts to minority or low-income populations.	The No-Action Alternative during the first 100 years at commercial and DOE sites would not result in disproportionately high and adverse impacts to minority or low-income populations.	The No-Action Alternative under Scenario 1 at commercial and DOE sites would not result in disproportionately high and adverse impacts to minority or low-income populations.	The No-Action Alternative under Scenario 2 at commercial and DOE sites could result in disproportionately high and adverse impacts to minority or low-income populations.

a. Updated using a conversion factor of 0.0006 latent cancer fatality per person-rem; no change to external dose coefficients.

b. With no effective institutional controls, the maximally exposed individual could receive a fatal dose of radiation within a few weeks to months. Death could be caused by acute direct radiation exposure.

c. Updated using a conversion factor of 0.0006 latent cancer fatality per person-rem and ingestion dose coefficients that overall are about 25 percent of the coefficients for the Yucca Mountain FEIS.

d. Updated using a conversion factor of 0.0006 latent cancer fatality per person-rem and inhalation dose coefficients that are approximately the same as coefficients for the Yucca Mountain FEIS.

dBA = A-weighted decibels.
DOE = U.S. Department of Energy.
km^2 = square kilometer.
LCF = Latent cancer fatality.
MEI = Maximally exposed individual.
NRC = U.S. Nuclear Regulatory Commission.

2.3.4 SUMMARY OF POTENTIAL PRECLOSURE IMPACTS OF THE PROPOSED ACTION

This section presents the total estimated environmental impacts for the Proposed Action. It combines the environmental impacts from the construction analytical period, operations analytical period, monitoring analytical period, and closure analytical period of the repository (Table 2-2) with the environmental impacts from transportation activities (Table 2-3).

As construction of the rail corridor approached the physical location of the repository and its surface facilities, the potential for impacts to overlap would increase. In most instances, DOE evaluated the potential impacts qualitatively and judged them to be small. However, there are several air quality and groundwater impacts from the repository and the rail actions that DOE could sum and quantify. The following paragraphs discuss those results.

2.3.4.1 Air Quality

Chapter 4, Section 4.1.2 describes air quality impacts for the repository. Chapter 6, Section 6.4 discusses air quality impacts from rail construction and operation. The air quality impacts from simultaneous construction of the proposed repository and of the railroad and associated rail facilities would not produce *criteria pollutant* concentrations that exceeded the regulatory limits at the boundary of the *analyzed land withdrawal area*. Table 2-5 shows the combined estimated concentrations of criteria pollutants at the land withdrawal boundary. Simultaneous operation of the repository, railroad, and its facilities would not produce criteria pollutant concentrations that exceeded the regulatory limit at the land withdrawal area boundary. In addition, while DOE would implement dust suppression measures during construction of both the repository and railroad to reduce releases of *particulate matter*, the Department did not take credit for such measures in the analysis. Therefore, the analysis was conservative.

The analyses indicate that even if the background concentrations of the criteria pollutants were added to the estimated maximum concentrations of all construction activities, the resultant concentrations would be below the *National Ambient Air Quality Standards*.

Carbon dioxide, a greenhouse gas, would be produced by the burning of fossil fuels and the manufacture of concrete during repository and railroad construction and operations. The amount of carbon dioxide emitted would be a small addition to existing State of Nevada and total U.S. carbon dioxide emissions. DOE is not aware of any methodology to correlate the carbon dioxide emissions exclusively from a specific proposed project to any specific impact on global climate change.

2.3.4.2 Groundwater

Groundwater withdrawals would occur for both the repository and rail actions from the same *hydrographic area*, specifically Area 227A, *Jackass Flats*. For the analysis, DOE assumed the rail corridor construction in the Jackass Flats area would start 2 years prior to repository construction. Figure 2-15 shows annual water demands for the time of greatest fluctuation, including the years of peak water demand. The highest combined annual water demand for rail and repository activities would be below the Nevada State Engineer's ruling of perennial yield (the amount that can be withdrawn annually without depleting reserves) for the Jackass Flats hydrographic area. For the peak years, the combined demand would be less than even the lowest estimated value of perennial yield [720,000 cubic meters

Table 2-5. Maximum construction analytical period concentrations of criteria pollutants at the analyzed land withdrawal area boundary from both repository and rail construction activities (micrograms per cubic meter).[a,b]

Pollutant	Averaging time	Regulatory limit[c]	Maximum concentration[d]	Percent of regulatory limit
Carbon monoxide	8-hour	10,000	300	3.0
	1-hour	40,000	2,400	5.9
Nitrogen dioxide	Annual	100	2.8	2.8
Sulfur dioxide	Annual	80	0.0022	0.0027
	24-hour	365	0.18	0.048
	3-hour	1,300	0.86	0.066
PM_{10}	24-hour	150	130	86
$PM_{2.5}$	Annual	15	0.16	1.1
	24-hour	35	13	37
Cristobalite	Annual	10[e]	0.048	0.48

a. Appendix B describes the analysis of maximum concentrations and percent of regulatory limits.
b. All numbers except regulatory limits are rounded to two significant figures.
c. Regulatory limits for criteria pollutants are from 40 CFR 50.4 through 50.11 and Nevada Administrative Code 445B.22097 (Table 3-5).
d. Sum of highest estimated concentrations at the accessible land withdrawal boundary regardless of direction. Does not include background concentrations. (Appendix B contains more information.)
e. There are no regulatory limits for public exposure to cristobalite. An EPA health assessment states that the risk of silicosis is less than 1 percent for a cumulative exposure of 1,000 micrograms per cubic meter × years. Using a 70-year lifetime, an approximate annual average concentration of 10 micrometers per cubic meter was established as a benchmark for comparison.

$PM_{2.5}$ = Particulate matter with an aerodynamic diameter of 2.5 micrometers or less.
PM_{10} = Particulate matter with an aerodynamic diameter of 10 micrometers or less.

(580 acre-feet)] for the western two-thirds of this hydrographic area. Coupled with the demand for Nevada Test Site activities in Jackass Flats, the total annual water demand would still be slightly below the lowest estimated value of perennial yield for the western two-thirds of the hydrographic area.

The Proposed Action would withdraw groundwater that would otherwise move into *aquifers* of the Amargosa Desert, but the combined water demand for the rail, repository, and Nevada Test Site activities in Jackass Flats would have, at most, small impacts on the availability of groundwater in the Amargosa Desert area in comparison with the quantities of water already being withdrawn there.

Table 2-6 lists the accumulated impacts of the Proposed Action (repository, national transportation, and construction and operation of a railroad in Nevada). It provides ranges of impacts that encompass impacts from both the Caliente and Mina implementing alternatives. In addition, it identifies repository and Nevada transportation impacts that would occur within overlapping regions of influence.

Considering the preclosure and postclosure impacts presented in this Repository SEIS, it can be concluded that the potential impacts associated with the repository design and operational plans assessed in this Repository SEIS are similar in scale to impacts presented in the Yucca Mountain FEIS.

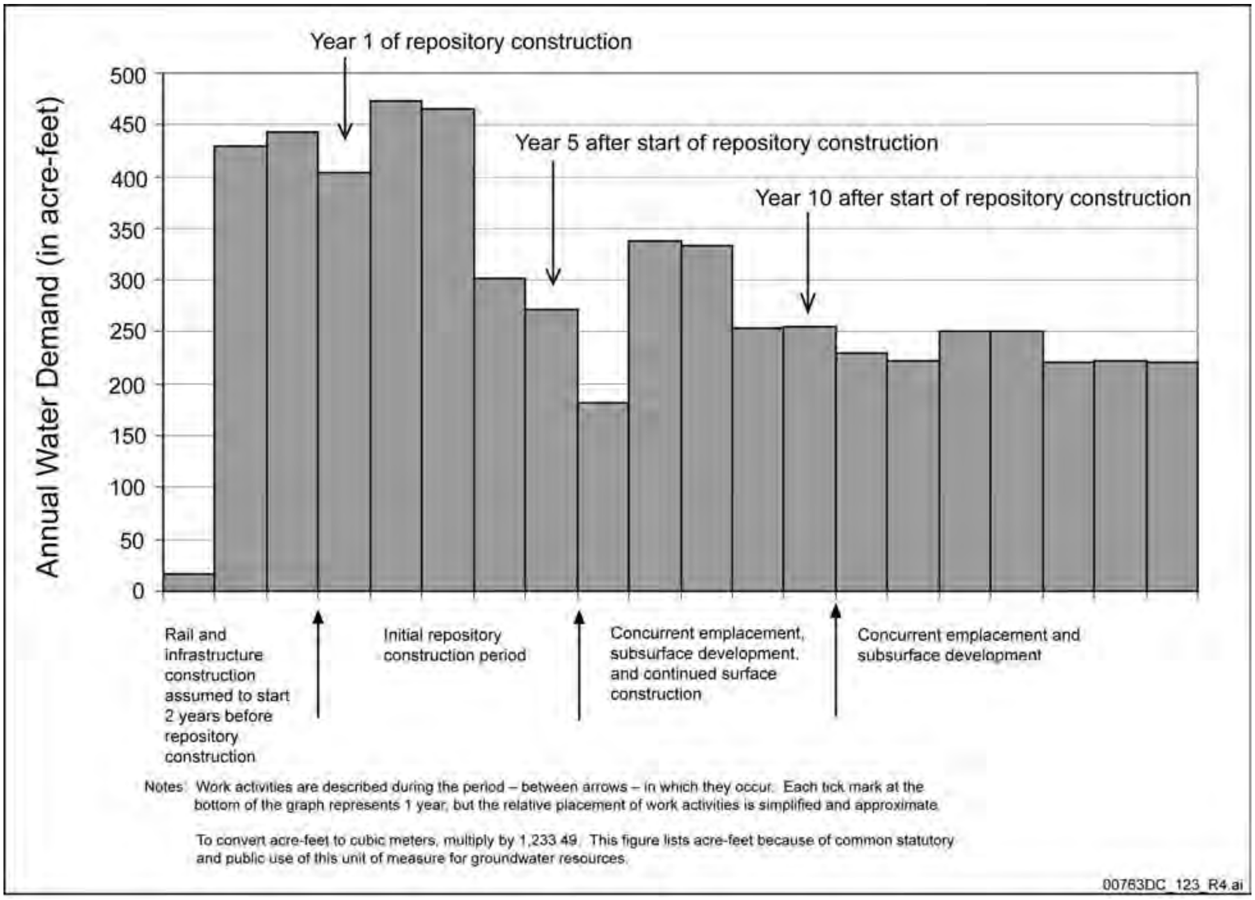


Figure 2-15. Combined annual water demand during the repository and rail construction period and the initial phases of operations.

Table 2-6. Summary of potential preclosure impacts of the Proposed Action.[a]

Resource area	Summary of all preclosure impacts (all preclosure impacts resulting from the repository, national transportation, and Nevada transportation)	Summary of repository and Nevada transportation impacts that would occur within overlapping regions of influence
Land use and ownership	Approximately 49 to 70 km^2 (12,000 to 17,000 acres) of total disturbed land; 600 km^2 (150,000 acres) of land withdrawn from public use. Loss of prime farmland soils would range from 0.011 to 1.8 km^2, (2.6 to 440 acres) which would be less than 0.1 percent of prime farmland soils in Lincoln and Nye Counties and less than 3 percent of the prime farmland soils of the Walker River Paiute Reservation. Land use change would occur on public lands and on Walker River Paiute Reservation for operations right-of-way. Private parcels the rail line would cross would range from 1 to 66; area of private land affected would range from 0.21 to 1.25 km^2 (53 to 310 acres). Private land needed for facilities: 0.65 to 0.89 km^2 (159 to 219 acres) Active grazing allotments the rail line would cross would range from 6 to 25. Animal unit months lost would range from 179 to 1,034. Sections with unpatented mining claims that the rail line would cross would range from 37 to 50.	About 12 km^2 (3,000 acres) of disturbed land; 600 km^2 (150,000 acres) of land withdrawn from public use.
Air quality	Releases from construction and operation of the repository would be well below regulatory limits (less than 3 percent) for all criteria pollutants except particulate matter. Maximum releases of PM_{10} would be 40 percent of limit at boundary of land withdrawal area. Rail line construction emissions would be distributed over the entire length of the rail alignment; therefore, no air quality standard would be exceeded. Rail line operations would not lead to an exceedance of air quality standards. Table 2-3 provides more detail about emissions by county.	Nye County is the only location where Nevada transportation impacts would overlap the repository region of influence. The Nevada transportation emissions would be distributed over the entire county and only the southern portion of the emissions from Nye County would be within the repository region of influence. Modeled concentrations of criteria pollutants at the boundary of the land withdrawal area would not exceed regulatory limits during simultaneous construction of the repository and railroad. Concentrations of all criteria pollutants except for particulate matter would be less than 6 percent of the regulatory limit. Concentrations of $PM_{2.5}$ would not exceed 37 percent, and concentrations of PM_{10} would not exceed 87 percent of the regulatory limit. The simultaneous operation of the repository and railroad would not exceed regulatory limits.

Table 2-6. Summary of potential preclosure impacts of the Proposed Action (continued).[a]

Resource area	Summary of all preclosure impacts (all preclosure impacts resulting from the repository, national transportation, and Nevada transportation)	Summary of repository and Nevada transportation impacts that would occur within overlapping regions of influence
Hydrology		
Surface water	Repository land disturbance would result in minor changes to runoff and infiltration rates. At repository site, potential for contaminants to be released and reach surface water would be minimal; only ephemeral drainage channels would be affected; there are no other surface-water resources at the site. Repository facilities would be above flood zones, or constructed dikes and diversion channels would keep floodwaters away; floodplain assessment concluded impacts would be small. Up to 0.22 km^2 (56 acres) of wetlands could be filled.	Construction of repository surface facilities would affect at least two drainage channels and floodplains (Busted Butte Wash and Drill Hole Wash) that the rail line would cross.
Groundwater	Potential for repository actions to change recharge rates and for contaminants to be released and reach groundwater would be minimal. Physical impacts to existing groundwater resource features such as existing wells or springs from railroad construction and operation would be small. Repository peak water demand (460 acre-feet per year)[b] would be below the lowest estimate of perennial yield (580 acre-feet) for the western two-thirds of the groundwater basin; after construction water demand would decrease to 330 acre-feet per year or less. Groundwater withdrawals during rail construction in some areas could affect existing groundwater resources and users. However, mitigation measures such as reducing the pumping rate or relocating some of the proposed wells would minimize these impacts. Groundwater for repository facility use would be withdrawn from wells in Jackass Flats. Groundwater for rail construction would mostly be withdrawn from new wells.	Water identified for rail line construction includes 572 acre-feet (over four years) plus 6 acre-feet per year for operations, all from the same groundwater basin as for repository activities. A peak annual water demand of 470 acre-feet would result from the combined Nevada transportation and repository needs, assuming primary construction periods did not overlap. This high level would last only 2 years and would occur during the second and third years after start of repository construction. The average annual water demand for the combined construction period would be 400 acre-feet. All combined water demand levels would be below the lowest estimate of perennial yield (580 acre-feet) for the western two-thirds of the groundwater basin. The two years of highest water demand would not result in a well drawdown that could affect the nearest public or private wells. Modeling for the Yucca Mountain FEIS showed small to moderate impacts from the Proposed Action groundwater withdrawals that are still applicable. The model's assumed withdrawal rate of 430 acre-feet per year is lower than the peak water demand, but over the life of the project is still conservatively high.

Table 2-6. Summary of potential preclosure impacts of the Proposed Action (continued).[a]

Resource area	Summary of all preclosure impacts (all preclosure impacts resulting from the repository, national transportation, and Nevada transportation)	Summary of repository and Nevada transportation impacts that would occur within overlapping regions of influence
Biological resources and soils	Loss of between 49 to 70 km^2 (12,000 to 17,000 acres) of desert soil, habitat, and vegetation. Adverse impacts to desert big horn sheep and special status species including western snowy plover and desert tortoise. Short-term impact of up to 0.28 km^2 (69 acres) wetland/riparian habitat. Long-term impact of up to 0.18 km^2 (45 acres) wetland/riparian habitat.	Loss of up to 12 km^2 (3,000 acres) of desert soil, habitat, and vegetation, but no loss of rare or unique habitat or vegetation; adverse impacts to individual threatened desert tortoises and loss of a small amount of low-density tortoise habitat, but no adverse impacts to the species as a whole; reasonable and prudent measures would minimize impacts.
Cultural resources	Numerous archaeological sites, as many as 60 eligible for the *National Register of Historic Places*, along segments of alignments subject to sample inventory and 3 sites in the repository region of influence. Opposing American Indian viewpoint. Construction could result in impacts to the early Mormon colonization cultural landscape, Pioche-Hiko silver mining community route, 1849 Emigrant Trail campsites, American Indian trail systems. Indirect effects to a National Register-eligible rock art site are likely from two quarry sites. No direct impacts to known paleontological resources.	Small potential for impacts; including three prehistoric sites eligible for the *National Register of Historic Places*; opposing American Indian viewpoint.
Socioeconomics		
New jobs (percent of workforce in affected counties)	Construction: Peaks would range from 0.05 percent above baseline in Clark County to 14-percent increase in Esmeralda County. Operation: Peaks would range from 0.01-percent increase in Lyon County to 14-percent increase in Esmeralda County.	Peak increases would be small, less than 1 percent in the region, Clark County, and Nye County when construction of repository and rail overlapped.
Peak real disposable income	Construction: Peak percent increases are: • Nye: 1.16 (repository); 0.4 to 0.9 (rail) • Clark: 0.05 (repository); 0.1 (rail) • Lincoln: 4.1 (rail) • Esmeralda: 7.6 to 27 (rail) • Lyon: 0.03 (rail) • Walker River Paiute Reservation: up to $386,000 • Mineral: 4.5 (rail) • Washoe County/Carson City: less than 0.3 (rail)	For Repository: In Clark County (2034), 58.3 million; in Nye County (2035) $27.5 million For Rail: In Clark County (2011) $100.6 million; in Nye County (2012) $9.6 million.

Table 2-6. Summary of potential preclosure impacts of the Proposed Action (continued).[a]

Resource area	Summary of all preclosure impacts (all preclosure impacts resulting from the repository, national transportation, and Nevada transportation)	Summary of repository and Nevada transportation impacts that would occur within overlapping regions of influence
Socioeconomics (continued)		
	Operations: Peak percent increases are: • Nye: 1.15 (repository); 0.1 to 0.3 (rail) • Clark: 0.05 (repository); less than 0.1 (rail) • Lincoln: 4.7 (rail) • Esmeralda: 2.9 to 10 (rail) • Lyon: 0.01 (rail) • Walker River Paiute Reservation: included in Mineral County • Mineral: 2.8 (rail) • Washoe County/Carson City: less than 0.1 (rail)	
Peak incremental Gross Regional Product	Construction: Peak percent increases are: • Nye: 1.42 (repository); 1.0 to 3.5 (rail) • Clark: 0.05 (repository); less than 0.1 to 0.1 (rail) • Lincoln: 28 (rail) • Esmeralda: 9.5 to 57 (rail) • Lyon: 0.04 (rail) • Walker River Paiute Reservation: up to $1.4 million • Mineral: 14 (rail) • Washoe County/Carson City: less than 0.3 (rail) Operations: Peak percent increases are: • Nye: 2.65 (repository); 0.2 to 0.5 (rail) • Clark: 0.05 (repository); less than 0.1 (rail) • Lincoln: 5.2 (rail) • Esmeralda: 3.8 to 24 (rail) • Lyon: 0.01 (rail) • Walker River /Paiute Reservation: included in Mineral County • Mineral: 1.9 (rail) • Washoe County/Carson City: less than 0.1 (rail)	For Repository: In Clark County (2034), $98.7 million; in Nye County (2034) $68.9 million. For Rail: In Clark County (2012), $154.5 million; in Nye County (2012), $42.8 million

Table 2-6. Summary of potential preclosure impacts of the Proposed Action (continued).[a]

Resource area	Summary of all preclosure impacts (all preclosure impacts resulting from the repository, national transportation, and Nevada transportation)	Summary of repository and Nevada transportation impacts that would occur within overlapping regions of influence
Occupational and public health and safety		
Public, Radiological		
MEI (probability of an LCF)	3.2×10^{-4} (repository) 1.3×10^{-4} (transportation)	2.9×10^{-4} (repository) 1.3×10^{-4} (transportation)
Population (LCFs)	8.7 to 8.8 (total)	8.0
Public, Nonradiological		
Fatalities due to emissions	Small; exposures well below regulatory limits.	Small; exposures well below regulatory limits.
Workers (involved and noninvolved)		
Radiological (LCFs)	13 to 14	4.4 to 4.9.
Nonradiological fatalities (includes commuting traffic and vehicle emissions fatalities)	64 to 66 (total)	56 to 59.
Maximum reasonably foreseeable transportation accident (LCFs)	0.012 (rural area) to 9.4 (urban area)	0.012 (rural area) to 9.4 (urban area)
Accidents		
Public, Radiological		
MEI (probability of an LCF)	2.6×10^{-10} to 2.1×10^{-5} (repository accidents)	2.6×10^{-10} to 2.1×10^{-5} (repository accidents)
Population (LCFs)	9.0×10^{-7} to 1.9×10^{-2} (repository accidents)	9.0×10^{-7} to 1.9×10^{-2} (repository accidents)
Workers, Radiological	5.8×10^{-4} to 3.5 rem (3.5×10^{-7} to 2.1×10^{-3} LCF) (repository accidents)	5.8×10^{-4} to 3.5 rem (3.5×10^{-7} to 2.1×10^{-3} LCF) (repository accidents)
Noise and vibration	Impacts to public would be small due to large distances from the repository to residences; workers exposed to elevated noise levels – controls and protection used as necessary. Noise from rail construction activities in Caliente would exceed Federal Transit Administration guidelines. Noise from rail construction would be temporary. Noise from operations would create adverse impacts at a maximum of nine noise-sensitive receptors. There would be no adverse vibration impacts from construction or operations.	Impacts to public would be small due to large distances from the repository to residences; workers exposed to elevated noise levels – controls and protection used as necessary.

Table 2-6. Summary of potential preclosure impacts of the Proposed Action (continued).[a]

Resource area	Summary of all preclosure impacts (all preclosure impacts resulting from the repository, national transportation, and Nevada transportation)	Summary of repository and Nevada transportation impacts that would occur within overlapping regions of influence
Aesthetics	The exhaust ventilation stacks on the crest of Yucca Mountain would be seen as an adverse aesthetic impact by American Indians. If the Federal Aviation Administration required beacons atop the stacks, they could be visible for several kilometers, especially west of Yucca Mountain. Aesthetic impacts would range from small to large along rail alignments (depending on segment) from operations and the installation of linear track, signals, communications towers, power poles connecting to the grid, access roads, Staging Yard, and quarries.	The exhaust ventilation stacks on the crest of Yucca Mountain would be seen as an adverse aesthetic impact by American Indians. If the Federal Aviation Administration required beacons atop the stacks, they could be visible for several kilometers, especially west of Yucca Mountain.
Utilities, energy, materials, and site services	Use of materials would be small in comparison with regional use; some effect on public water systems and public wastewater treatment facilities due to population growth from construction and operations employment; annual fossil-fuel use would be less than 7 percent of statewide use during construction and less than 2 percent of statewide use during operation; electric power delivery system to the Yucca Mountain site would have to be enhanced.	Use of materials would be small in comparison with regional use; some effect on public water systems and public wastewater treatment facilities due to population growth from construction and operations employment; annual fossil-fuel use would be less than 7 percent of statewide use during construction and less than 2 percent of statewide use during operation; electric power delivery system to the Yucca Mountain site would have to be enhanced.
Waste and hazardous materials	Small impacts from nonhazardous waste (solid and industrial waste) disposal to regional solid waste facilities. Small impacts from use of hazardous materials. Small impacts from hazardous-waste disposal to regional licensed hazardous waste facilities. Small impacts from low-level radioactive waste disposal to a DOE low-level waste disposal site, Agreement State site, or an NRC-licensed site.	Small impacts from nonhazardous waste (solid and industrial waste) disposal to regional solid waste facilities. Small impacts from use of hazardous materials. Small impacts from hazardous-waste disposal to regional licensed hazardous waste facilities. Small impacts from low-level radioactive waste disposal to a DOE low-level waste disposal site, Agreement State site, or an NRC-licensed site.
Environmental justice	No identified high and adverse impact to members of the general public; no identified subsections of the population, including minority or low-income populations that would receive disproportionate impacts; no identified unique exposure pathways, sensitivities, or cultural practices that would expose minority or low-income populations to disproportionately high and adverse impacts. (Section 4.1.13) DOE acknowledges the opposing American Indian viewpoint.	Constructing and operating the proposed geologic repository at Yucca Mountain and constructing and operating the railroad to transport spent nuclear fuel and high-level radioactive waste from commercial and DOE sites to the repository would not result in disproportionately high and adverse impacts to minority or low-income populations.

Table 2-6. Summary of potential preclosure impacts of the Proposed Action (continued).[a]

Resource area	Summary of all preclosure impacts (all preclosure impacts resulting from the repository, national transportation, and Nevada transportation)	Summary of repository and Nevada transportation impacts that would occur within overlapping regions of influence
Manufacturing repository components	Small impacts to all resources with the exception of moderate socioeconomic and materials impacts.	Not applicable.
Airspace restrictions	Small impact to airspace use; airspace restriction could be lifted once operations had been completed.	Small impacts to airspace use; airspace restriction could be lifted once operations had been completed.

a. Short-term impacts for the Rail Alignment EIS are impacts limited to the construction phase (4 to 10 years). Long-term impacts for the Rail Alignment EIS are impacts that could occur throughout and beyond the life of the railroad operations phase (up to 50 years).

b. To convert acre-feet to cubic meters, multiply by 1,233.49. This table lists acre-feet because of common statutory and public use of this unit of measure for groundwater resources.

DOE = U.S. Department of Energy.
km^2 = square kilometer.
LCF = Latent cancer fatality.
MEI = Maximally exposed individual.
NRC = U.S. Nuclear Regulatory Commission.
$PM_{2.5}$ = Particulate matter with an aerodynamic diameter of 2.5 micrometers or less.
PM_{10} = Particulate matter with an aerodynamic diameter of 10 micrometers or less.

2.4 Collection of Information and Analyses

As stated in the Yucca Mountain FEIS, some of the studies to obtain or evaluate the information necessary for the assessment of Yucca Mountain as a repository were ongoing and, therefore, some of the information was incomplete. The complexity and variability of any natural system, including that at Yucca Mountain, will result in some uncertainty associated with scientific analyses and findings. It is important to understand that research can produce results or conclusions that might disagree with other research. The interpretation of results and conclusions has led to the development of views that differ from those that DOE has presented.

During the scoping process for this Repository SEIS, DOE received input from a number of organizations interested in the Proposed Action or No-Action Alternative or from potential recipients of impacts from those actions. These organizations included the State of Nevada, local governments, and American Indian tribes. Their input included documents that present research or information that, in some cases, disagrees with the views that DOE presents in this Repository SEIS. The Department reviewed these documents and evaluated their findings for inclusion as part of this Repository SEIS analyses. If the information represented a substantive view, DOE has made every effort to incorporate that view in this Repository SEIS and to identify its source.

2.4.1 INCOMPLETE OR UNAVAILABLE INFORMATION

DOE and others have continued to gather information since the publication of the Yucca Mountain FEIS. As a result, this Repository SEIS includes information that was not available for the Yucca Mountain FEIS

2.4.2 UNCERTAINTY

DOE has continued to conduct analyses, one purpose of which is to better define or reduce uncertainties associated with repository performance and to reduce health and safety risks during operation of the repository. The conclusions of analyses continue to have some associated uncertainty as a result of the assumptions DOE used and the complexity and variability of the analyzed process. Chapter 5 of this Repository SEIS provides a further description of uncertainties associated with postclosure impacts.

2.4.3 OPPOSING VIEWS

As was the case in the Yucca Mountain FEIS, opposing views are defined in this Repository SEIS as differing views or opinions currently held by organizations or individuals outside DOE. These views are considered to be opposing if they include or rely on data or methods with which DOE is not in agreement.

DOE has attempted to identify and address the range of opposing views in this Repository SEIS. The Department identified potential opposing views by reviewing public comments received during the scoping process and on the Draft Repository SEIS, as well as published or other information in the public domain. Sources of information included reports from universities, other federal agencies, the State of Nevada, counties, municipalities, other local governments, and American Indian tribes. DOE reviewed the potential opposing views to determine if they:

- Have arisen since the Yucca Mountain FEIS was published;

- Address issues analyzed in this Repository SEIS;
- Differ from the DOE position;
- Are based on scientific, regulatory, or other information supported by credible data or methods that relate to the impacts analyzed in this Repository SEIS; or
- Have significant basic differences in the data or methods used in the analysis or to the impacts described in this Repository SEIS.

DOE has included opposing views that meet the above criteria in this Repository SEIS where it discusses the particular topic.

2.4.4 PERCEIVED RISK AND STIGMA

In the Yucca Mountain FEIS, DOE evaluated *perceived risk* and *stigma* associated with construction and operation of a repository at Yucca Mountain and from the transportation of spent nuclear fuel and high-level radioactive waste. In the Yucca Mountain FEIS, DOE recognized that nuclear facilities can be perceived to be either positive or negative, depending on the underlying value systems of the individual forming the perception. Thus, perception-based impacts would not necessarily depend on the actual physical impacts or risk of repository operations, including transportation. A further complication is that people do not consistently act in accordance with negative perceptions, and thus the connection between public perception of risk and future behavior would be uncertain or speculative at best.

PERCEIVED RISK AND STIGMA

DOE uses the term **risk perception** to mean how an individual perceives the amount of risk from a certain activity. Studies show that perceived risk varies with certain factors, such as whether the exposure to the activity is voluntary, the individual's degree of control over the activity, the severity of the exposure, and the timing of the consequences of the exposure.

DOE uses **stigma** to mean an undesirable attribute that blemishes or taints an area or locale.

DOE concluded that, although public perception regarding the proposed geologic repository and transportation of spent nuclear fuel and high-level radioactive waste could be measured, there is no valid method to translate these perceptions into quantifiable economic impacts. Researchers in the social sciences have not found a way to reliably forecast linkages between perceptions or attitudes reported in surveys and actual future behavior. At best, only a *qualitative* assessment is possible about what broad outcomes seem most likely. The Yucca Mountain FEIS did identify some studies that report, at least temporarily, a small relative decline in residential property values might result from the designation of transportation corridors in urban areas.

The Yucca Mountain FEIS presented the following conclusions regarding perceived risk and stigma:

- While in some instances risk perceptions could result in adverse impacts on portions of a local economy, there are no reliable methods whereby such impacts could be quantified with any degree of certainty.
- Much of the uncertainty is irreducible.

- Based on a qualitative analysis, adverse impacts from perceptions of risk would be unlikely or relatively small.

DOE has incorporated the more detailed discussion of perceived risk and stigma related to the Proposed Action in this Repository SEIS by reference to Chapter 2 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 2-95 and 2-96).

An independent economic impact study (DIRS 172307-Riddel et al. 2003, all) conducted since the publication of the Yucca Mountain FEIS examined, among other things, the social costs of perceived risk to Nevada households living near transportation routes. The study developed such an estimate in terms of households having a willingness to accept compensation for different levels of perceived risk and a willingness to pay to avoid risk. The results of the study indicated that during the first year of transport, net job losses (and associated drop in residential real estate demand and decreases in gross state product) relative to the baseline would occur in response to people moving to protect themselves from transport risk. However, the initial impact would be offset rapidly, as the population shifted to a more risk-tolerant base. The results of this study are similar to those studies identified in the Yucca Mountain FEIS.

Other conclusions of this study are that the public and DOE have widely divergent risk beliefs and that the public is very uncertain about the risks they face. At the same time, over 40 percent of the respondents in a public survey conducted as part of this study felt that DOE information is reliable or very reliable, while another 40 percent feel that DOE's information is somewhat reliable. These results suggest social costs could be mitigated by reducing the risk people perceive from transport through information and education programs that are well researched and effectively presented.

While stigmatization of southern Nevada can be envisioned under some scenarios, it is not inevitable or numerically predictable. Any such stigmatization would likely be an aftereffect of unpredictable future events, such as serious accidents, which may not occur. As a consequence, DOE did not attempt to quantify any potential for impacts from risk perceptions or stigma in this Repository SEIS.

2.5 Preferred Alternative

DOE's preferred alternative—to proceed with the Proposed Action to construct, operate, monitor, and eventually close a geologic repository for the disposal of spent nuclear fuel and high-level radioactive waste at Yucca Mountain—has not changed since the Department published the Yucca Mountain FEIS. The preferred alternative includes using mostly rail as the mode of transportation for spent nuclear fuel and high-level radioactive waste, both nationally and in the State of Nevada. The preferred alternative also includes construction and operation of the proposed railroad along the Caliente rail alignment in the State of Nevada, and to implement the Shared-Use Option as set forth in the Rail Alignment EIS. The analyses in this Repository SEIS, including incorporated portions of the Rail Alignment EIS, have not identified any new potential environmental impacts that would be the basis for not proceeding with the Proposed Action.

REFERENCES

166894 BSC 2004 BSC (Bechtel SAIC Company) 2004. *Naval Waste Package Design Report*. 000-00C-DNF0-00800-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20040316.0010; ENG.20050817.0012.

169766 BSC 2004 BSC (Bechtel SAIC Company) 2004. *Commercial SNF Waste Package Design Report*. 000-00C-DSU0-02800-000-00B. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20040709.0001; ENG.20050817.0021.

170878 BSC 2004 BSC (Bechtel SAIC Company) 2004. *HLW/DOE SNF Codisposal Waste Package Design Report*. 000-00C-DS00-00600-000-00B. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20040701.0007; ENG.20050817.0014.

156764 DOE 1999 DOE (U.S. Department of Energy) 1999. *Radiological Control.* DOE-STD-1098-99. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20011210.0187.

155970 DOE 2002 DOE (U.S. Department of Energy) 2002. *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*. DOE/EIS-0250F. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20020524.0314; MOL.20020524.0315; MOL.20020524.0316; MOL.20020524.0317; MOL.20020524.0318; MOL.20020524.0319; MOL.20020524.0320.

180786 DOE 2006 DOE (U.S. Department of Energy) 2006. "Transport Aging and Disposal Canister (TAD)." Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. Accessed May 22, 2007. ACC: MOL.20070712.0034. URL: http://www.ocrwm.doe.gov/ym_repository/studies/seis/tads.shtml

185304 DOE 2008 DOE (U.S. Department of Energy) 2008. *Transportation, Aging and Disposal Canister System Performance Specification.* WMO-TADCS-000001, Rev. 1 ICN 1. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: DOC.20080331.0001.

172307	Riddel et al. 2003	Riddel, M.; Boyett, M.; and Schwer, R.K. 2003. *Economic Impact of the Yucca Mountain Nuclear Waste Repository on the Economy of Nevada*. Las Vegas, Nevada: University of Nevada, Las Vegas, Center for Business and Economic Research. ACC: MOL.20041207.0449.

3

Affected Environment

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

3. AFFECTED ENVIRONMENT

To analyze potential environmental *impacts* that could result from the implementation of the *Proposed Action*, the U.S. Department of Energy (DOE or the Department) has compiled extensive information about the *environment* that the Proposed Action could affect. The Department used this information to establish the baseline against which it measured potential impacts (Chapter 4). Chapter 3 describes (1) environmental conditions that currently exist at and in the region of the proposed *repository* site at Yucca Mountain (Section 3.1); (2) environmental conditions along the proposed transportation *corridors* in Nevada that DOE could use to ship *spent nuclear fuel* and *high-level radioactive waste* to the *Yucca Mountain site* (Section 3.2); and (3) environmental conditions at the 72 commercial and 4 DOE sites in the United States that manage spent nuclear fuel and high-level *radioactive* waste (Section 3.3).

Where noted in this chapter of the *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F-S1) (Repository SEIS), DOE summarizes, incorporates by reference, and updates Chapter 3 of the *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F; DIRS 155970-DOE 2002, pp. 3-1 to 3-227) (Yucca Mountain FEIS) and presents new information, as applicable, from studies and investigations that continued after the completion of the Yucca Mountain FEIS. If the Department did not use information from the FEIS, but rather based the information in a subsection on input from continuing studies and investigations, the introduction to that subsection so states and does not reference the FEIS. To help ensure that the source of the information is clear, DOE states it is summarizing, incorporating by reference, and updating the FEIS in the introduction to each applicable section or subsection of Section 3.1.

3.1 Affected Environment at the Yucca Mountain Repository Site

To define the existing environment at and in the region of the proposed repository, DOE has compiled environmental baseline information for 13 resource and subject areas. This environment includes the manmade structures and physical disturbances from DOE-sponsored site selection studies (1977 to 1988), *site characterization* studies to determine the suitability of the site for a repository (1989 to 2001), and disturbances from *maintenance* of the *Yucca Mountain Repository* site (2001 to present). This chapter and supporting documents contain baseline information for:

- Land use and ownership. Land use practices and land ownership information in the Yucca Mountain region, which includes overflight restrictions in the Yucca Mountain region (Section 3.1.1);
- *Air quality* and climate. The quality of the air in the Yucca Mountain region and the area's climatic conditions (such as temperature and precipitation) (Section 3.1.2);
- Geology. The *geologic* characteristics of the Yucca Mountain region at and below the ground surface, the frequency and severity of *seismic* activity, volcanism, and mineral and energy resources (Section 3.1.3);

- *Hydrology*. Surface-water and *groundwater* features in the Yucca Mountain region and the quality of the water (Section 3.1.4);

- Biological resources and soils. Plants and animals that live in the Yucca Mountain region, the occurrence of special-status species and *wetlands*, and the kinds and quality of soils in the region (Section 3.1.5);

- Cultural resources. Historic and archaeological resources in the Yucca Mountain region, the importance those resources hold and for whom (Section 3.1.6);

- Socioeconomics. The labor market, population, housing, some public services, *real disposable personal income*, *Gross Regional Product*, government spending, and DOE payment equal to taxes in the Yucca Mountain region (Section 3.1.7);

- Occupational and public health and safety. The levels of *radiation* that occur naturally in the Yucca Mountain air, soil, animals, and water; radiation *dose* estimates for Yucca Mountain workers from *background radiation*; radiation *exposure*, dispersion, and accumulation in air and water for the Nevada Test Site area from past nuclear testing and current operations; and public radiation dose estimates from background radiation (Section 3.1.8);

- Noise and vibration. Noise and vibration sources and levels of noise and vibration that commonly occur in the Yucca Mountain region during the day and at night, and the applicability of Nevada standards for noise in the region (Section 3.1.9);

- Aesthetics. The visual resources of the Yucca Mountain region in terms of land formations, vegetation, and color, and the occurrence of unique natural views in the region (Section 3.1.10);

- Utilities, energy, and site services. The amounts of power supplied to the region; the means by which power is supplied; the availability of gasoline, diesel, natural gas, and propane; and the availability of construction materials (Section 3.1.11);

- Waste and hazardous materials. Ongoing *solid* and *hazardous waste* and wastewater management practices at Yucca Mountain, the kinds of waste generated by current activities at the site, the means by which DOE disposes of its waste, and DOE recycling practices (Section 3.1.12); and

- *Environmental justice*. The locations of *low-income* and *minority* populations in the Yucca Mountain region and the income levels among *low-income populations* (Section 3.1.13).

DOE evaluated the existing environment in regions of influence for each of the 13 areas. Table 3-1 defines these regions, which are specific to each resource or subject area in which DOE could reasonably expect to predict impacts, if any, related to the repository. The Department assessed human health *risks* from exposure to airborne *contaminant* emissions for an area within approximately 84 kilometers (52 miles), and economic effects, such as job and income growth, in a two-county socioeconomic region.

The vicinity around Yucca Mountain has been the subject of a number of studies in support of mineral and energy resource exploration, nuclear weapons testing, and other DOE activities at the Nevada Test Site. From 1977 to 1988, the Yucca Mountain Project performed studies to assist in the site selection

Table 3-1. Regions of influence for the proposed Yucca Mountain Repository.

Resource/subject area	Region of influence
Land use and ownership	The analyzed land withdrawal area, lands DOE proposes for an access road from U.S. Highway 95 and where DOE could construct offsite facilities (Section 3.1.1).
Air quality and climate	An approximate 84-kilometer (52-mile) radius around the repository and at the boundary of the analyzed land withdrawal area (Section 3.1.2).
Geology	The physiographic setting (characteristic landforms), stratigraphy (rock strata), and geologic structure (structural features that result from rock deformations) of the region and of Yucca Mountain (Section 3.1.3).
Hydrology	Surface water: Construction areas that would be susceptible to erosion, areas that permanent changes in flow would affect, and areas downstream of the repository that eroded soil or potential spills of contaminants would affect.
	Groundwater: Aquifers that would underlie areas of construction and operations, aquifers that could be sources of water for construction and operations, and aquifers downstream of the repository that repository use or postclosure performance of the repository could affect (Section 3.1.4).
Biological resources and soils	Area that contains all potential surface disturbances that would result from the Proposed Action plus additional area to evaluate local animal populations, roughly equivalent to the analyzed land withdrawal area, as well as land proposed for an access road from U.S. Highway 95 and land where DOE could construct offsite facilities (Section 3.1.5).
Cultural resources	Area that contains all potential surface disturbances that would result from the Proposed Action, as well as land proposed for an access road from U.S. Highway 95 and land where DOE could construct offsite facilities (Section 3.1.6).
Socioeconomics	The two-county (Clark and Nye) area in which repository activities could most influence local economies and populations (Section 3.1.7).
Occupational and public health and safety	Workers at the repository and potentially affected workers at nearby Nevada Test Site facilities and members of the public who reside within an 84-kilometer (52-mile) radius of the geologic repository operations area (Section 3.1.8).
Noise and vibration	The Yucca Mountain site and existing and future residences to the south in the town of Amargosa Valley (Section 3.1.9).
Aesthetics	The approximate boundary of the analyzed land withdrawal area, an area west of the boundary from where people could see the ventilation stacks, and the area south of the boundary where DOE would construct the access road from U.S. Highway 95 and several buildings (Section 3.1.10).
Utilities, energy, and site services	Public and private resources on which DOE would draw to support the Proposed Action (for example, private utilities and cement suppliers) (Section 3.1.11).
Waste and hazardous materials	On- and offsite areas, which would include landfills and hazardous and radioactive waste processing and disposal sites, in which DOE would dispose of site-generated repository waste (Section 3.1.12).
Environmental justice	Varies with resource area and corresponds to the region of influence for each resource area (Section 3.1.13).

DOE = U.S. Department of Energy.

process for a repository. These studies, which involved the development of roads, drill holes, trenches, and seismic stations, along with non-Yucca Mountain activities, disturbed about 2.5 square kilometers

(620 acres) of land in the vicinity of Yucca Mountain. Yucca Mountain site characterization activities began in 1989 and continued through 2001. These activities included surface and *subsurface* excavations and borings, and testing to evaluate the suitability of Yucca Mountain as the site for a repository. As of 2001, these activities had disturbed about an additional 1.5 square kilometers (370 acres) in the vicinity of Yucca Mountain. Since 2001, there has been minimal additional land disturbance. Reclamation activities have started and will continue to occur as DOE releases areas from further study.

The existing environment at Yucca Mountain includes the *Exploratory Studies Facility* [which includes the tunnel (*drift)*], the North and South portal pads and supporting structures, an excavated rock storage area, a topsoil storage area, borrow pits, *boreholes*, trenches, roads, and supporting facilities and disturbances from site characterization activities.

3.1.1 LAND USE AND OWNERSHIP

The *region of influence* for land use and ownership includes the *analyzed land withdrawal area*, land proposed for an access road from U.S. Highway 95, and land where DOE would construct offsite facilities. The analysis for this Repository SEIS assumed DOE would build the proposed offsite facilities on Bureau of Land Management land near Gate 510 of the Nevada Test Site. This section summarizes, incorporates by reference, and updates Section 3.1.1 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-6 to 3-12). The following sections summarize important characteristics of land use and ownership. Section 3.1.1.1 discusses regional land use and ownership. Section 3.1.1.2 discusses current land use and ownership at Yucca Mountain. Section 3.1.1.3 discusses the American Indian treaty issue. Section 3.1.1.4 discusses current airspace use near the Yucca Mountain site.

3.1.1.1 Regional Land Use and Ownership

This section summarizes, incorporates by reference, and updates Section 3.1.1.1 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-6 and 3-7). The Federal Government manages more than 85 percent of the land, about 240,000 square kilometers (93,000 square miles), in Nevada. About 42,000 square kilometers (16,000 square miles) are under state, local, or private ownership, and about 5,000 square kilometers (2,000 square miles) are American Indian lands. The Yucca Mountain site is in Nye County, which has an area of approximately 47,000 square kilometers (18,000 square miles) and is the largest county in Nevada. The Federal Government manages almost 98 percent of the land in the county, which includes the Nevada Test and Training Range (formerly Nellis Air Force Range), the Nevada Test Site, Bureau of Land Management-administered lands, a portion of Death Valley National Park, and portions of the Humboldt-Toiyabe National Forest. Private land uses in Nye County include residences, commercial facilities, and industrial sites that are largely, but not exclusively, within the boundaries of unincorporated towns, and agricultural and mining properties inside and outside these towns. The closest year-round housing near the repository is at what was once referred to as Lathrop Wells, about 22 kilometers (14 miles) south of the site; this location is now part of the unincorporated town of Amargosa Valley.

The Bureau of Land Management controls most of the lands to the south of the analyzed land withdrawal area and manages them in accordance with the *Record of Decision for the Approved Las Vegas Resource Management Plan and Final Environmental Impact Statement* (DIRS 176043-BLM 1998, all). This resource management plan designates land in the town of Amargosa Valley adjacent to the repository site entrance for *disposal* to the private sector, which indicates that the land has limited public use. Some land in the vicinity of the intersection of U.S. Highway 95 and Nevada State Route 373 is privately owned.

In 1999, Congress directed the Bureau of Land Management to expedite the conveyance of disposal lands in the vicinity of the intersection of U.S. Highway 95 and State Route 373 for conveyance to Nye County (Public Law 106-113). On March 9, 2001, the Bureau of Land Management issued a notice of realty action (66 FR 14194) to announce the noncompetitive sale of public lands (N-66239) and a recreation and public purpose conveyance in Nye County, Nevada (N-54086), which are both near this intersection (DIRS 181688-Bowlby 2007, all). The Bureau offered realty action N-66239 as a noncompetitive sale of approximately 1.4 square kilometers (350 acres) of public land to Nye County. Under the conditions of sale, Nye County had the exclusive right to purchase any and all of the proposed land at fair market value for a commercial purpose for a period of 5 years. Nye County purchased approximately 0.247 square kilometer (61 acres). The exclusive right to purchase expired on November 28, 2004. Although the exclusive right to purchase under special legislation has expired, Nye County has requested to purchase an additional 1.198 square kilometers (296 acres) by direct sale. Once the appraisal is complete, the Bureau will issue a *Federal Register* notice to notify the public of the potential sale and opportunity for comment. The process is likely to take a minimum of 6 months before Nye County may obtain possession of these 1.198 square kilometers, if the Bureau of Land Management approves a sale. Realty action N-54086 is a conveyance of 1.902 square kilometers (470 acres) of public land to Nye County for recreational or public purposes. The published intent of Nye County, once the land action is complete, is to lease the land to the Nevada Science and Technology Center, a nonprofit corporation, for the development of the Nevada Space Museum, outdoor exhibit areas, and associated facilities. Nye County and the Bureau of Land Management are involved in ongoing planning efforts for this area. The Nye County Yucca Mountain Project Gateway Area Concept Plan presents a land use concept to ensure orderly and compatible development of an approximate 23-square-kilometer (9-square-mile) area around the repository site entrance (DIRS 182345-Giampaoli 2007, all).

3.1.1.2 Current Land Use and Ownership at Yucca Mountain

This section summarizes, incorporates by reference, and updates Section 3.1.1.2 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, p. 3-9). *The Yucca Mountain Development Act of 2002* (Public Law 107-200; 116 Stat. 735) designated the Yucca Mountain site for development as a *geologic repository*. For this Repository SEIS, the Yucca Mountain site is synonymous with the analyzed land withdrawal area. Figure 3-1 shows land use and ownership near Yucca Mountain, including land use agreements and the analyzed land withdrawal area. The analyzed land withdrawal area includes approximately 600 square kilometers (150,000 acres) and comprises approximately 320 square kilometers (79,000 acres) administered by DOE (Nevada Test Site), approximately 96 square kilometers (24,000 acres) administered by the U.S. Air Force (Nevada Test and Training Range), approximately 180 square kilometers (44,000 acres) administered by the Bureau of Land Management, and approximately 0.81 square kilometer (200 acres) of private land (Patented Mining Claim No. 27-83-0002). Patented Mining Claim No. 27-83-0002 is an active mining operation for Cind-R-Lite to mine volcanic cinders for use as a sole-source raw material in the manufacture of cinderblocks.

Most of the land controlled by the Bureau of Land Management in the analyzed land withdrawal area is associated with the Bureau's current right-of-way (N-47748) for previous Yucca Mountain site characterization activities. On December 20, 2007, the Bureau of Land Management extended this right-of-way until December 31, 2014 (DIRS 184655-BLM 2007, all). This land is open to public use with the

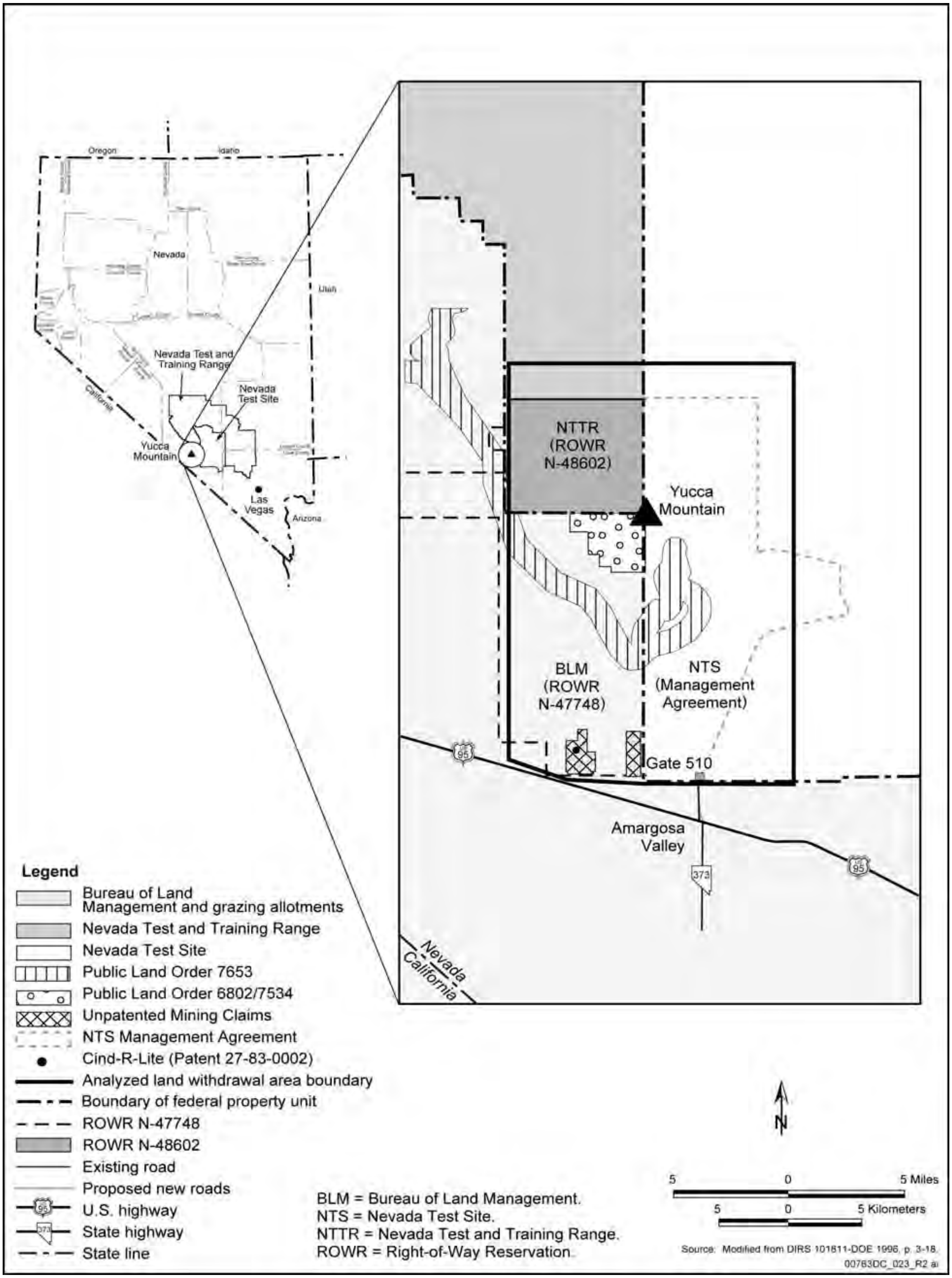


Figure 3-1. Land use and ownership near Yucca Mountain.

exception of approximately 17.22 square kilometers (4,255.50 acres) near the site of the proposed repository [Public Land Order 6802, extended via Public Land Order 7534 until January 31, 2010 (67 FR 53359)] and the existing patented mining claim.

The Bureau of Land Management manages surface resources on the Nevada Test and Training Range and granted DOE right-of-way N-48602 in 1994 to use about 75 square kilometers (19,000 acres) of land for site characterization activities. On April 4, 2004, the Bureau renewed the right-of-way, which was effective from April 10, 2004, through January 6, 2008. On January 2, 2008, the Bureau granted a 60-day extension and on March 6, 2008, the Air Force concurred with a 6-year renewal of the right-of-way (DIRS 185209-Domm 2008, all). This land is closed to public access and use.

The Bureau of Land Management issued Public Land Order 7653 in the *Federal Register* on December 28, 2005 (70 FR 76854). The order withdrew approximately 1,249 square kilometers (308,600 acres) of public land in Nevada in the Caliente *rail corridor* from surface entry and new mining claims for 10 years to enable DOE to evaluate the land for the potential construction, operation, and maintenance of a *rail line* for the transportation of spent nuclear fuel and high-level radioactive waste. Approximately 49 square kilometers (12,000 acres) of these lands are inside the analyzed land withdrawal area [approximately 26.3 square kilometers (6,500 acres) on Bureau of Land Management land and approximately 23 square kilometers (5,700 acres) on Nevada Test Site land] (Figure 3-1).

The Bureau of Land Management announced the receipt of a land withdrawal application on January 10, 2007, from DOE that requested the withdrawal of approximately 842 square kilometers (208,037 acres) of public land in Nevada from surface entry and mining through December 27, 2015, to evaluate the land for the potential construction, operation, and maintenance of a rail line for the transportation of spent nuclear fuel and high-level radioactive waste (72 FR 1235). The notice segregated the land from surface entry and mining for as long as 2 years (until January 9, 2009) while DOE conducts studies and analyses to support a final decision on the withdrawal application. Approximately 6.3 square kilometers (1,600 acres) of these lands are inside the analyzed land withdrawal area for the repository. Of the 6.3 square kilometers, approximately 1.4 square kilometers (350 acres) are small areas immediately adjacent to the Bureau of Land Management lands withdrawn by Public Land Order 7653. The additional 4.9 square kilometers (1,200 acres) are small areas immediately adjacent to the Nevada Test Site lands withdrawn by Public Land Order 7653 and an area that extends that withdrawal to the north by approximately 1.6 kilometers (1 mile).

The Bureau of Land Management land open to public use contains a number of unpatented mining claims. The Bureau permits off-road vehicle use and there is a designated utility corridor in the southern portion of these lands. A portion of an unused grazing allotment overlaps the analyzed land withdrawal area. This nonactive allotment has no permittees. More detailed information for the land controlled by the Bureau of Land Management in the region of Yucca Mountain is available in the *Record of Decision for the Approved Las Vegas Resource Management Plan and Final Environmental Impact Statement* (DIRS 176043-BLM 1998, all).

Geodetic control monuments could exist in the analyzed land withdrawal area or areas to the south that DOE has proposed for an access road from U.S. Highway 95 and offsite facilities. Geodetic control monuments are physical reference objects placed in the ground for the purpose of surveying. Monuments serve to mark points used for geodetic control networks as well as points used to reference property boundaries. The National Geodetic Survey defines and manages a national geodetic control network that provides the foundation for transportation and communication; mapping and charting; and a multitude of scientific and engineering applications.

In addition to disturbances from repository site characterization and confirmation activities, the Nevada Test Site and the U.S. Department of Defense have actively used the land proposed for the repository. To analyze the amount of previously undisturbed land that construction, operations, and *monitoring* of the repository would disturb, DOE considered that 2.43 square kilometers (600 acres) were previously disturbed.

3.1.1.3 American Indian Treaty Issue

This section summarizes, incorporates by reference, and updates Section 3.1.1.4 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-11 and 3-12). The Western Shoshone Tribe maintains that the Ruby Valley Treaty of 1863 gives them rights to 97,000 square kilometers (37,000 square miles) in Nevada, which includes the Yucca Mountain region. A legal dispute with the Federal Government led to a monetary award as payment for the land. However, the Western Shoshone have not accepted this award and maintain that there is no settlement. The U.S. Treasury is holding the monies in an interest-bearing account. In 1985, the U.S. Supreme Court ruled that even though the money has not been distributed the United States has met its obligations with the Commission's final award and the payment of the award into an interest-bearing trust account in the United States Treasury (DIRS 148197-United States v. Dann 1985, all).

In July 2004, President George W. Bush and Congress approved payment to the Western Shoshone Tribe of more than $145 million in compensation and accrued interest based on the 1872 value of 97,000 square kilometers (37,000 square miles) (Public Law 108-270; 118 Stat. 805). Under provisions of the law, payment by the United States Government officially subsumed Western Shoshone claims to 97,000 square kilometers of land in Nevada, Utah, California, and Idaho, based on the Ruby Valley Treaty of 1863. The law will distribute approximately $145 million in funds that the Indian Land Claims Commission awarded the Tribe. There are approximately 6,000 eligible tribal members, and the law sets aside a separate revenue stream for educational purposes.

On March 4, 2005, the Western Shoshone National Council filed a lawsuit against the United States, DOE, and the U.S. Department of the Interior in the federal district court in Las Vegas, Nevada. The complaint sought an injunction to stop federal plans for the use of Yucca Mountain as a repository based on the five established uses of the land within the boundaries of the 1863 Ruby Valley Treaty. On May 17, 2005, the U.S. District Court rejected a request from the Western Shoshone National Council for a preliminary injunction to stop DOE from applying for a license for the Yucca Mountain Project. The District Court dismissed the case for lack of jurisdiction in a judgment entered on November 1, 2005.

3.1.1.4 Airspace Use near Yucca Mountain

There are three types of airspace in the proximity of Yucca Mountain: Class A, Class G, and special use. Class G airspace is that airspace from the ground level to 5,500 meters (18,000 feet) above mean sea level; Class G airspace is uncontrolled airspace, over which air traffic control does not exercise authority. Class A airspace is airspace above 18,000 feet above mean sea level. Special-use airspace is airspace "wherein activities must be confined because of their nature, or wherein limitations are imposed upon aircraft operations that are not a part of those activities, or both" (DIRS 182869-FAA 2007, all). Special-use airspace is further subdivided into *restricted areas* and military operations areas, as well as four other categories that this Repository SEIS does not discuss. The Federal Aviation Administration defines the two types of special-use airspace that occur in the proximity of Yucca Mountain as follows:

- Restricted areas are a type of special-use airspace that separate or confine air activities that are considered dangerous or unsafe to aircraft not involved in the activity. Regulations prohibit flights by nonparticipating military and civilian or commercial aircraft in this airspace without the controlling authority authorization. Restricted airspace can be designated for joint use, in which air traffic controllers can route nonparticipating civilian or military aircraft when there is no conflict with scheduled activities. If the area is not designated for joint use, nonparticipating aircraft are normally not permitted at any time. Restricted areas are rulemaking actions that are implemented by a formal amendment to 14 CFR Part 73.

- Military operations areas are a type of special-use airspace that allow for the separation of military training activities from other air traffic. Military operations areas are nonrulemaking actions.

Figure 3-2 shows the types of airspace in the vicinity of Yucca Mountain. The figure shows the proximity of the special-use airspace, including restricted areas and military operations areas, to Yucca Mountain and the analyzed land withdrawal area. The Yucca Mountain site is several kilometers from restricted areas R-4806, R-4807, and R-4809, which occupy approximately 12,100 square kilometers (4,700 square miles). The U.S. Air Force uses these restricted areas, which are part of the Nevada Test and Training Range, extensively for training and test flights. The Air Force provides operational control for restricted areas R-4806, R-4807, and R-4809.

DOE is the controlling authority for activities in restricted area R-4808, which is part of the Nevada Test Site. Restricted area R-4808 covers about 4,400 square kilometers (1,700 square miles) and consists of two areas, north (R-4808N) and south (R-4808S) (Figure 3-2). The Federal Aviation Administration has designated R-4808N as non-joint use. Portions of R-4808N overlay the footprint of the proposed repository. R-4808S is designated a joint-use area for the Nevada Test Site, Nellis Air Traffic Control Facility, and the Federal Aviation Administration Los Angeles Air Route Traffic Control Center to use on an as-needed basis.

Between the military operations area in California and the restricted airspace in Nevada, there is a corridor of Class A and Class G airspace that commercial, military, and private aircraft use (Figure 3-2). Within this corridor, there is airspace within 1.6 kilometers (1 mile) from the planned repository surface facilities, bordered to the north and east by the DOE restricted airspace and to the south by the Class A and G airspace, that is designated a low-altitude tactical navigation area. This airspace is used by the U.S. Air Force for A-10 aircraft and helicopter flights. The Air Force makes approximately 30 flights a week in this area. Other aircraft in this airspace generally consist of small piston-engine airplanes, helicopters, and gliders. *Identification of Airplane Hazards* discusses a ground survey of this area and concludes that there is little civilian air activity (DIRS 181770-BSC 2007, pp. 22 and 23).

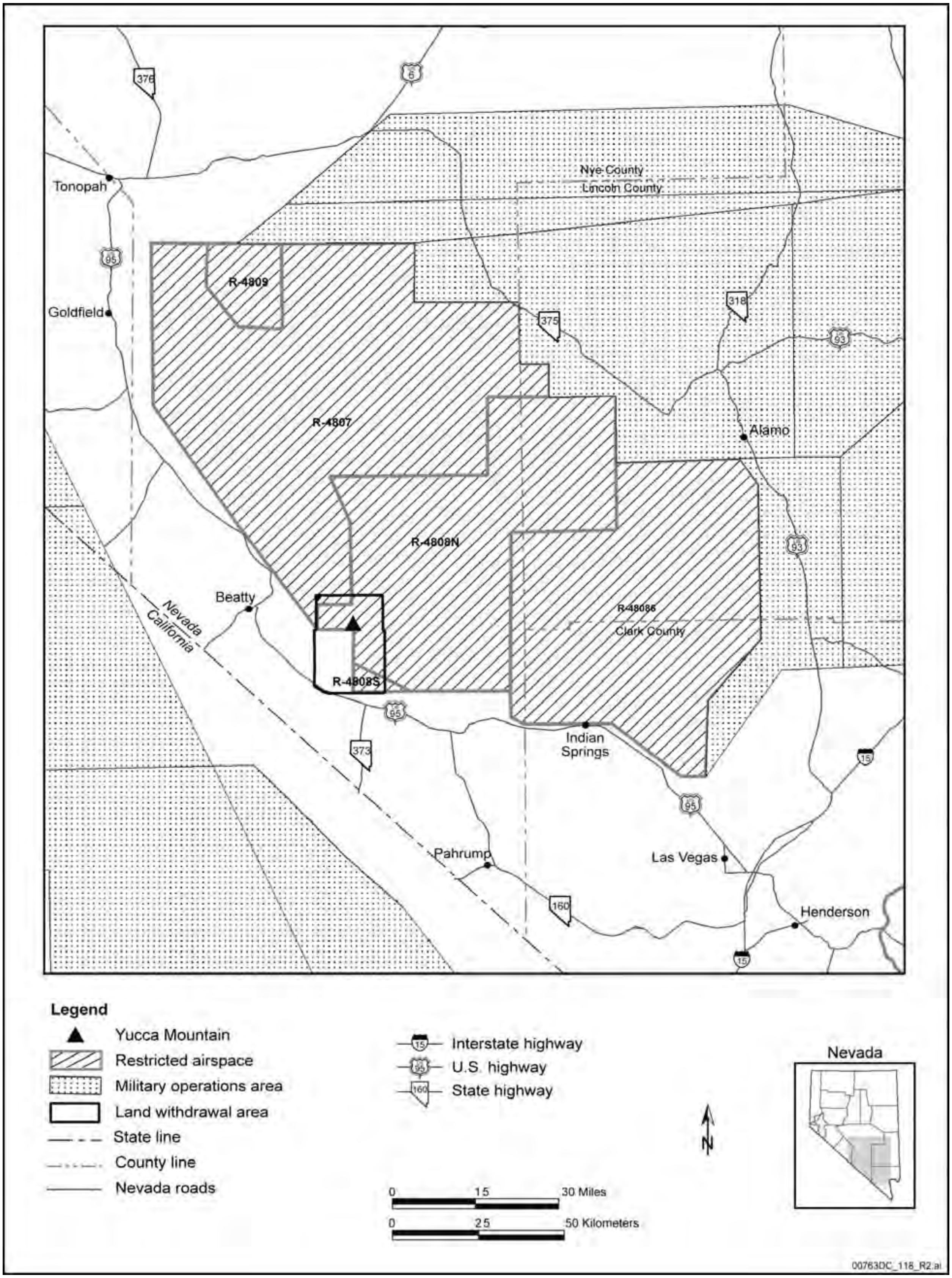


Figure 3-2. Airspace use near Yucca Mountain.

3.1.2 AIR QUALITY AND CLIMATE

> **AMBIENT AIR**
>
> The surrounding atmosphere, usually the outside air, as it exists around people, plants, and structures. It is not the air in immediate proximity to emission sources.

The region of influence for air quality and climate is an area within a radius of approximately 84 kilometers (52 miles) around the Yucca Mountain site. This region encompasses portions of Esmeralda, Clark, Lincoln, and Nye counties in Nevada and a portion of Inyo County, California.

To determine the air quality and climate for Yucca Mountain, DOE site characterization activities included *ambient air* and meteorological data collection. DOE has monitored the air for *criteria pollutants:* gases (*carbon monoxide*, *nitrogen dioxide*, *ozone*, and *sulfur dioxide*) and *PM_{10}*. PM_{10} is *particulate matter* with an aerodynamic diameter of 10 micrometers or less. This section summarizes, incorporates by reference, and updates Section 3.1.2 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-12 to 3-17).

3.1.2.1 Air Quality

Air quality is determined by measuring concentrations of certain pollutants (called criteria pollutants) in the atmosphere. The U.S. Environmental Protection Agency (EPA) established the *National Ambient Air Quality Standards*, as directed by the *Clean Air Act* (42 U.S.C. 7401 et seq.), to define the levels of air quality that are necessary to protect the public health (primary standards) and the public welfare (secondary standards) with an adequate margin of safety. The National Ambient Air Quality Standards specify the maximum pollutant concentrations and frequencies of occurrence for specific averaging periods.

> **PARTICULATE MATTER**
>
> **$PM_{2.5}$:**
> Particulate matter with an aerodynamic diameter of 2.5 micrometers or less (about 0.0001 inch).
>
> **PM_{10}:**
> Particulate matter with an aerodynamic diameter of 10 micrometers or less (about 0.0004 inch).
>
> As a frame of reference, the diameter of the average human hair is approximately 70 micrometers.

The criteria pollutants under the National Ambient Air Quality Standards are ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, particulate matter, and lead. The Nevada Administrative Code defines the Nevada standards of quality for *ambient* air for each criteria pollutant. The Nevada standards are the same as the National Ambient Air Quality Standards with the exception of a more restrictive carbon monoxide standard in locations with a ground elevation above 5,000 feet. The EPA designates an area as being in attainment for a particular pollutant if the concentration of that pollutant in ambient air is below the EPA standards. Areas in violation of one or more of these standards are called "*nonattainment areas*." If an area has not been designated as nonattainment and if there are no representative air quality data, the area is listed as "unclassifiable." For regulatory purposes, unclassifiable areas are considered to be in attainment. Section 176(c)(1) of the *Clean Air Act* requires federal agencies to ensure that their actions conform to applicable implementation plans for the achievement and maintenance of National Ambient Air Quality Standards for criteria pollutants. To achieve conformity, a federal action must not contribute to new violations of standards for ambient air quality, increase the frequency or severity of existing violations, or delay timely attainment of standards in the area of concern (for example, a state or a smaller air quality region). The EPA general conformity regulations (40 CFR 93, Subpart B) contain guidance for determination of whether a proposed federal action would cause emissions to be above certain levels in locations designated as nonattainment or maintenance areas. By definition, a "maintenance area" is a region that was previously in nonattainment, but that EPA or the state has redesignated as an attainment area with a requirement to develop a maintenance plan.

The Prevention of Significant Deterioration program of the *Clean Air Act* controls air quality in attainment areas; its goal is to prevent significant deterioration of existing air quality. This program is applicable only to point sources and does not apply to transportation sources. Under the Prevention of Significant Deterioration provisions, Congress established a land classification scheme for areas of the country with air quality better than the National Ambient Air Quality Standards. Under this scheme, Class I allows very little deterioration of air quality, Class II allows moderate deterioration, and Class III allows more deterioration, but in all cases the pollution concentrations must not violate any National Ambient Air Quality Standard. Congress designated certain areas as mandatory Class I, which precludes redesignation to a less-restrictive class to acknowledge the value of maintaining these areas in relatively pristine condition. In addition, Congress protected other nationally important lands by originally designating them as Class II and restricting redesignation to Class I only. All other areas were initially classified as Class II, with the possibility of redesignation as Class I or Class III.

The quality of the air at the Yucca Mountain site and the nearby parts of the Nevada Test Site, Nevada Test and Training Range (including southwestern Lincoln County), southwestern Esmeralda County, and southern Nye County within the air quality region of influence is unclassifiable because there are limited air quality data (40 CFR 81.329). However, the limited data collected at the site indicate that the air quality is within applicable National Ambient Air Quality Standards and is, therefore, in attainment.

While the air quality in most of Nye County is unclassifiable, a portion of Hydrologic Basin 162 (near the Town of Pahrump) has a maintenance status. Historical monitoring data since 2000 for PM_{10}, collected by the Nevada Division of Environmental Protection, documented exceedences of the National Ambient Air Quality Standards. Nye County and Pahrump, in cooperation with the Nevada Division of Environmental Protection, successfully negotiated with the EPA to enter into a Memorandum of Understanding. The Memorandum requires the parties to prepare a Clean Air Action Plan for the portion of Basin 162 within the Pahrump Regional Planning District, where rapid growth and development have affected air quality with increased *fugitive dust* levels. As required by the Memorandum, Nye County has enacted an ordinance to regulate construction and other ground-disturbing activities and has implemented a mandatory program of Best Practicable Methods for use on all ground disturbances of 0.5 acre or greater.

The portions of Clark County within the air quality region of influence are in attainment with National Ambient Air Quality Standards and Nevada standards. Inyo County, California, is in attainment with national and California ambient air quality standards for carbon monoxide, nitrogen dioxide, and sulfur dioxide. Portions of Inyo County in the air quality region of influence are in attainment with the national PM_{10} standard, but are in nonattainment with the more restrictive California standard (DIRS 179903-California Air Resources Board 2006, all). In the region of influence, all areas are designated Class II. One area, Death Valley National Park, is a protected Class II area. Death Valley National Park could be redesignated Class I, which would make the allowable deterioration less than that currently allowed. The nearest boundary of Death Valley National Park is approximately 35 kilometers (22 miles) southwest of the proposed Yucca Mountain site development areas.

The construction and operation of a facility in an attainment area could be subject to the requirements of the Prevention of Significant Deterioration program if the facility received a classification as a major point source of air pollutants. At present, the proposed Yucca Mountain site development areas and the Nevada Test Site have no sources subject to those requirements.

DOE maintains an air quality operating permit from the State of Nevada. The permit places specific operating conditions on equipment such as generators and compressors that DOE used during site characterization and uses during current activities. These conditions include limiting the emission of criteria pollutants; defining the number of hours per day and per year a system is allowed to operate; and determining the testing, monitoring, and recordkeeping necessary for the system. Nevada renewed the air quality operating permit in 2006 (DIRS 179968-DeBurle 2006, all).

DOE began monitoring PM_{10} in 1989 as part of site characterization activities and later as part of the Nevada air quality operating permit requirements. Monitoring for PM_{10} continues even though it is no longer a requirement of the air quality operating permit. Concentration levels of PM_{10} remain well below applicable National Ambient Air Quality Standards (Table 3-2). From October 1991 through September 1995, DOE monitored gaseous criteria pollutants (carbon monoxide, nitrogen dioxide, ozone, and sulfur dioxide) as part of site characterization. During air monitoring for gaseous pollutants, the concentration levels of each pollutant, except ozone, were well below applicable National Ambient Air Quality Standards and Nevada standards (Table 3-2). The maximum 1-hour ozone concentration was 80 percent of the National Ambient Air Quality Standard, which was revoked in 2005. An 8-hour ozone concentration was not measured. DOE did not monitor for particulate matter with an aerodynamic diameter of 2.5 micrometers or less ($PM_{2.5}$) as part of site characterization. $PM_{2.5}$, which is a subset of PM_{10}, was not regulated under the National Ambient Air Quality Standards until 1997. Sources of $PM_{2.5}$ include smoke, power plants, and gasoline and diesel engines.

3.1.2.2 Climate

The region around Yucca Mountain has a semiarid climate, with annual precipitation totals that range between approximately 10 and 25 centimeters (4 and 10 inches). Mean nighttime and daytime air temperatures typically range from 22 to 34 degrees Celsius (°C) [72 to 93 degrees Fahrenheit (°F)] in the summer and from 2° to 10.5°C (34° to 51°F) in the winter. Temperature extremes range from -15° to 45°C (5° to 113°F). On average, the daily range in temperature change is about 10°C (18°F).

In the valleys, local topography channels airflow, particularly at night during stable conditions. With the exception of the nearby confining terrain, which includes washes and small canyons on the east side of Yucca Mountain, local wind patterns have a strong daily cycle of daytime winds from the south and nighttime winds from the north. Confined areas also have daily cycles, but the wind directions are along terrain axes, typically upslope in the daytime and downslope at night. Figure 3-3 shows the wind patterns in the vicinity of the proposed repository, and illustrates the fluctuations in data from different heights and times of day.

Severe weather can occur in the region, usually in the form of summer thunderstorms. These storms can generate an abundance of lightning, strong winds, and heavy and rapid precipitation. Tornadoes can occur, although they are not a substantial threat.

Table 3-2. Comparison of criteria pollutant concentrations measured at the Yucca Mountain site with national, Nevada, and California ambient air quality standards.

Criteria pollutant	Primary and Secondary NAAQS (except as noted)		Highest concentration measured at Yucca Mountain[b,c]	Nevada standards[d]	California standards[e]
	Averaging period	Concentration[a]			
Sulfur dioxide	Annual[f]	0.03 part per million	0.002	Same	None
	24-hour[g]	0.14 part per million	0.002	Same	0.04 part per million
Sulfur dioxide (secondary)	3-hour[g]	0.5 part per million	0.002	Same	None
PM_{10}[h]	24-hour[i]	150 micrograms per cubic meter	67	Same	50 micrograms per cubic meter
$PM_{2.5}$	Annual[j]	15 micrograms per cubic meter	NA[k]	None	12 micrograms per cubic meter
	24-hour[l]	35 micrograms per cubic meter	NA	None	No separate state standard
Carbon monoxide	8-hour[g]	9 parts per million	0.2	Same[m]	Same
	1-hour[g]	35 parts per million	0.2	Same	20 parts per million
Nitrogen dioxide	Annual[f]	0.053 part per million	0.002	Same	None
Ozone	8-hour[n]	0.075 part per million	NA	None	0.07 part per million
	1-hour[o]	None	0.096	0.12 part per million	0.09 part per million
Lead	Quarterly average	1.5 micrograms per cubic meter	NA	Same	1.5 micrograms per cubic meter for 30-day average

a. Source: 40 CFR 50.4 through 50.12.
b. Units correspond to the units listed in the concentration column.
c. Source: DIRS 155970-DOE 2002, p. 3-13.
d. Source: Nevada Administrative Code 445B.22097.
e. Source: DIRS 179903-California Air Resources Board 2006, all.
f. Average not to be exceeded in the period shown.
g. Average not to be exceeded more than once in a calendar year.
h. PM_{10} annual standard was revoked effective December 17, 2006. Available evidence does not suggest a link between long-term exposure to PM_{10} and health problems.
i. Number of days per calendar year exceeding this value should be less than 1.
j. Expected annual arithmetic mean should be less than the value shown.
k. No $PM_{2.5}$ monitoring data have been collected at Yucca Mountain. NAAQS regulations for $PM_{2.5}$ were not issued until 1997, which was after site characterization monitoring had finished. Ongoing monitoring for fugitive dust (PM_{10}) does not monitor for $PM_{2.5}$; $PM_{2.5}$ is created by fossil-fuel combustion and is not a major component of fugitive dust.
l. 98th-percentile value should be less than value shown. Effective December 17, 2006.
m. The Nevada ambient air quality standard for carbon monoxide is 9 parts per million at less than 5,000 feet above mean sea level and 6 parts per million at or above 5,000 feet; Nevada Administrative Code 445B.22097.
n. On March 12, 2008, the U.S. Environmental Protection Agency revised the 8-hour ozone standards from 0.08 parts per million to 0.075 parts per million, to be effective on May 27, 2008. To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed this 0.075 parts per million.
o. As of June 15, 2005, the EPA revoked the 1-hour ozone standard in all areas except the 14, 8-hour ozone nonattainment Early Action Compact Areas (DIRS 181491-EPA 2007, all). None of the areas is in Nevada.

NA = Not available.
NAAQS = National Ambient Air Quality Standard.
PM_{10} = Particulate matter with an aerodynamic diameter of 10 micrometers or less.
$PM_{2.5}$ = Particulate matter with an aerodynamic diameter of 2.5 micrometers or less.

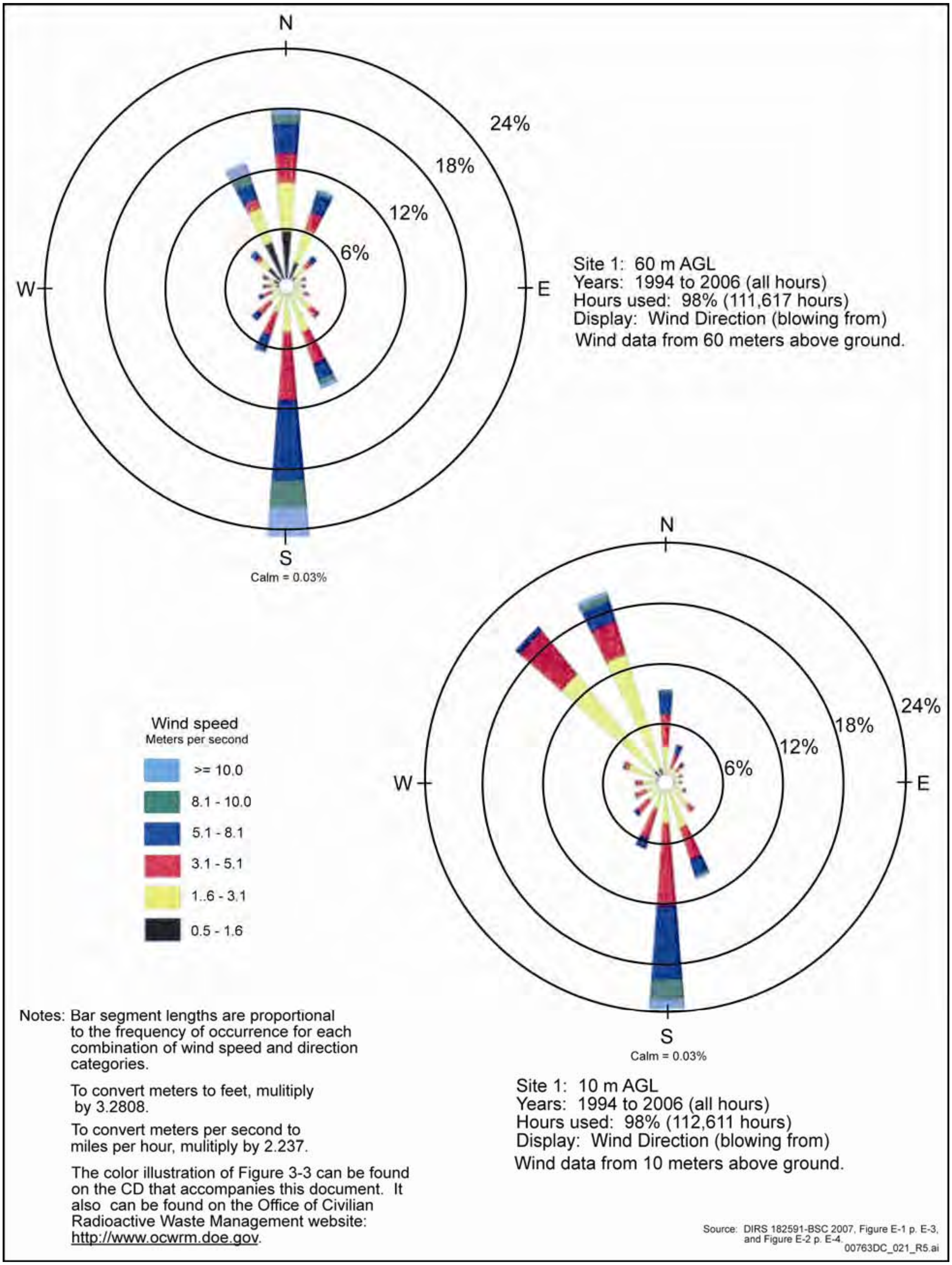


Figure 3-3. Wind patterns in the Yucca Mountain vicinity.

Paleoclimatology

Paleoclimatology is the study of ancient climates by examination of biological and geological proxy indications of climatic conditions in the geologic past. The primary assumption to predict future climatic conditions in the Yucca Mountain region is that climate is cyclical and, therefore, a study of past climates provides an insight into potential future climates. Studies indicate that past climatic conditions at Yucca Mountain, which therefore could occur in the future, fall into the following categories: (1) a warm and dry interglacial period similar to the present-day climate, (2) a warm and wet monsoon period characterized by hot summers and increased summer rainfall, and (3) a cool and wet glacial-transition period (DIRS 170002-BSC 2004, all). The interglacial period has the lowest annual precipitation and highest annual temperatures of the climate periods, and represents the current climate at Yucca Mountain.

The following compares the three climate categories (DIRS 170002-BSC 2004, all; DIRS 161591-Sharpe 2003, all):

1. The warm and dry interglacial period would be similar to the present-day climate, which has a mean annual temperature of 13°C (55°F) and a mean annual precipitation of 12 centimeters (5 inches).

2. The warmer and wetter monsoon period would have mean annual temperatures that ranged from approximately 13° to 17°C (55° to 63°F) and mean annual precipitation between 12 and 40 centimeters (5 and 16 inches).

3. The cooler and wetter intermediate glacial-transition period would have mean annual temperatures that ranged from approximately 8° to 10°C (46° to 50°F) and mean annual precipitation between 20 and 45 centimeters (8 and 18 inches).

3.1.3 GEOLOGY

In the Yucca Mountain FEIS, DOE described the region of influence for geology as the physiographic setting (characteristic landforms), *stratigraphy* (rock strata), and geologic structure (structural features that result from rock deformations) of the region and of Yucca Mountain. DOE also addressed *seismicity* (*earthquake* activity) and volcanism in the Yucca Mountain region as geologic phenomena that could affect a repository. In addition, DOE described the potential for mineral and energy resources to occur at or near the site of the proposed repository. This Repository SEIS addresses the same region of influence and associated factors. This section summarizes, incorporates by reference, and updates Section 3.1.3 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-17 to 3-34) and presents new information, as applicable, from studies and investigations that have continued since completion of the Yucca Mountain FEIS.

Since 1997, Nye County, Nevada, has been performing investigations under a cooperative agreement with DOE to address technical issues and data gaps in the physical characterization of the land between Yucca Mountain and the potentially *affected environment* where Nye County residents live and work. These efforts, under Nye County's Independent Scientific Investigations Program and Early Warning Drilling Program, have included drilling of exploratory boreholes and monitoring wells, sampling of borehole cuttings and cores, and geologic and geophysical logging. DOE considered the information these programs gathered in the geology and hydrology discussions in the Yucca Mountain FEIS and has incorporated, as applicable, information it has collected since the completion of the Yucca Mountain FEIS into this Repository SEIS, particularly in the Section 3.1.4 hydrology discussion. More information on the Nye County programs is available from the County's Internet site at http://www.nyecounty.com.

Inyo County, California, has also performed investigative work under a cooperative agreement with DOE. The focus of the Inyo County work has been the investigation of geologic and hydrologic features related to potential groundwater transport of radionuclides into the county, particularly the connection between the lower carbonate aquifer and the surface environment (DIRS 185423-ICYMRAO n.d., p. 1). In its work, Inyo County supported a U.S. Geological Survey effort to update a geologic map of the southern Funeral Mountains, including groundwater discharge sites. This effort involved geophysical studies in the southern Funeral Mountains, the Amargosa Valley area, and the Devils Hole area to better understand the subsurface in those areas. In addition, the County completed several deep exploratory wells to locate and characterize the lower carbonate aquifer in the area of the southern Funeral Mountains and Amargosa Desert. Because a primary purpose of the Inyo County efforts was to obtain a better characterization of the carbonate aquifer in these areas, Section 3.1.4 addresses results of these studies further. Inyo County has posted reports from its efforts at the Inyo County Yucca Mountain Repository Assessment Office Web site (http://www.inyoyucca.org/lsn.html).

3.1.3.1 Physiography (Characteristic Landforms)

Yucca Mountain is in the southern part of the *Great Basin*, which is characterized by generally north-trending, linear mountain ranges separated by intervening valleys, or basins. The mountain ranges are mostly the result of past episodes of faulting that resulted in the elevation differences between the ranges and the adjacent valleys. Erosion of the mountains filled the adjacent valleys with rock debris that ranges from very coarse boulders to sand and silt. Within this setting, Yucca Mountain is part of the southwestern Nevada volcanic field, a volcanic plateau that formed between about 14 and 11.5 million years ago. As a result, Yucca Mountain is a product of both volcanic activity and faulting. Most of the volcanic rocks now at or near the surface of Yucca Mountain erupted from the Timber Mountain caldera (one of the centers of the southwestern Nevada volcanic field), the remnants of which are north of Yucca Mountain.

In general, west-facing slopes at Yucca Mountain are steep and east-facing slopes are gentle. The crest of Yucca Mountain reaches elevations from 1,500 to 1,900 meters (4,900 to 6,300 feet) above sea level, while the bottoms of the adjacent valleys are approximately 650 meters (2,100 feet) lower. Pinnacles Ridge borders the mountain on the north, Crater Flat is to the west, the *Amargosa Desert* is south, and the Calico Hills and *Jackass Flats* are on the east side. Figure 3-6 of the Yucca Mountain FEIS shows these and other physiographic features in the vicinity of Yucca Mountain. Crater Flat, which is between Bare Mountain to the west and Yucca Mountain to the east, contains four prominent volcanic cinder cones that rise above the valley floor. Jackass Flats is an oval-shaped valley surrounded (in a clockwise direction) by Yucca, Shoshone, Skull, and Little Skull mountains. Both Crater Flat and Jackass Flats drain southward to the *Amargosa River*. Drainage from Jackass Flats is via *Fortymile Wash*, a prominent drainage along the east side of Yucca Mountain.

3.1.3.1.1 *Site Stratigraphy and Lithology*

A thick series of volcanic rocks (including those of Yucca Mountain) that overlie much older *sedimentary rocks* of largely marine origin dominate the rock strata, or *stratigraphic units*, in the region of Yucca Mountain. Table 3-3 lists the generalized rock units of the region by the geologic age of their deposition.

Table 3-3. Highly generalized stratigraphy for the Yucca Mountain region.

Geologic age designation	Major rock types (lithologies)
Cenozoic Era	
Quaternary Period (less than 1.6 Ma)	Alluvium and colluvium; basalt.
Tertiary Period (65 – 1.6 Ma)	Silicic ash-flow tuffs; minor basalts. Predominantly volcanic rocks of the southwestern Nevada volcanic field (includes Topopah Spring Tuff, host rock for the proposed repository).
Mesozoic Era (240 – 65 Ma)	Rocks of this age are of minor significance to the Yucca Mountain region. Small Mesozoic igneous intrusions occur near Yucca Mountain.
Paleozoic Era (570 – 240 Ma)	Three major lithologic groups (lithosomes) predominate: a lower (older) carbonate (limestone, dolomite) lithosome deposited during the Cambrian through Devonian periods, a middle fine-grained clastic lithosome (shale, sandstone) formed during the Mississippian Period, and an upper (younger) carbonate lithosome formed during the Pennsylvanian and Permian periods.
Precambrian Era (greater than 570 Ma)	Quartzite, conglomerates, shale, limestone, and dolomite that overlie older igneous and metamorphic rocks that form the crystalline "basement."

Source: DIRS 155970-DOE 2002, p. 3-21.
Ma = Approximate years ago in millions.

Only Tertiary Period and younger rocks are exposed at Yucca Mountain, but older rock units are exposed at Bare Mountain, the Calico Hills, and the Striped Hills, to the west, northeast, and southeast of Yucca Mountain, respectively. Detailed information about the characteristics of the older rocks beneath Yucca Mountain is sparse because only one borehole, about 2 kilometers (1.2 miles) east of Yucca Mountain, has penetrated these rocks. Paleozoic Era carbonate rocks occur in this borehole at a depth of about 1,250 meters (4,100 feet). Investigations by Nye County, Nevada, and Inyo County, California, have completed other exploratory boreholes in the Paleozoic carbonate rocks to the south of Yucca Mountain.

DOE has studied the Tertiary Period volcanic units in which it would emplace spent nuclear fuel and high-level radioactive waste at Yucca Mountain in great detail. These units consist mostly of tuffaceous rock, or *tuff*, which forms when a mixture of volcanic gas and ash violently erupts, flows, and settles in large sheets. The different volcanic units or layers are characterized based on changes in depositional features, the development of zones of welding and crystallization, and the development of alteration products in some rocks. DOE used mineral and chemical composition and properties such as density and porosity to distinguish some units. Table 3-7 of the Yucca Mountain FEIS listed the units that form the Tertiary volcanic rock sequence at Yucca Mountain from youngest (about 11.5 million years old) to oldest (more than 14 million years old) and provided characteristics of each. Tuffs of the Paintbrush Group, primarily bracketed by the Timber Mountain Group tuffs above and the Calico Hills Formation below, are of primary significance to the Proposed Action because of their proximity to the proposed repository *emplacement* level. At the base of the Paintbrush Group is the Topopah Spring Tuff, in which DOE tunneled the Exploratory Studies Facility and where the emplacement area would be. Figure 3-4 is a map of the general bedrock geology of the proposed repository location; the Yucca Mountain FEIS contained a similar figure. Figure 3-4 shows the updated shape and location of the repository outline (the proposed drift boundary). Figure 3-5 is a vertical cross section through the southern part of the area in Figure 3-4. The cross section shows the subsurface expression of the mapped units, including such structural aspects as the east-dipping rock units and the predominantly west-dipping normal *faults*.

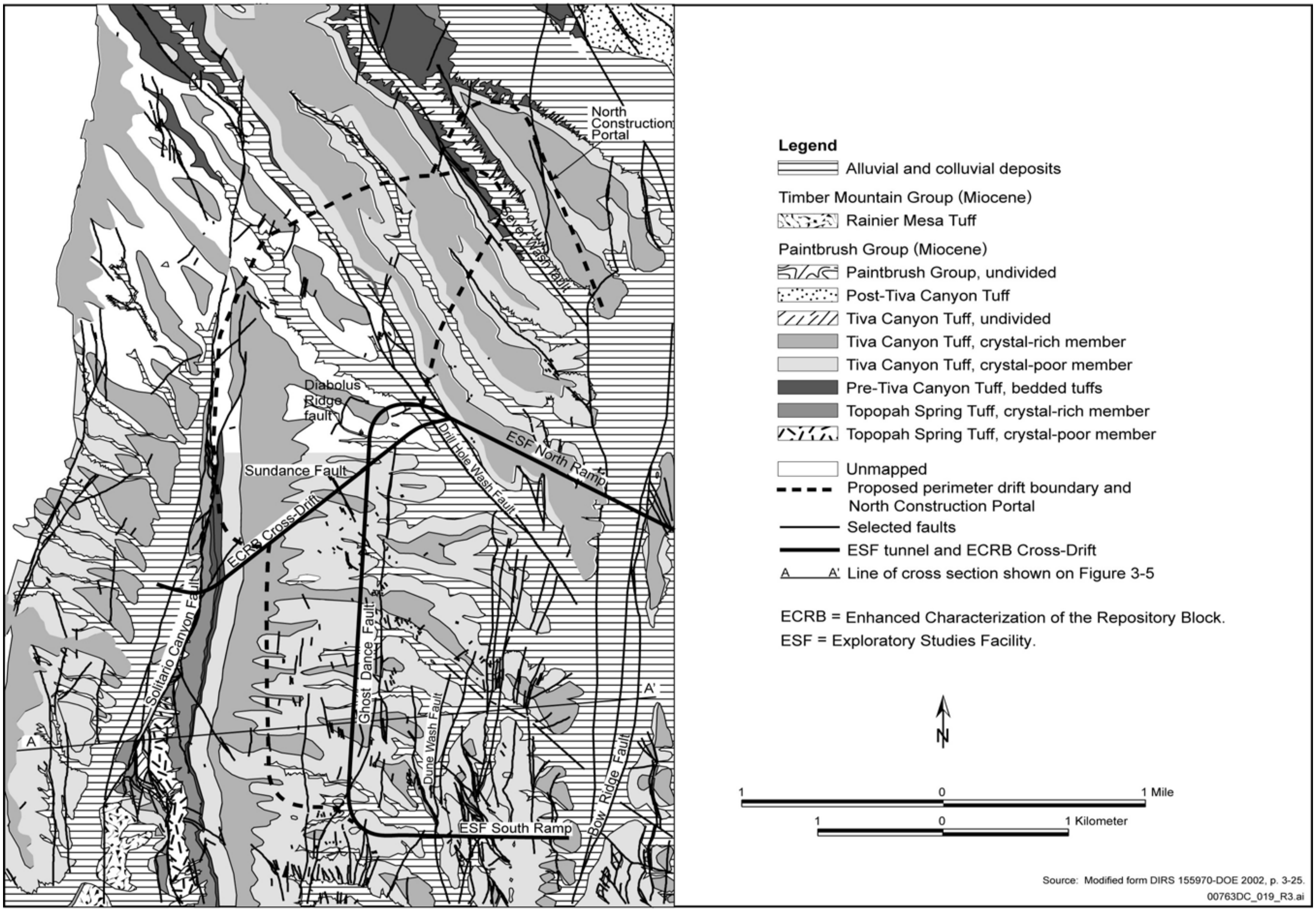


Figure 3-4. General bedrock geology of the proposed repository.

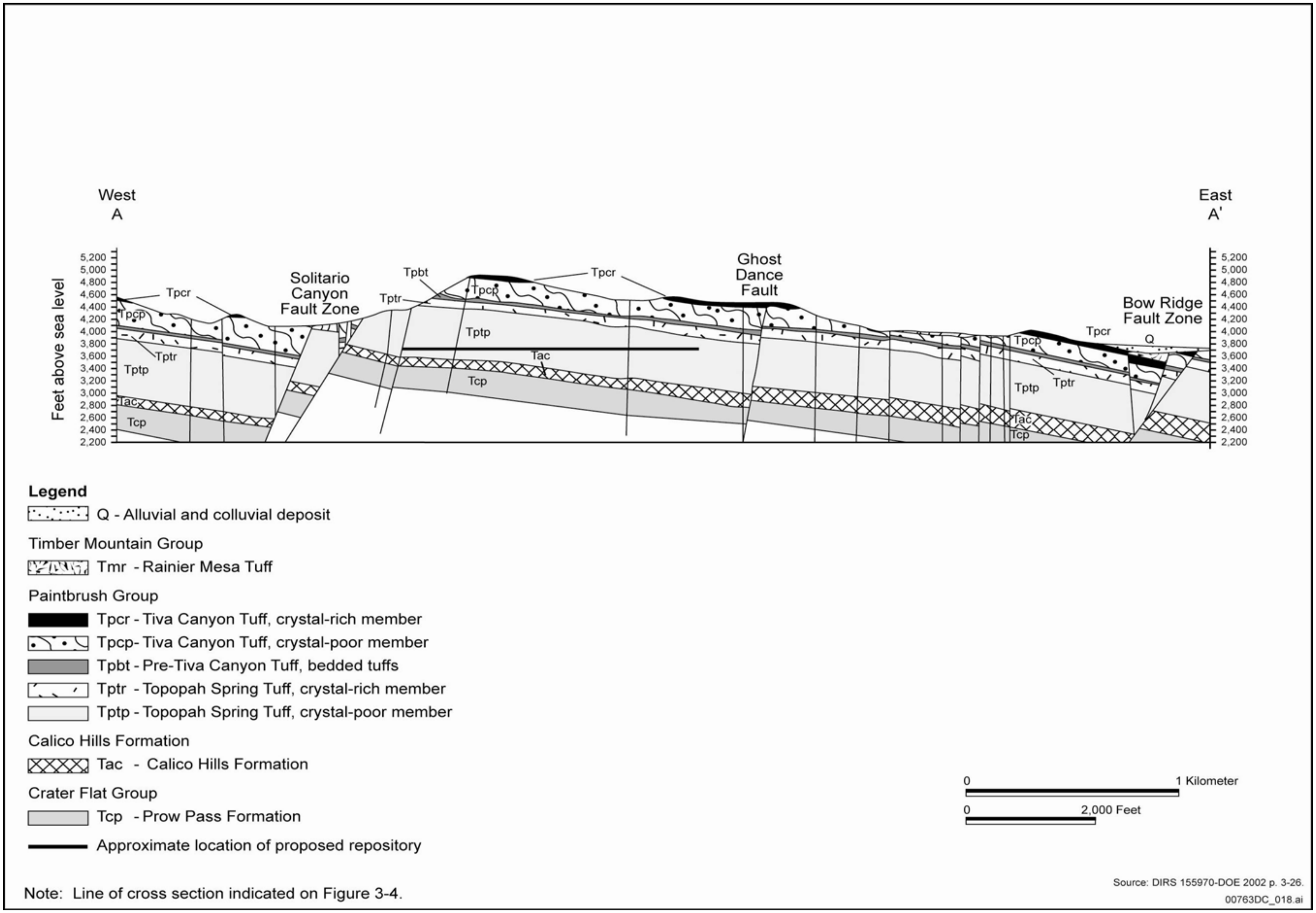


Figure 3-5. Simplified geologic cross section of Yucca Mountain, west to east.

The volcanic rock units in Figures 3-4 and 3-5 formed during the Tertiary Period and, although younger volcanic rocks occur locally in the Yucca Mountain vicinity, they are of limited extent and represent low-volume eruptions. The younger rock formations typically consist of a single main cone surrounded by a small field of basalt flows. Four northeast-trending cinder cones in the center of Crater Flat (to the west of Yucca Mountain) are primary examples of volcanic remnants that are younger than the Tertiary Period rock sequences. These four cinder cones are about 1 million years old. The youngest basaltic center in the vicinity is the 70,000- to 90,000-year-old Lathrop Wells center, a single cone about 16 kilometers (10 miles) south of the Yucca Mountain *South Portal development area*. The youngest stratigraphic units at Yucca Mountain are the surficial deposits shown in Figures 3-4 and 3-5 as alluvial (stream) and colluvial (hill slope) deposits.

3.1.3.1.2 *Selection of Repository Host Rock*

DOE based the selection of the repository emplacement area on several considerations: (1) depth below the ground surface sufficient to protect spent nuclear fuel and high-level radioactive waste from exposure to the surface environment, (2) extent and characteristics of the host rock, (3) location of major faults that could adversely affect the stability of underground openings or act as pathways for water flow, and (4) location of the *water table* in relation to (below) the proposed repository. DOE would use the same middle to lower portion of the Topopah Spring Tuff (Figure 3-5) for the emplacement area, as the Yucca Mountain FEIS described.

Experience and information that DOE has gained from the excavation of the Exploratory Studies Facility, excavation of the Enhanced Characterization of the Repository Block *Cross-Drift*, and associated studies show this section of rock meets the selection criteria. DOE has demonstrated that it can construct stable openings in this rock, that the rock's thermal and mechanical properties enable it to accommodate the anticipated range of temperatures, that the location of the volume of rock necessary to host the repository is between faults with evidence of displacement during the Quaternary Period (that is, in the past 1.6 million years and, in this case, the faults are the major north-trending, block-bounding faults), and that the location of the water table is well below the selected repository horizon [more than 210 meters (690 feet) (DIRS 185301-DOE 2008, p. 1-3)] .

3.1.3.1.3 *Potential for Volcanism at the Yucca Mountain Site*

There have been extensive investigations of the volcanic geology and stratigraphy at Yucca Mountain and the surrounding region, and DOE has used this information to evaluate the potential for future eruptions to occur that could adversely affect long-term performance of the proposed repository. In 1995 and 1996, a panel of 10 recognized experts from federal agencies, national laboratories, and universities evaluated the potential for disruption of the repository by a volcanic intrusion, also known as a dike. The result of that effort was an estimate of the average *probability* of 1 chance in 7,000 that a volcanic dike could intersect or disrupt the repository during the first 10,000 years after *repository-closure*. As the Yucca Mountain FEIS reported, DOE increased this probability to 1 chance in 6,300 to account for a slightly larger repository footprint than the expert panel considered (DIRS 155970-DOE 2002, p. 3-27). The likelihood of an intersection increases by small amounts if the footprint size increases because the larger area presents a larger "target" for the dike to intersect, should an *event* occur.

Since DOE completed the Yucca Mountain FEIS, the size and shape of the repository footprint has changed slightly, and so has the probability of a dike intersection. DOE based the new calculation on the work in 1995 and 1996 by the panel of experts. The estimated probability of a dike intrusion is now 1 chance in 5,900 during the first 10,000 years, with 5th- and 95th-percentile values of 1 chance in 133,000 and 1 in 1,800, respectively (DIRS 169989-BSC 2004, pp. 7-1 and 7-2, and Table 7-1).

DOE has collected additional aeromagnetic and ground magnetic data about the Yucca Mountain vicinity since 2002. As reported in *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada* (DIRS 169989-BSC 2004, p. 6-79), there were 20 to 24 identified magnetic anomalies in Crater Flat and northern Amargosa Valley. These anomalies could represent buried basaltic volcanoes. At the time, the expert elicitation effort of 1995 and 1996 knew of eight of these anomalies and included them in the evaluations. DOE evaluated the effect of the additional anomalies on the probability calculations for a volcanic dike intersection. Using several assumptions, which included that the anomalies actually represent basaltic volcanic centers, the mean annual frequency of intersection could increase (DIRS 169989-BSC 2004, pp. 6-79 to 6-83). In 2004, DOE completed a high-resolution aeromagnetic survey, then initiated a drilling program in the areas of the anomalies to determine the age and other characteristics of encountered basalts. The Department completed seven new drill holes at locations it selected to include each major cluster or alignment of anomalies. Four of the anomalies are buried basalt; three of these were dated as Miocene basalts with ages ranging from about 11.1 to 9.4 million years, and the other was dated as younger Pliocene basalt with an age of about 3.8 million years (DIRS 182132-NRC 2007, pp. 58 and 59). The other three drill holes found only tuff material, though one might include basalt. If basalt was present at a depth greater than the drill hole in this last case, it would probably be of Miocene age. These findings reduce some of the uncertainty about buried basalts in the region and could lower estimates of the probability of a dike intrusion of the repository because Miocene basalts, being much older, would have limited influence on models or estimates of future volcanic recurrence. In addition, it was significant for future estimates of volcanic recurrence that none of the younger, post-Miocene basalt occurred in drill holes on the east side of Yucca Mountain. Thus, there is no evidence that the younger volcanic zone in Crater Flat extends east through Yucca Mountain (DIRS 182132-NRC 2007, pp. 62 and 165). DOE is conducting an update of the 1995 and 1996 expert elicitation to review and interpret the new information. For the analysis in this Repository SEIS, the Department used the information derived from the 1995 and 1996 panel of experts.

3.1.3.2 Geologic Structure

Geologic structures, such as folds and faults, result from the deformation of rocks after their original formation. The Yucca Mountain FEIS discussed the north-trending, block-bounding faults that crustal extension has formed during the last 20 million years and the intrablock and subsidiary faults that occur between the block-bounding faults. The estimated total displacement along the major block-bounding faults in the Yucca Mountain region during the last 12 million years ranges from less than 100 to more than 500 meters (330 to 1,600 feet). Displacements on these faults during the Quaternary Period (the last 1.6 million years) range from 0 to 6 meters (0 to 20 feet), with most about 1 to 2.5 meters (3.3 to 8.2 feet). In terms of the amount of movement per seismic event, the block-bounding faults of primary significance to Yucca Mountain have moved from 0 to 1.7 meters (0 to 5.6 feet) per event. The Solitario Canyon Fault along the west side of Yucca Mountain and the Bow Ridge Fault along the east side are the major block-bounding faults that bracket the emplacement area. Within this block, there is no clear evidence of any Quaternary movement along the intrablock and subsidiary faults (that is, the age of the last movement along these intrablock and subsidiary faults is either pre-Quaternary or undetermined).

In addition to rock *fractures* from faulting, there are fractures (or joints) in the rock at Yucca Mountain where there has been no displacement of the sides in relation to each other. These joints are divided into different types based on how and when they form. The Yucca Mountain FEIS described early cooling joints, later tectonic joints, and joints due to erosional unloading. Joints do not typically form through-going features like faults, but do have geoengineering aspects (those in relation to rock excavation) and hydrologic aspects (groundwater movement in rock) that DOE considered in the repository performance analysis.

The Yucca Mountain FEIS provided details on the geologic structure of the Yucca Mountain region and the location of the proposed repository. This information included Figure 3-10 of the FEIS, which showed the locations of the major faults at Yucca Mountain superimposed on the outline of the repository emplacement area, and Table 3-8 of the FEIS, a list of major faults by name, with descriptions and summaries of displacement characteristics.

3.1.3.3 Modern Seismic Activity

The Yucca Mountain FEIS described the nature of seismic activity at the Nevada Test Site since 1978 and included a description of the largest recorded historic earthquake within 50 kilometers (30 miles) of Yucca Mountain, which was the Little Skull Mountain earthquake in 1992 about 20 kilometers (12 miles) southeast of Yucca Mountain. This seismic event had a Richter scale magnitude of 5.6 and was apparently triggered by a 7.3-magnitude earthquake at Landers, California, 300 kilometers (190 miles) to the south of Yucca Mountain, which occurred 20 hours earlier (DIRS 169734-BSC 2004, p. 4-38). The Little Skull Mountain event caused no damage at Yucca Mountain, but some damage did occur at the Field Operations Center in Jackass Flats about 5 kilometers (3 miles) north of the epicenter.

Since the completion of the Yucca Mountain FEIS, the largest earthquake to occur in the vicinity of Yucca Mountain from 2002 through 2006 was a magnitude 4.4 event in June 2002, also at Little Skull Mountain in the aftershock zone of the 1992 earthquake (DIRS 172053-von Seggern and Smith 2003, pp. 20 and 25). There are no known reports of damage to facilities or changes in the subsurface rock at Yucca Mountain from the June 2002 event. The 1992 event is still the largest recorded event within 50 kilometers (30 miles) of Yucca Mountain. During report years 2003 through 2005, no earthquakes of magnitude 3 or greater occurred in the Yucca Mountain vicinity and in 2006 one earthquake occurred with a magnitude greater than 3 (reported at 3.4) (DIRS 184947-Smith and von Seggern 2007, p. 11; DIRS 184948-von Seggren and Smith 2007, p.7; DIRS 184946-Smith 2007, p.15).

Seismic Hazard

The Yucca Mountain FEIS described DOE's effort to use historical records of earthquakes, evidence of prehistoric earthquakes, and observed ground motions during modern earthquakes to predict the nature and frequency of future seismic events at Yucca Mountain. The Department convened two panels of scientific experts, one to characterize future earthquakes in relation to the potential for surface fault displacement and the other to consider the associated ground motion and how it would diminish with distance. The *Probabilistic Seismic Hazard Analyses for Fault Displacement and Vibratory Ground Motion at Yucca Mountain, Nevada* (DIRS 103731-CRWMS M&O 1998, all) provided the results of the two-panel effort and resulted in the preliminary bases for the design of facilities at Yucca Mountain and for forecasting elements of the repository's long-term performance in the Yucca Mountain FEIS. Key conclusions, which DOE has carried into subsequent evaluations (DIRS 176828-SNL 2007, pp. 6-25 to 6-33 and 6-208 to 6-211), include estimates of annual probabilities for different fault displacements and ground motion magnitudes that could occur at Yucca Mountain as a result of seismic events. For example, the analyses concluded (as the Yucca Mountain FEIS described) that faults, other than major block-bounding faults, are likely to experience displacement of more than 0.1 centimeter (0.04 inch) less than once in 100,000 years.

The Yucca Mountain FEIS noted that DOE needed to complete additional investigations of ground motion site effects before development of a final seismic design basis for the surface facilities. Since the completion of the FEIS, DOE has continued its seismic investigations and evaluations, resulting in numerous reports and a refined seismic analysis and design methodology. The most recent *Project Design Criteria Document* (DIRS 179641-BSC 2007, pp. 209 and 210) includes derived ground motion criteria at surface and subsurface (at the repository elevation) locations for 1,000-, 2,000-, and 10,000-year return period earthquakes. The design criteria document identifies baseline ground motion distributions (horizontal and vertical ground acceleration by frequency) and posted updates from further studies. The Project's *Seismic Analysis and Design Approach Document* (DIRS 184494-BSC 2007, all) and *Preclosure Seismic Design and Performance Demonstration Methodology for a Geologic Repository at Yucca Mountain Topical Report* (DIRS 181572-DOE 2007, all) documented the details of how DOE uses these earthquake data. These documents detailed DOE's use of the "risk-informed" approach in seismic design, which requires that facilities and structures with more severe failure consequences have lower probabilities of failure from seismic events. According to the Design Approach document (DIRS 184497-BSC 2007, pp. 10 to 13), DOE designed project structures, systems, and components not important to safety in accordance with standard criteria from the International Building Code 2000 (DIRS 173525-ICC 2003, all), and designed those that are important to safety in accordance with applicable codes and standards for the design of nuclear power plants as identified in NUREG-0800 (DIRS 138431-NRC 1987, all). Facilities, systems, and components important to safety would include those where spent nuclear fuel would be managed, for example, the Wet Handling Facility (described in Section 2.1.2.1.4); those not important to safety would include, for example, the Administration Facility and Craft Shops (described in Section 2.1.2.3.6), where there would be no nuclear materials managed and activities would be more routine in nature.

DOE would achieve seismic safety for structures, systems, and components important to safety through a combination of two important aspects: (1) the assignment of an appropriate seismic design basis (that included the inherent conservatism in design codes, standards, and acceptance criteria), and (2) the probabilistic assessments of the seismic hazard that demonstrated capacity to support regulatory compliance. DOE would design structures, systems, and components important to safety to meet one of the following objectives: (1) that an earthquake magnitude that could cause a failure would have a probability of occurrence of less than 1 in 10,000 before repository-closure; or (2) if a seismic event with a higher probability of occurrence than 1 in 10,000 could cause failure before repository-closure, the related radiological dose consequences of such an event would have to meet the performance objectives set by regulatory requirements. In other words, facilities can incorporate less stringent seismic design considerations if a failure caused by a seismic event would have minimal consequences.

The Yucca Mountain FEIS discussion of seismic hazard referenced a study in *Science* magazine that reported unusually high crustal strain rates in the Yucca Mountain area (DIRS 103485-Wernicke et al. 1998, all). The article concluded that, if these high strain rates were correct, DOE's analysis could underestimate the potential for volcanic and seismic hazards. As the Yucca Mountain FEIS described, DOE continued its investigations on the crustal strain rate in the Yucca Mountain region through a grant to the University of Nevada and with an improved array of geodetic monitoring stations. In an article in the *Journal of Geophysical Research* (DIRS 175199-Wernicke et al. 2004, Abstract), the authors concluded that the high crustal strain rates between 1991 and 1997 were associated with the 1992 Little Skull Mountain earthquake. They noted that the strain rates from after 1998 (specifically from 1999 to 2003) did not appear to show an effect due to the earthquake and were notably lower. However, the lower strain rates were still higher than geologic predictions; that is, the geodetic estimates of deformation rates were not consistent with the low magnitude of Quaternary Period displacement that generally occurs in faults at Yucca Mountain. The findings of an independent interpretation of the geodetic information by University of Nevada researchers supported this conclusion (DIRS 180378-Hill and Blewitt 2006, all). In addition, this later effort suggested the possibility that the higher-than-expected strain rates might be due to relaxation of geologic features from a number of past earthquakes. DOE installed several new network stations in 2005 and, according to Hill and Blewitt, continued monitoring could help to test *alternative* scenarios for the cause of this apparent inconsistency.

Locations worldwide, including other locations in the Basin and Range Province, have observed differences between strain measured from geodetic stations and expectations from geologic data (DIRS 185127-Quittmeyer 2008, all; DIRS 185128-Coopersmith 2008, all). This is a broad field of ongoing scientific inquiry and the scientific community is considering other reasons for these differences, including the possibility that some strain might be released aseismically (that is, without seismic activity) (DIRS 185127-Quittmeyer 2008, all) or that short-term irregularities in strain rates are simply not observable in the geologic record (DIRS 185128-Coppersmith 2008, all). DOE considered the new strain data in evaluations of the probability for seismic activity at Yucca Mountain and determined that they did not affect the probability values concluded by the effort (DIRS 185335-Smistad 2008, all).

3.1.3.4 Mineral and Energy Resources

The Yucca Mountain FEIS described the concern that the Yucca Mountain analyzed land withdrawal area could have the potential for mineral resources that could lead to future exploration and inadvertent *human intrusion* into the repository. The Yucca Mountain FEIS also described DOE's efforts to investigate that potential and the resultant conclusion that the potential for economically useful mineral or energy resources within a conceptual *controlled area* around Yucca Mountain is low.

The Cind-R-Lite quarry is a mineral extraction operation (Section 3.1.1.2) outside the land area DOE evaluated for mineral resources, but it is inside the analyzed land withdrawal area. This operation is at a volcanic cinder cone approximately 10 kilometers (6 miles) northwest of the town of Amargosa Valley, just north of U.S. Highway 95, and includes the mining of cinder for the manufacture of light-weight, high-strength cinder blocks. As described in Section 3.1.1.2, this operation is on a patented mining claim, which is private property.

3.1.4 HYDROLOGY

In the Yucca Mountain FEIS, DOE described the region of influence for hydrology in terms of surface water and groundwater. The region of influence for surface water included areas of land disturbance that could be susceptible to erosion, areas that permanent changes in surface-water flow could affect, and areas downstream of the proposed repository that eroded soil or potential spills of contaminants could affect. The groundwater region of influence included *aquifers* that underlie areas of construction and operations, aquifers that could be sources of water for construction and operations, and aquifers downgradient of the proposed repository that repository use could affect, which included long-term releases of radioactive materials. This Repository SEIS addresses the same regions of influence. This section summarizes, incorporates by reference, and updates Section 3.1.4 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-34 to 3-69) and provides new information, as applicable, from studies and investigations that continued after completion of the FEIS.

In its introduction to hydrology, the Yucca Mountain FEIS described several key characteristics of the hydrologic system of the Yucca Mountain region of influence, which included its very dry climate, limited surface water, high potential evaporation, and deep aquifers. Yucca Mountain is in the Death Valley regional groundwater flow system (or simply Death Valley region) where the floor of Death Valley is the regional hydrologic sink and surface water and groundwater generally do not leave except by *evapotranspiration*. Because there are no changes to the information, this Repository SEIS incorporates by reference the more detailed discussion in the Yucca Mountain FEIS of the key characteristics of the hydrologic system in the Yucca Mountain region.

3.1.4.1 Surface Water

3.1.4.1.1 *Regional Surface Drainage*

Yucca Mountain is in the southern Great Basin, which has few perennial streams and other surface-water bodies. The Amargosa River and its tributaries, which are dry along most of their lengths, drain Yucca Mountain and surrounding areas. The exceptions are short stretches of the river channel that are fed by groundwater discharges (that is, springs and seeps). The Amargosa River drainage terminates in the Badwater Basin in Death Valley. The nearest surface-water impoundments to Yucca Mountain are several ponds and reservoirs in the Ash Meadows National Wildlife Refuge, approximately 50 kilometers (30 miles) to the southeast. The impoundments and springs in the Ash Meadow area drain to the Amargosa River through Carson Slough.

The Amargosa River is an interstate water because it flows from Nevada into California and at least some portions of this ephemeral stream could be classified as waters of the United States as defined in 33 CFR Part 328 and regulated under Section 404 of the *Clean Water Act* (33 U.S.C. 1251 et seq.). Fortymile Wash, a tributary of the Amargosa River, and some of its tributaries in and near the *geologic repository operations area* might also be waters of the United States. In June 2007, the EPA and the U.S. Army Corps of Engineers released interim guidance that addresses the jurisdiction over waters of the United States (72 FR 31824, June 8, 2007). Based on this new guidance, it is less likely that the ephemeral washes and riverbeds in this area would be considered waters of the United States. However, for construction actions proposed in these washes, the Corps of Engineers would still have to determine the limits of jurisdiction under Section 404 of the *Clean Water Act*.

3.1.4.1.2 *Yucca Mountain Surface Drainage*

This section summarizes occurrences of past floods and the DOE evaluation of flood potential in the areas DOE would use for the Proposed Action.

Occurrence

There are no perennial streams, natural bodies of water, or naturally occurring wetlands in the analyzed land withdrawal area. Several named washes on the east side of Yucca Mountain drain into Fortymile Wash, as shown in Figure 3-6 (along with estimated flood zones). Solitario Canyon Wash collects

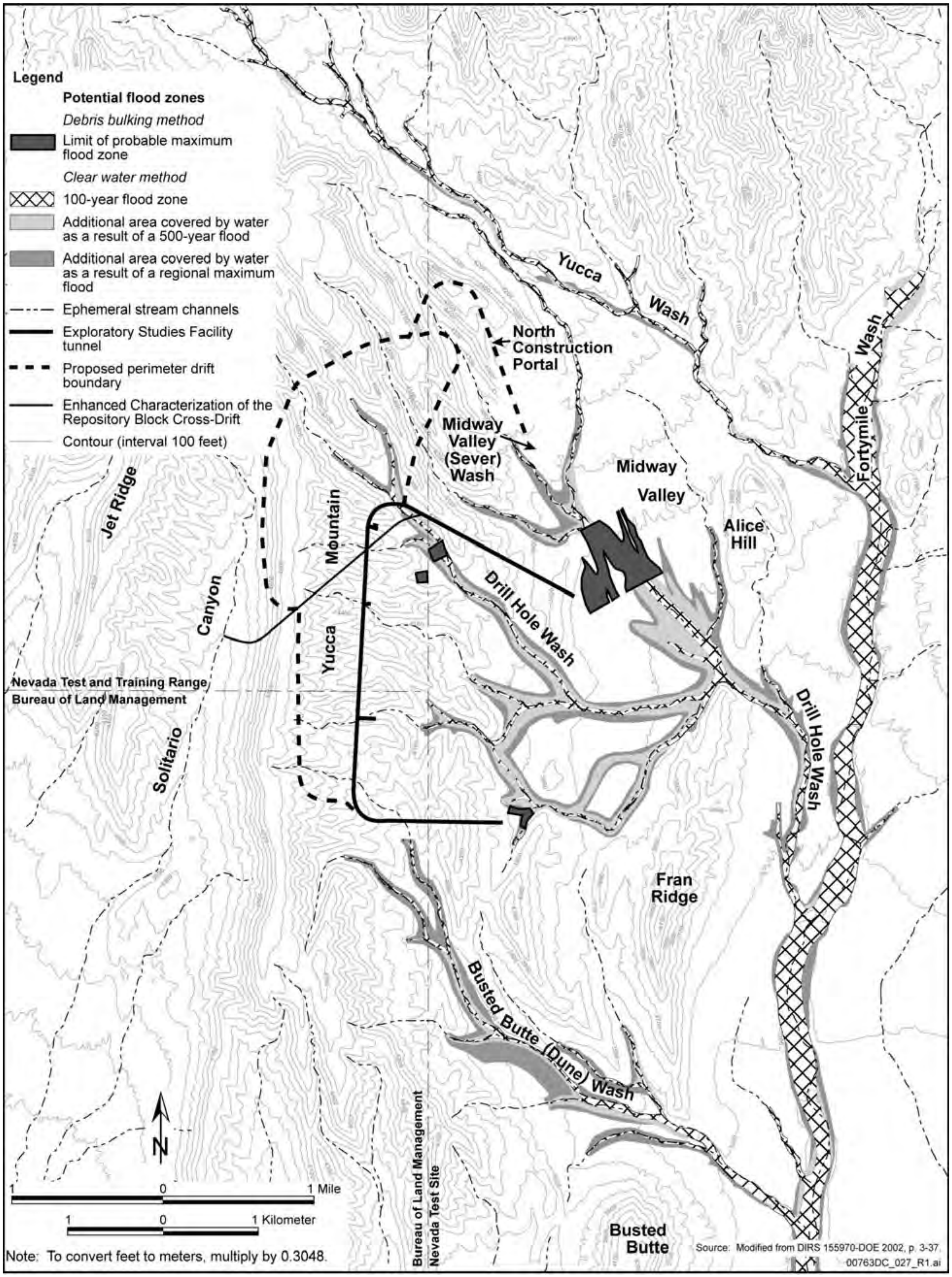


Figure 3-6. Site topography and potential flood areas.

drainage from the west side of Yucca Mountain. Both the west and east sides of Yucca Mountain drain into the ephemeral Amargosa River. Washes at Yucca Mountain carry water only in response to intense precipitation events and rapid snowmelt. Instances in which a large portion of the drainage system carries water at the same time are infrequent because they require the generation of runoff over a large area at the same time, and intense precipitation events in this region are generally confined to small areas. In March 1995 and February 1998, Fortymile Wash and the Amargosa River flowed simultaneously through their primary channels to Death Valley. The 1995 event represented the first documented case of this flow condition. Although not documented, similar incidents probably occurred during the preceding 30 years when there were several instances for which records show sections of the primary channels flowing with floodwater.

Flood Potential

Although water flow in washes at Yucca Mountain is an unusual occurrence, flooding can occur as a result of intense summer thunderstorms or sustained winter precipitation. As a result, DOE has used several different, recognized methodologies to calculate estimates of predicted flood levels, which include a probable maximum flood. Figure 3-6 shows these flood levels. The three flood levels for each of the prominent washes are the 100-year, 500-year, and regional maximum floods. The *100-year flood* is of a magnitude that is likely to occur, on average, only once every 100 years. This means there is a probability of 0.01 that a flood of this size would occur in any 1 year. A 500-year flood would be likely to occur, on average, only once in 500 years and there would be a probability of 0.002 that it would occur in any 1 year. The regional maximum flood is a larger flood that considers size of the extreme floods that occur elsewhere in Nevada and in nearby states.

Figure 3-6 also shows the results of a fourth flood level estimate using the probable maximum flood method, which is based on American National Standards Institute and American Nuclear Society Standards for Nuclear Facilities (DIRS 103071-ANS 1992, all) and is considered the most severe reasonably possible flood. DOE calculated potential flood levels for the probable maximum flood only for specific locations on certain washes (the isolated segments of dark shading in Figure 3-6). The Department selected these specific locations for the calculations to verify that specific repository features, which would include the openings to the subsurface, would not be in the inundation zone of the probable maximum flood. This flood calculation incorporated the effects of mud and debris the flood would carry, which would significantly increase the volume of the flood flow and the lateral extent of area it would cover.

The flood levels in Figure 3-6 are the same as those in the Yucca Mountain FEIS. The FEIS also presented estimates of the peak discharges due to these flood levels. Appendix C of this Repository SEIS is a floodplain and wetlands assessment DOE prepared that further addresses flooding issues in relation to the ephemeral washes at Yucca Mountain.

Surface-Water Quality

DOE has collected stream-water samples (at times of flow) at and near Yucca Mountain for comparison with groundwater samples. The Department analyzed these samples for general chemical characteristics (that is, mineral content) and summarized the results in the Yucca Mountain FEIS. Stream-water samples contained a lower mineral content than groundwater samples, which suggests less interaction between the rock and water.

3.1.4.2 Groundwater

This section discusses groundwater first in the region, in general, then more specifically at Yucca Mountain. Section 3.1.4.2 of the Yucca Mountain FEIS discussed differences of opinion on the groundwater system (DIRS 155970-DOE 2002, pp. 3-39 to 3-69).

3.1.4.2.1 *Regional Groundwater*

Yucca Mountain is in the Death Valley region, which is complex, with many aquifers and confining units that can vary greatly in their characteristics over distance. In some areas, confining units allow movement between aquifers, and in other areas they can be sufficiently impermeable to support artesian conditions where water will rise in a well to a higher elevation than that first encountered. In general, the principal water-bearing units in the Death Valley region can be classified as volcanic aquifers, alluvial aquifers, and carbonate aquifers. The mountainous areas in the north-central portion of the Death Valley region are mostly of volcanic origin and contain associated volcanic aquifers. Alluvial aquifers occur in the basin-fill areas between mountains and include the large Amargosa Desert (Figure 3-7). This discussion uses "alluvial aquifers" as a simplification for the basin- or valley-fill materials specific to the Amargosa Desert. Studies by the U.S. Geological Survey (DIRS 173179-Belcher 2004, all) and by Nye County (DIRS 156115-Nye County Nuclear Waste Repository Project Office 2001, all) identify multiple units in their characterizations of these basin-fill materials. The hydrogeologic framework model the Survey developed describes the unconsolidated basin-fill sediments as including two alluvial aquifers, two alluvial confining units, an interfingered limestone aquifer, and two volcanic units (DIRS 173179-Belcher 2004, pp. 39 and 40). These units differ in their makeup and in their manner of deposition, as well as in their hydraulic parameters. In this discussion, alluvial aquifer refers to the various unconsolidated materials in the Amargosa Desert through which groundwater moves. DOE recognizes that this portion of the groundwater flow path has a complex geology.

Carbonate rocks occur at widely different depths throughout the Death Valley region, including at the surface, and often are very thick in a particular location. Beneath Yucca Mountain and the northern Amargosa Desert, the carbonate aquifers occur at great depths below the volcanic and alluvial aquifers. Carbonate rocks are often characterized as the most *permeable* rocks in the region; the *permeability* is due primarily to fractures, faults, and solution channels (DIRS 173179-Belcher 2004, p. 65). However, these rocks formed during the Paleozoic Era (Table 3-3) and have been subject to a long, complex history of tectonic activity (DIRS 156115-Nye County Nuclear Waste Repository Project Office 2001, p. F53) and associated structural deformations. The carbonate aquifers are regionally extensive, particularly in the eastern and southern portions of the Death Valley region, but there are differing opinions among investigators on how extensively they are interconnected over the region. Because of the structural deformations, some investigators view the carbonate aquifer as often occurring in compartments (DIRS 156115-Nye County Nuclear Waste Repository Project Office 2001, p. F53) that might have a hydraulic connection to the carbonate rock in an adjacent compartment. Other investigators view the lower carbonate aquifer as highly connected over the region. They reason that because of the great thickness of the carbonate rock in most areas, even large fault displacements often result in carbonate rock-to-carbonate rock contacts across the fault, providing a route for transmission of water. This latter model views the lower carbonate aquifer as acting, where applicable, to integrate individual valleys into a single groundwater basin (DIRS 185423-ICYMRAO n.d., p. 88). Both views agree that when hydraulically connected, carbonate aquifers provide a path for flow between groundwater basins (DIRS 173179-Belcher 2004, p. 65).

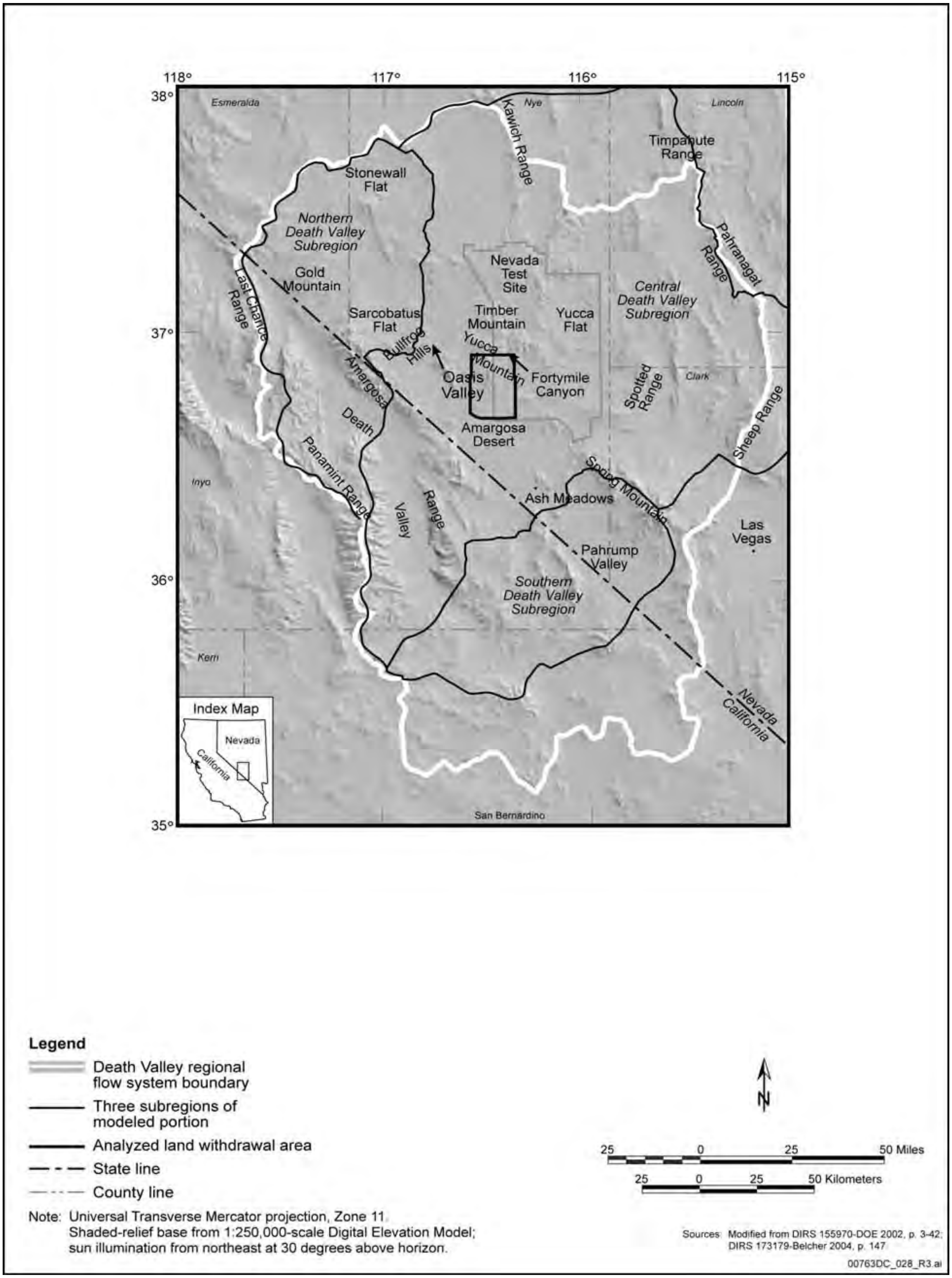


Figure 3-7. Boundaries of Death Valley regional groundwater flow system.

The alluvial aquifers below the Amargosa Desert receive underflow from groundwater basins to the east and the north, including the aquifers that underlie Yucca Mountain. Deep drill holes indicate the presence of a carbonate aquifer below Yucca Mountain that extends into the Amargosa Desert. Groundwater flow in the northwest Amargosa Desert is generally to the southeast toward the central part of the basin and then south toward the discharge area at Alkali Flat with some of the flow perhaps moving into Death Valley. In contrast, flow in the southeastern portion of Amargosa Desert is generally to the west and southwest. Some of the flow in the southeast part of Amargosa Desert discharges via springs and evapotranspiration at the Ash Meadows area. The remainder of the flow from the east merges with the more southerly flow in the south-central portion of Amargosa Desert and continues toward Alkali Flat.

Basins

Studies of the Death Valley region often divide the area into the Northern, Central, and Southern Death Valley subregions (Figure 3-7). As shown in Figure 3-8, the Central subregion is further divided into three groundwater basins: (1) Pahute Mesa-Oasis Valley, (2) Ash Meadows, and (3) Alkali Flat-Furnace Creek (which contains Yucca Mountain). The Yucca Mountain FEIS discussed each of these basins in detail, which included the identification of areas of recharge and discharge (if any), the general direction of groundwater flow, and where subsurface flow leaves the basin. The remaining information in this section, summarized from the Yucca Mountain FEIS, focuses on the Alkali Flat-Furnace Creek groundwater basin, which the Proposed Action could affect the most.

The Alkali Flat-Furnace Creek groundwater basin is so named because of the evidence that the groundwater in this basin discharges mainly at Alkali Flat (also known as Franklin Lake Playa) and potentially to the Furnace Creek area of Death Valley (Figure 3-8). Fortymile Wash and precipitation that infiltrates the surface are sources of recharge near Yucca Mountain, but the primary sources of recharge to the Alkali Flat-Furnace Creek groundwater basin are the high mountains to the north of Yucca Mountain and those to the south and southwest across the Amargosa Desert. Water that infiltrates at Yucca Mountain joins with water in the Fortymile Canyon section of the basin (Figure 3-8) and flows south to the Amargosa Desert and a primary discharge area of Alkali Flat, with some flow potentially moving into Death Valley along the same general course followed by the Amargosa River channel (DIRS 173179-Belcher 2004, pp. 155 and 156). DOE has recently updated a model of net infiltration for the Yucca Mountain site (DIRS 174294-SNL 2007, all) (Section 3.1.4.2.2). For the Yucca Mountain FEIS, estimates from this infiltration model are directly comparable with published estimates of the amount of water that moves through the Amargosa Desert to reach a conclusion that contributions from recharge at Yucca Mountain would be a very small percentage of the total flow. DOE has performed modeling studies of the *saturated zone* groundwater flow path from Yucca Mountain and estimated it would take 810 years for 50 percent of a conservative, nonsorbing radionuclide in the absence of *decay* added to groundwater beneath Yucca Mountain to travel 18 kilometers (11 miles) along the flow path. Some of the tracer would reach that distance faster, but half would take longer (DIRS 177392-SNL 2007, p. 6-31).

As groundwater in the Alkali Flat-Furnace Creek groundwater basin moves south beneath the Amargosa Desert, underflow from the Ash Meadows groundwater basin joins it. A line of springs fed by Ash Meadows basin groundwater marks a portion of the boundary between the two basins and supports *habitat* in the Ash Meadows National Wildlife Refuge. Devils Hole, a groundwater-filled cave in a fault zone, is in this area. As the Yucca Mountain FEIS noted, there is evidence that the carbonate aquifer feeds the line of springs in the Ash Meadows area. In this area, there is a relatively sharp decrease in

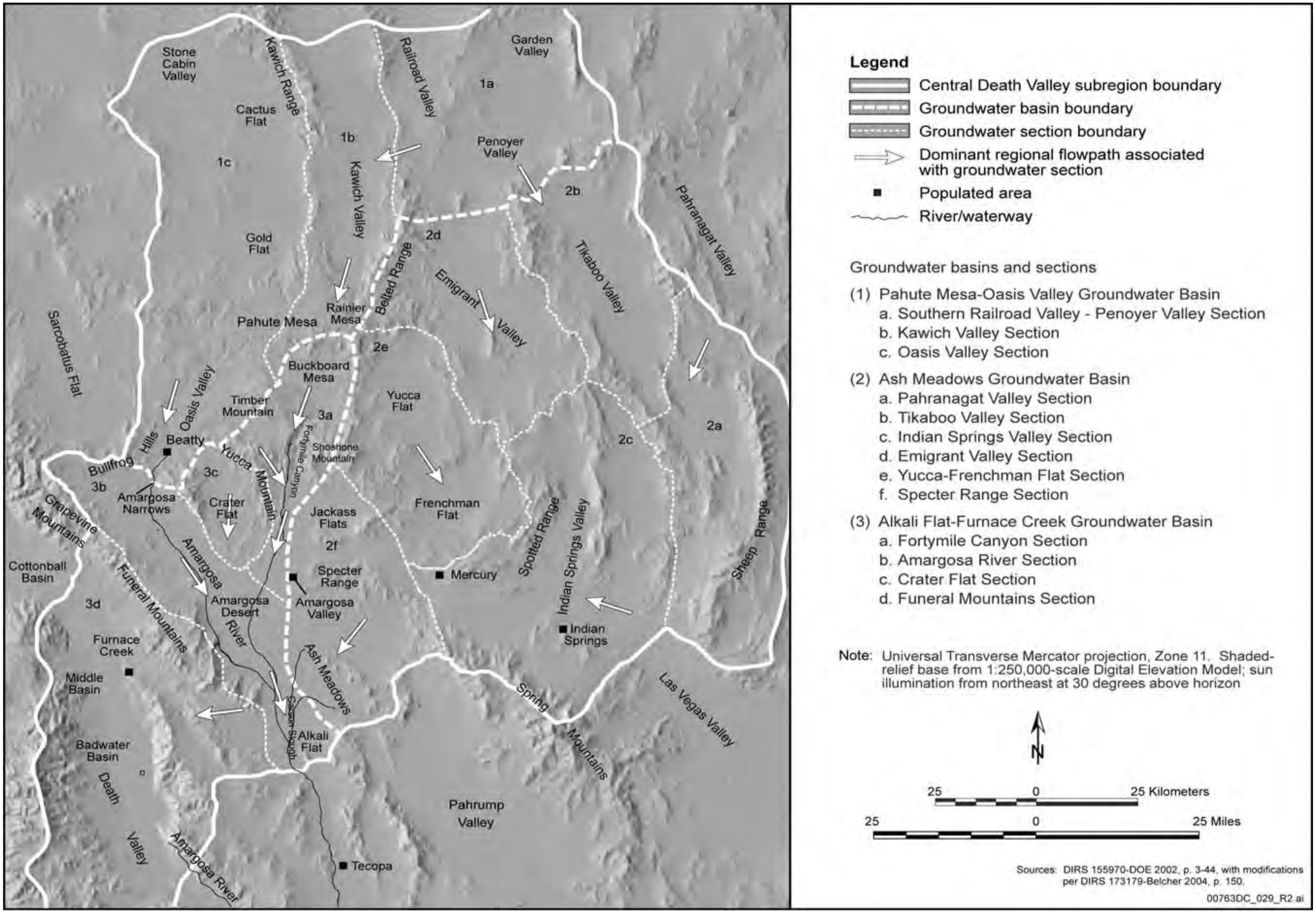


Figure 3-8. Groundwater basins and sections of the Central Death Valley subregion.

groundwater head, or elevation, from east to west, so it is clear that groundwater at Ash Meadows moves into the Alkali Flat-Furnace Creek basin rather than the opposite.

The Yucca Mountain FEIS described studies that DOE and others have initiated to reduce uncertainties about the regional groundwater flow system, particularly studies by Nye County under a cooperative agreement with DOE. Since the completion of the Yucca Mountain FEIS, DOE has established a similar program with Inyo County in California. The Department has obtained new borehole data and other information from these ongoing County efforts (DIRS 180739-Williams 2003, p. A-4) and incorporated them in the regional hydrogeologic framework model, which the U.S. Geological Survey developed (DIRS 173179-Belcher 2004, all) and which continues to evolve, to simulate groundwater conditions and movement in the Death Valley region. A primary change to the model since the completion of the Yucca Mountain FEIS is characterization of the depth and extent of the alluvial layers and the alluvial aquifer in the area south of Yucca Mountain (DIRS 180739-Williams 2003, p. 2-39), which is the focus of the Nye County drilling program. A recent update to the hydrogeologic framework model (DIRS 174109-SNL 2007, all) includes data collected through Phase IV of the Nye County program. One of the many objectives of the Nye County program has been to locate the tuff-*alluvium* contact—the zone where water moving south from Yucca Mountain changes from primarily flowing in the fractured rock of the volcanic aquifer to dispersed flow through the relatively porous material of the alluvial aquifer. The Nye County report on its Phase IV drilling program interprets the Highway 95 Fault as the southern boundary of the volcanic aquifers (DIRS 182194-NWRPO 2005, p. 70). The Highway 95 Fault is a Tertiary fault that roughly aligns with U.S. Highway 95 in the area where Fortymile Wash enters the Amargosa Desert. Drilling results show volcanic aquifers on the north side of the fault that line up with older Tertiary sedimentary rocks on the south side. Nye County speculated that contact with the less permeable Tertiary rock forces the southward groundwater flow up into the overlying alluvial aquifer system, which continues into lower Fortymile Wash and the Amargosa Desert (DIRS 182194-NWRPO 2005, p. 70). These and other updates to the hydrogeologic framework model have resulted in an increasingly more realistic representation of the groundwater flow system, which supports a more detailed understanding of the potential long-term effects of the Proposed Action.

A primary focus of the Inyo County efforts has been the investigation of the source of the water that discharges from springs on the east side of Death Valley and if there is a hydraulic connection between those springs and the groundwater moving beneath Yucca Mountain. Inyo County has supported the following work: (1) updates to geologic mapping of the southern Funeral Mountains; (2) drilling of exploratory monitoring wells in the southwest Amargosa Desert area near the southern Funeral Mountains; (3) geophysical surveys in the area from the southern Funeral Mountains on the west to the Devils Hole area of Ash Meadows on the east, and including the portion of the Amargosa Desert in between; and (4) analysis of geochemical data on spring waters in the area of Death Valley National Park and in the Yucca Mountain study area (DIRS 185423-ICYMRAO n.d., all). From the mapping, drilling, and geophysical survey data and information from the U.S. Geological Survey's regional model (DIRS 173179-Belcher 2004, all), Inyo County generated two groundwater flow models to evaluate possible flow characteristics in the lower carbonate aquifer in the subregion south from Yucca Mountain. The first model was a simple flow model of the lower carbonate aquifer that demonstrated the possibility of a relatively fast pathway from beneath Yucca Mountain to the springs in Death Valley. Inyo County based the second model on two interpretive maps for the base of the lower carbonate aquifer in the southern Funeral Mountains, where upper portions of the rocks that comprise the lower carbonate aquifer are exposed (DIRS 173179-Belcher 2004, pp. 28 and 33). Both maps supported the presence of two subsurface spillways where water in the lower carbonate aquifer could flow across the Furnace Creek Fault to the southwest and supply water to the Funeral formation, which is the primary source for the Death Valley springs (DIRS 185423-ICYMRAO n.d., pp. 96 to 100). Inyo County used flow system parameters based on the configuration of these maps and several measured parameters to establish the second groundwater flow model, which simulated Death Valley spring discharge rates "quite well." The County concluded that this second model demonstrated the feasibility of flow from the carbonate aquifer in the Amargosa Desert to the major springs in the Furnace Creek area of Death Valley.

The primary conclusions from the Inyo County efforts are that the lower carbonate aquifer appears to be a significant contributor to the springs in the Furnace Creek area of Death Valley and this aquifer represents a potentially rapid pathway for contaminants to reach the biosphere. Inyo County and DOE agree that the pathway simulated in the simple flow model is not a viable pathway for contaminants originating at the repository site as long as there is an upward gradient in the carbonate aquifer, which has been observed in boreholes in the Yucca Mountain vicinity. Inyo County efforts provide additional support to the conceptual model of regional flow DOE considered in the evaluation of repository postclosure performance (summarized in Chapter 5 of this Repository SEIS). The conceptual model of flow is, and has been, that the groundwater in the Amargosa Desert area contributes to the discharges from the springs in the Furnace Creek area of Death Valley. Slightly different from the Inyo County conclusions, the conceptual flow model DOE used indicates that contaminants from the repository could find their way to the Death Valley springs even if they did not reach the lower carbonate aquifer at Yucca Mountain. The U.S. Geological Survey's regional hydrogeologic framework model cites earlier studies of the region to conclude that the carbonate rocks beneath the Funeral Mountains might provide pathways for flow from the alluvial aquifers beneath the Amargosa Desert toward Death Valley (DIRS 173179-Belcher 2004, p. 155). The predominant flow in the alluvial aquifer of the Amargosa Desert is south to discharge areas at Alkali Flat and along the Amargosa River, but some of the flow is probably toward the southwest to the Furnace Creek area of Death Valley. Further, the relatively rapid flow path generated by the Inyo County flow model is consistent with the low end of the range of travel times to the accessible environment that the saturated zone flow and transport abstraction model (DIRS 183750-SNL 2008, pp. 6-109 to 6-112), which DOE used to evaluate postclosure performance of the repository, considered. The accessible environment location DOE evaluated for postclosure performance is not a spring discharge in Death Valley; rather, it is the *reasonably maximally exposed individual* much closer to the repository. As described in Chapter 5, impacts at the Death Valley springs can be conservatively assumed to be no different from those at the evaluated location, even under the unexpected condition of all contaminant migration moving toward the springs.

DOE has incorporated hydrogeologic information that Nye and Inyo counties collected in studies to define groundwater flow paths based on naturally occurring chemical and isotopic constituents in the water. Chloride and sulfate are primary examples of the chemical constituents under study, and deuterium (hydrogen-2) and oxygen-18 are examples of isotopes the studies are tracking. The concentrations of these constituents in groundwater depend on such parameters as the location and time the water first infiltrated from the surface, the rock materials through which it passed on its route and the resulting rock-water interactions, and the mixing that has occurred in the groundwater. Groundwater samples from different locations have different chemical signatures that reflect individual *pathway* histories (DIRS 177391-SNL 2007, Appendix A, pp. A-1 and A-83). The regional groundwater flow paths these geochemical signatures identify are consistent with the general flow directions that were developed from the potentiometric surface of the groundwater (DIRS 177391-SNL 2007, p. 7-36), as summarized above and described in more detail in the Yucca Mountain FEIS.

An objective of Inyo County's analysis of geochemical data from spring waters in the area was to determine the source of the water that moves beneath the Funeral Mountains to discharge points (springs) in the Furnace Creek area of Death Valley. The analysis was able to link the Death Valley springs to the carbonate aquifer, but the ultimate source of those waters remains partially unknown. The Inyo County effort concluded, as described in earlier studies, that the water probably originated as recharge in (1) the area of the Nevada Test Site, including Yucca Mountain, (2) the Amargosa Basin, or (3) the area to the east that includes the Ash Meadows springs, or a combination of the three (DIRS 185423-ICYMRAO n.d., p. 85). DOE's evaluation of geochemical data on water from various locations in the area concluded that the chemical and isotopic characteristics of the Death Valley discharges are similar to those in the Ash Meadows basin and dissimilar in several chemical concentrations to groundwater from the alluvial aquifer in the Amargosa Desert. This suggests that the deep underflow of groundwater from the underlying carbonate aquifer (rather than the alluvial aquifer in the Amargosa Desert) that contributes to discharges in the Ash Meadows area is the primary source of the spring discharge in Death Valley (DIRS 177391-SNL 2007, Appendix A, pp. A-212 to A-214). This implies a westward component of flow in the underlying carbonate aquifer in this area of the Amargosa Desert where the general direction of flow in the alluvial aquifer is south and even a little to the southeast. Geochemical investigations by the University of Nevada, Las Vegas (DIRS 181435-Koonce et al. 2006, all) support the conclusion that spring discharge in Death Valley involves primarily carbonate-derived groundwater. Conclusions of this study suggest there could be a contribution of volcanic aquifer groundwater from areas to the north of Ash Meadows and north of the Amargosa Desert in the Death Valley discharges. In terms of groundwater flow from beneath the area of Yucca Mountain, connection of this flow with spring discharge in Death Valley appears to substantiate the basis for the name of the Alkali Flat-Furnace Creek groundwater basin. That is, the predominant flow in the basin might contribute to discharges in the Furnace Creek area of Death Valley. Water moving south from the volcanic aquifers (as from the Yucca Mountain area) and into the alluvial aquifer of the Amargosa Desert might contribute to those discharges but, based on the geochemical data, does not appear to be the primary source (DIRS 177391-SNL 2007, Appendix A, p. A-214).

Use

The Yucca Mountain FEIS discussed the concept of *hydrographic areas*, which the State of Nevada uses as basic map units in its water planning and appropriation efforts, and which often have slightly different boundaries than the sections shown in Figure 3-8. Figure 3-9 shows the hydrographic areas in the general area of Yucca Mountain. The FEIS characterized use of water from the Fortymile Canyon-Jackass Flats hydrographic area (Area 227A) for the Yucca Mountain Project and the Nevada Test Site, but identified the highest water use in the nearby region as in the Amargosa Desert hydrographic area (Area 230) immediately to the south of Area 227A (Figure 3-9). Table 3-11 of the FEIS summarized pertinent information on the hydrographic areas in the immediate area of Yucca Mountain, including estimates of annual groundwater withdrawals from each hydrographic area (DIRS 155970-DOE 2002, p. 3-48). Table 3-4 updates this information. Water withdrawal quantities, with the exception of those for Oasis Valley, are the annual averages from 2000 to 2004, which are the last 5 years of available record published by the U.S. Geological Survey. The withdrawals for Jackass Flats, Crater Flat, and the Amargosa Desert each show a slight decrease from those in the Yucca Mountain FEIS. The decrease for Jackass Flats is attributable to a decrease in characterization activities at Yucca Mountain. The largest amount of water withdrawal continues to be in the Amargosa Desert, where the annual volume is about 16 million cubic

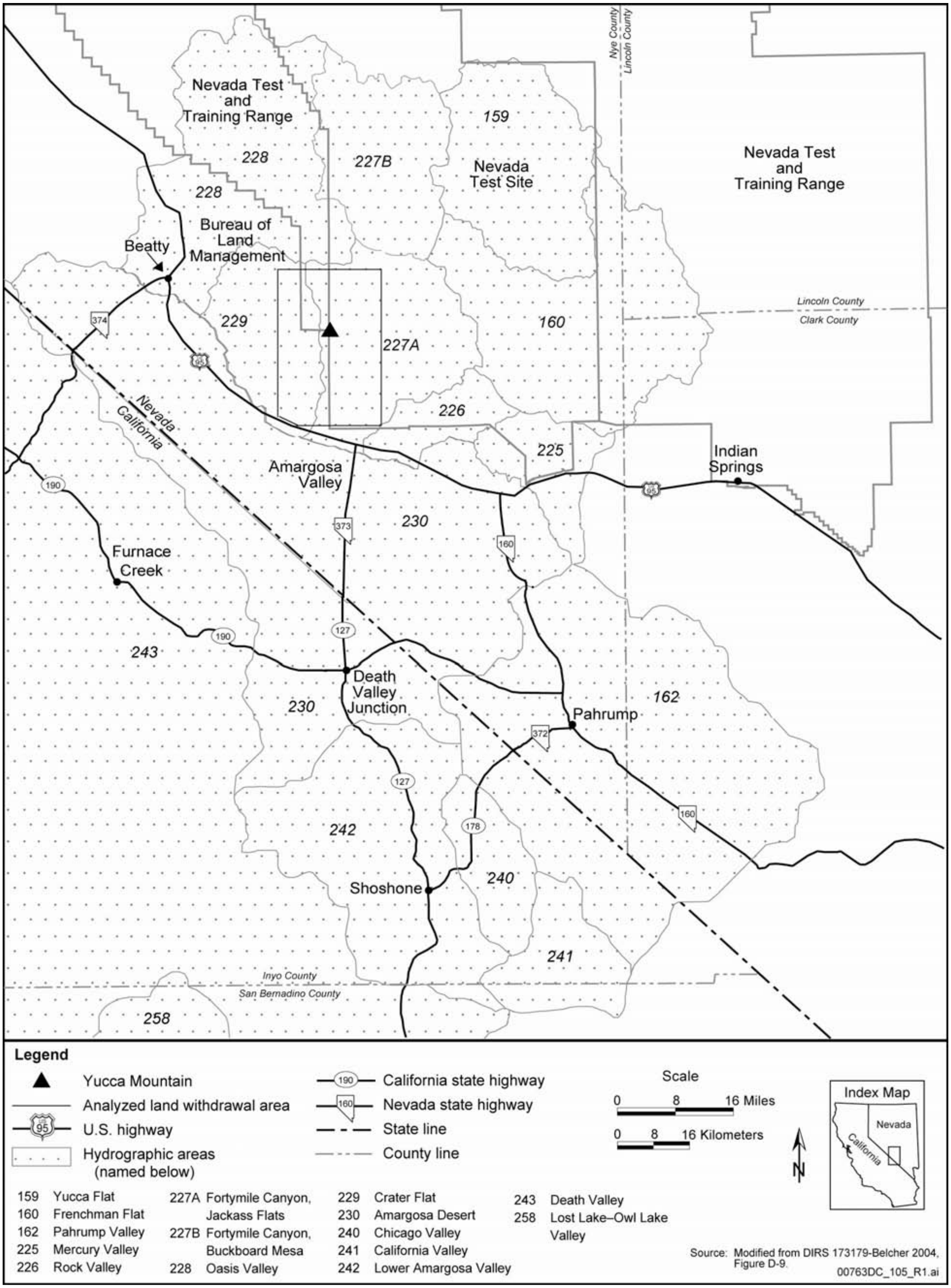


Figure 3-9. Hydrographic areas in the Yucca Mountain region.

Table 3-4. Perennial yield and water use in the Yucca Mountain region.

Hydrographic area[a]	Perennial yield[b,c,d] (acre-feet per year)[e]	Current appropriations/ committed resources[f,g] (acre-feet per year)	Average annual withdrawals, 2000 to 2004, unless noted otherwise (acre-feet)	Chief uses
Jackass Flats (Area 227A)	880[h] – 4,000	58[i]	89[j,k]	Nevada Test Site programs and minor amounts for the Yucca Mountain Project
Crater Flat (Area 229)	220 – 1,000	1,100	63[j]	Mining, minor amounts for the Yucca Mountain Project
Amargosa Desert (Area 230)	24,000 – 34,000	25,000[l]	13,000[j,l]	Irrigation, mining, livestock, quasi-municipal or commercial, and domestic
Oasis Valley (Area 228)	1,000 – 2,000	1,300	130 (for 2000)[g]	Irrigation and municipal

Note: To convert acre-feet to cubic meters, multiply by 1,233.49. This table lists acre-feet because of common statutory and public use of this unit of measure for groundwater resources.

a. A specific area in which the State of Nevada allocates and manages the groundwater resources.
b. The quantity of groundwater that can be withdrawn annually from a groundwater reservoir, or basin, for an indefinite period without depleting the reservoir; also referred to as safe yield.
c. Source: DIRS 147766-Thiel 1999, pp. 8 and 10 to 12.
d. In many of its planning documents, the Nevada Division of Water Resources identifies a combined perennial yield of 24,000 acre-feet for Hydrographic Areas 225 through 230.
e. An acre-foot is a commonly used hydrologic measurement of water volume equal to the amount of water that would cover an acre of ground to a depth of 1 foot.
f. The amount of water that the State of Nevada authorizes for use; the amount used might be much less. These appropriations are for underground rights only, and do not cover Federal Reserve Water Rights held by the Nevada Test Site or U.S. Air Force. This latter exclusion is the reason withdrawals from Area 227A are shown as exceeding the identified appropriations (that is, the Nevada Test Site withdrew water under its Federal Reserve Water Rights).
g. Source (except for Crater Flat): DIRS 182821-Converse Consultants 2005, pp. 99 and 100 for committed resources, p. 38 for annual withdrawal from Oasis Valley.
   Source (for Crater Flat): DIRS 178726-State of Nevada 2006, all.
h. The low estimate for perennial yield from Jackass Flats breaks the quantity down into 300 acre-feet for the eastern third of the area and 580 acre-feet for the western two-thirds. The Yucca Mountain Project production wells are in the western portion of this hydrographic area.
i. Based on the southern boundary of Area 227A, as defined in a 1979 Designation Order by the State Engineer, there should be only 17 acre-feet of committed resources in Area 227A. However, water rights information from the Nevada Division of Water Resources shows 58 acre-feet in committed resources for this area. The apparent discrepancy appears to be the result of 41 acre-feet of committed resources (including one certificate for domestic use and one for commercial use) being inside the pre-1979 boundary and outside the post-1979 boundary. Both certifications are for wells near U.S. Highway 95. The remaining 17 acre-feet of committed resources (which appear to be in Area 227A) are attributed to two certificates the Bureau of Land Management owns for stock watering wells.
j. Sources: DIRS 178692-La Camera et al. 2005, pp. 72 and 73 for water withdrawals from 2000 to 2003; DIRS 178691-La Camera et al. 2006, p. 69 for water withdrawals in 2004. (Includes only Nevada Test Site water use in Area 227A.)
k. Sources include only Nevada Test Site water use from Area 227A. The sources for the Yucca Mountain Project water use from Area 227A (about 21 acre-feet per year) are DIRS 181575-Wade 2000, all; DIRS 181576-Wade 2000, all; DIRS 181577-Wade 2000, all; DIRS 181578-Wade 2001, all; DIRS 181580-Wade 2002, all; DIRS 181581-Wade 2003, all; DIRS 181582-Wade 2004, all; and DIRS 181583-Wade 2005, all.
l. A recent ruling (Ruling 5750; DIRS 185182-Taylor 2007, all) by the Nevada State Engineer identifies 24,000 acre-feet as the best estimate of perennial yield for the Amargosa Desert area, but stipulates that the 24,000-acre-feet value includes 17,000 acre-feet annually of spring discharges at Ash Meadows to satisfy the certificated rights of the U.S. Fish and Wildlife Service for wildlife purposes (and which is not included in the 25,000 acre-feet annually of committed resources shown in the table). This position results in only 7,000 acre-feet of the perennial yield remaining for traditional groundwater withdrawals.

meters (13,000 acre-feet). As listed in Table 3-4, water appropriations in the Amargosa Desert continue to be higher than the amount of water actually withdrawn. As noted in footnote “l” in Table 3-4, a recent ruling from the Nevada State Engineer describes the spring discharges at Ash Meadows as a committed portion of the Amargosa Desert’s perennial yield. Under this interpretation, it can be seen in Table 3-4 that the remaining portion of the perennial yield is exceeded by the current levels of pumping from that hydrographic area.

The Yucca Mountain FEIS described the U.S. Supreme Court decision (DIRS 148102-Cappaert et al. v. United States et al. 1976, all) in 1976 to restrict groundwater withdrawal in the Ash Meadows area to protect the water level in Devils Hole and the endangered Devils Hole pupfish. Ash Meadows is in the Amargosa Desert hydrographic area. Although Table 3-4 lists total combined groundwater withdrawals from the Amargosa Desert, the U.S. Geological Survey tracks withdrawals in the Ash Meadows area separately from those in other parts of the Amargosa Desert. Withdrawals from Ash Meadows are a very small portion (less than 1 percent) of the total withdrawals.

Regional Groundwater Quality

The Yucca Mountain FEIS described the results from a 1997 survey of several wells and springs in the Yucca Mountain region to assess the quality of the regional groundwater. The survey collected samples from five groundwater sources in the Amargosa Desert, which consisted of three wells and two springs, and from three wells at Yucca Mountain. Table 3-12 of the FEIS summarized the results from this sampling effort and compared them with EPA drinking water standards (DIRS 155970-DOE 2002, p.3-49), with the recognition that these standards are for public water supply systems, not for potential water sources for such systems. The evaluation concluded that the overall quality of the regional groundwater is good and that the tested groundwater sources in the Amargosa Desert area met primary drinking-water standards. However, a few sources exceeded secondary and proposed standards.

Specifically, four Amargosa Desert sources exceeded a proposed standard for radon; one of those four exceeded secondary standards for sulfate and total dissolved solids and a proposed standard for uranium. Since the completion of the Yucca Mountain FEIS, the proposed standard for natural uranium has gone into effect but the proposed standard for radon is still pending. The standard for uranium is 0.03 milligram per liter [40 CFR 141.66(e)], which is slightly higher than the proposed standard considered in the FEIS. The single Amargosa Desert source that exceeded the proposed standard for uranium with a reported concentration of 0.02 milligram per liter would meet the new standard. Section 3.1.4.2.2 of this Repository SEIS addresses the radon and uranium results and the associated standards further in the discussion of water quality at Yucca Mountain. In addition, since the completion of the Yucca Mountain FEIS, the primary drinking-water standard for arsenic was lowered from 0.05 milligram per liter to 0.01 milligram per liter (40 CFR 141.23). The five samples from the Amargosa Desert area had arsenic levels that ranged from 0.01 to 0.022 milligram per liter (DIRS 104828-Covay 1997, all), so only the single source with an arsenic level of 0.01 milligram per liter would meet the current standard.

3.1.4.2.2 *Groundwater at Yucca Mountain*

This section summarizes the characteristics of groundwater at Yucca Mountain in both the *unsaturated zone* and the saturated zone.

Unsaturated Zone

Water Occurrence. The Yucca Mountain FEIS stated that the occurrence of water in the unsaturated zone at Yucca Mountain extended from the crest of the mountain approximately 750 meters (2,500 feet) down to the top of the water table. In this zone, DOE has found water in the rock *matrix*, along faults and other fractures, and in isolated pockets of saturated rock termed *perched water*. DOE provided the conceptual model shown in Figure 3-10 with the discussion of the movement and presence of water in the unsaturated zone. Although the conceptual model shows water moving throughout the unsaturated zone, the representation shows the pathways, not the amount of water. At the time of FEIS completion, DOE had excavated more than 10.6 kilometers (6.6 miles) of tunnels and testing *alcoves* in Yucca Mountain

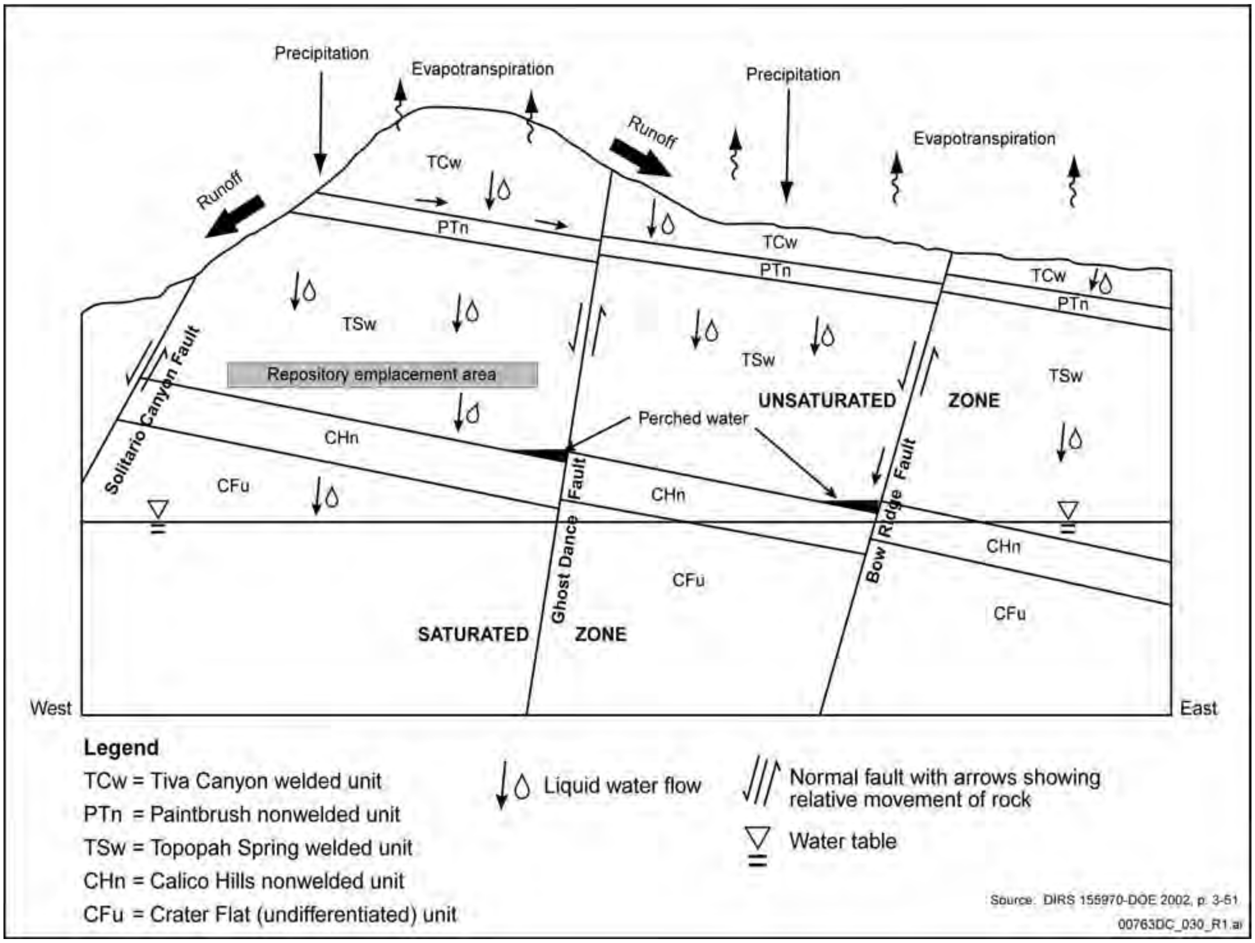


Figure 3-10. Conceptual model of water flow at Yucca Mountain.

and found no active flow of water; the Department observed only one fracture in the rock to be moist. Since the completion of the FEIS, DOE has observed and documented a seepage event, which occurred in February 2005 in the South Ramp of the Exploratory Studies Facility after a period of extremely high precipitation in the area. The recorded precipitation from October 2004 through February 2005, at 32.5 centimeters (12.8 inches), was roughly 3.5 times the average for the preceding 9 years (1995 to 2004) for the months of October though February (DIRS 177754-Finsterle and Seol 2006, p.1). The seepage or dripping occurred in strata of the Tiva Canyon welded unit, above the Paintbrush nonwelded unit (Figure 3-10). The Paintbrush nonwelded unit acts to slow the downward movement of water and the Tiva Canyon welded unit is likely to exhibit relatively fast flow. No seepage was observed in the proposed repository area, which is in the Topopah Spring welded unit below the Paintbrush nonwelded unit. An evaluation in May 2006 (DIRS 177754-Finsterle and Seol 2006, all) verified that the seepage event was consistent with conceptual models of the site. The evaluation minimally adapted the modeling approach used to estimate long-term ambient seepage into emplacement areas of the repository to estimate short-term seepage into the South Ramp. It found that the model and approach developed for the long-term performance of the repository estimated seepage in the South Ramp area reasonably consistent with observations in February 2005 (DIRS 177754-Finsterle and Seol 2006, p. 17). DOE reported the detection of the seepage to the U.S. Nuclear Regulatory Commission (NRC) (DIRS 173954-Ziegler 2005, all), but did not identify it as a "Technically Significant Condition" because DOE's conceptual models of the site predicted this type of seepage under high-precipitation conditions.

DOE's investigations of the unsaturated zone at Yucca Mountain found that water in the pores of rock is older and chemically distinct from water in fractures and in the perched water bodies. Water that moves along fractures probably is responsible for recharge of the perched water where the moving water encounters less-*permeable* rock and fault fill materials. As shown in Figure 3-10, perched water bodies occur near the base of the Topopah Spring welded unit, about 100 to 200 meters (330 to 660 feet) below the proposed repository horizon. To help characterize the nature of water movement in the unsaturated zone, DOE has performed carbon dating on samples of perched water and found apparent ages, or residence times, of 3,500 to 11,000 years. Because there are limitations on the use of carbon dating in this type of circumstance, DOE looked for the presence of tritium in the perched water, which would indicate contributions from water after 1952, which atmospheric nuclear weapons testing would have affected. The results indicated that tritium levels, if present, were too small for reliable detection.

Hydrologic Properties of Rock. The Yucca Mountain FEIS described the layers of rock and deposited materials at Yucca Mountain and the areas immediately surrounding it. The FEIS presented the layers, from the top down, in terms of stratigraphic units, which are defined by geologic properties of the rock, and hydrogeologic units, which reflect the manner in which water moves through the rock. In general, the origin of the rock and the manner of its deposition determine the stratigraphic units. Changes in these characteristics often coincide with changes in how water moves, so stratigraphic and hydrogeologic units might start or stop at the same observed physical change in the rock strata. In other instances, however, they might not coincide. For example, deposition of a sequence of volcanic rock might have occurred through one continuous event that formed a single stratigraphic unit, but if the upper portions of the sequence were more fractured, enhancing the potential for water movement, it would probably be designated as a separate hydrogeologic unit from the lower portion of the sequence. Figure 3-17 of the Yucca Mountain FEIS showed the strata, or layers, that DOE mapped through subsurface investigations in the Yucca Mountain vicinity (DIRS 155970-DOE 2002, p. 3-52). The layers are in terms of the stratigraphic units discussed in the geology sections of the affected environment and the hydrogeologic units that provide the basis for hydrology discussions. Table 3-13 of the FEIS listed the specific hydrogeologic units in the unsaturated zone at Yucca Mountain (DIRS 155970-DOE 2002, p. 3-53). Both provided descriptive characteristics of the identified rock layers.

Water Source and Movement. Precipitation at Yucca Mountain runs off, evaporates, or infiltrates into the ground where it is subject to later evaporation or *transpiration* by vegetation. Some of the water infiltrates deeply enough to be out of the influence of surface effects and can continue to move downward if conditions support such movement. DOE efforts since the completion of the Yucca Mountain FEIS have included development of a new model of net infiltration for the Yucca Mountain site (DIRS 174294-SNL 2007, all). According to this model, net infiltration under the current climate averages

14.3 millimeters (0.56 inch) per year over the study area of 125 square kilometers (30,900 acres), roughly centered over the Yucca Mountain site, and 17.6 millimeters (0.69 inch) per year over the repository footprint (DIRS 174294-SNL 2007, p. 6-170). Over smaller areas, the model shows wide variations in infiltration due to physical parameters such as soil, bedrock, vegetation, and the amount of lateral runoff. Soil depth is one of the most significant factors in estimates of local infiltration. The model estimates that areas of shallow [with average depths of 0.4 meter (1.3 feet)] or no soil comprise about 58 percent of the land area within the 125-square-kilometer study area, but account for almost 97 percent of the total infiltration (DIRS 174294-SNL 2007, p. 6-82 and p. 6-195). To assess the long-term performance of the proposed repository, the infiltration model includes estimates of infiltration during a monsoon climate and a cooler and wetter glacial-transition climate. These are the three climates (present-day, monsoon, and glacial-transition) DOE has predicted and modeled to occur up to 10,000 years into the future for the Yucca Mountain area (DIRS 174294-SNL 2007, p. 1-1). Both the monsoon and glacial-transition climates involve predicted net infiltration rates that are higher than those for the present-day climate (DIRS 174294-SNL 2007, p. 6-203).

Once through surface alluvium, water in the unsaturated zone at Yucca Mountain moves either very slowly through pore spaces in the rock or relatively rapidly through faults and fractures. Flow through faults and fractures probably occurs in episodic events that correspond to periods of high surface infiltration and, as noted above, is the likely source of the isolated perched water bodies under the zone where DOE would construct the proposed repository. The nature of this downward movement depends on the hydrogeologic properties of the rock layers. The Tiva Canyon welded unit (Figure 3-10) at the top of the rock sequence (and below the alluvium in many areas) at Yucca Mountain supports fairly rapid water transport through factures, but the underlying Paintbrush nonwelded unit has high porosity and low fracture density and tends to slow the water. DOE studies described in the Yucca Mountain FEIS investigated the presence of the naturally occurring radioactive isotope chlorine-36 in the Exploratory Studies Facility. Those studies suggested that some isolated pathways in the Paintbrush nonwelded unit allow small amounts of water to reach the underlying Topopah Spring welded unit fairly rapidly. The repository would be in the Topopah Spring welded unit, which has extensive fracturing that allows relatively rapid water movement. At the base of the Topopah Spring welded unit, water encounters low-permeability zones that include the top of the Calico Hills nonwelded unit. All of these rock layers, or hydrogeologic units, dip (slant) as shown in Figure 3-10, so water continues to move downward, but laterally, over the top of the low-permeability zone until it reaches a vertical pathway, such as a fault. Perched water bodies can form when the water encounters less permeable rock and *fault-gouge material* that block it from reaching a fault such that lateral and vertical movement is blocked and the water accumulates. As shown in Figure 3-10, water moving through the Calico Hills nonwelded unit (or past the unit through fault zones) encounters the Crater Flat unit and the water table.

Although the preceding discussion included terms such as “slow” and “rapid” in the description of water movement in the unsaturated zone at Yucca Mountain, it describes water movement in one hydrogeologic unit in comparison with another, so movement speed is relative. DOE has developed models of groundwater movement in the unsaturated zone (DIRS 184614-SNL 2007, all) that begin with the results of the net infiltration model described above and model the flow of water down to the water table. DOE ran the models under many infiltration scenarios for the present-day climate to construct a range of possible outcomes and to identify the scenario having the best correlation with measured field conditions and other modeled results (DIRS 184614-SNL 2007, p. 6-79). Adjusting the models to simulate transport of tracers, the most likely infiltration scenario estimates it would take about 8,000 years for 50 percent of a conservative (no loss through degradation, decay, or adsorption) tracer, moving at the same rate as the infiltrating water, to move roughly 300 meters (980 feet) from the repository to the underlying water table. (The depth to the water table is an approximate value because it varies over the lateral extent of the repository.) Ten percent of the tracer would reach the water table in about 300 years, but half would take longer than 8,000 years (DIRS 184614-SNL 2007, p. 6-102).

The Yucca Mountain FEIS described chlorine-36 studies in detail because the results suggested that infiltrating water pathways of 50 years or less could exist from the surface to the subsurface level of the proposed repository. Because of the significance of these results and the complexities and uncertainties of the analyses, DOE initiated additional studies to determine if independent laboratories and related isotopic studies could corroborate the findings. Since the completion of the Yucca Mountain FEIS, DOE and the U.S. Geological Survey completed a significant element of these studies in the form of a validation study (DIRS 179489-BSC 2006, all). The U.S. Geological Survey designed the study to include investigations for chlorine-36 and tritium (another radioactive isotope). In addition to the U.S. Geological Survey, study participants included two DOE national laboratories. The validation study resulted in mixed findings. One study participant ran the analyses, but the results did not show evidence of chlorine-36-to-total-chlorine ratios that would indicate the presence of recent bomb-pulse water. Another participant reproduced the results from the earlier studies that the Yucca Mountain FEIS discussed. The concurrent tritium studies concluded that water extracted from rock in areas of known faulting indicated the presence of modern water (water that entered the unsaturated zone after 1952) (DIRS 179489-BSC 2006, pp. v and vi). The report of the validity study includes recommendations to improve the study and to understand better the results obtained (DIRS 179489-BSC 2006, pp. 59 and 60). These findings, although inconsistent and inconclusive, have not precluded the presence of relatively fast pathways for small amounts of water in some subsurface locations.

Unsaturated Zone Groundwater Quality. The Yucca Mountain FEIS compared the water chemistry of pore water and perched water collected at Yucca Mountain. The pore water was higher in dissolved minerals than the perched water, particularly chloride, which indicates that perched water had little interaction with rock. This, in turn, provided strong evidence that flow through faults and fractures is the primary source of perched water.

Saturated Zone

Water Occurrence. The Yucca Mountain FEIS described the aquifers and confining units in the *saturated zone* at Yucca Mountain. It indicated that the upper and lower volcanic aquifers consisted primarily of the Topopah Spring Tuff and the lower tuffs of the Crater Flat Group, respectively. As shown in Figure 3-10, the upper Topopah Spring Tuff (or the equivalent hydrogeologic unit, the Topopah Spring welded unit) in which the upper volcanic aquifer occurs, is above the water table in the area of the proposed repository and below the water table to the east and south of the repository footprint. Further south of the Yucca Mountain site and downgradient in the groundwater flow path, the volcanic aquifers gradually change or, as the recent Nye County investigations indicate, abruptly end when they reach a fault and groundwater movement continues in the alluvial aquifer into the valley-fill materials of the Amargosa Desert. Underlying the volcanic and alluvial aquifers is the lower carbonate aquifer (generally referred to as the carbonate aquifer in this document), as shown in the highly stylized and simplified cross section of Figure 3-11. The carbonate aquifer, which is more than 1,250 meters (4,100 feet) below the proposed repository horizon, consists of Paleozoic carbonate rocks (limestone and dolomite) that were extensively fractured during many periods of mountain building. Studies indicate that this deep aquifer

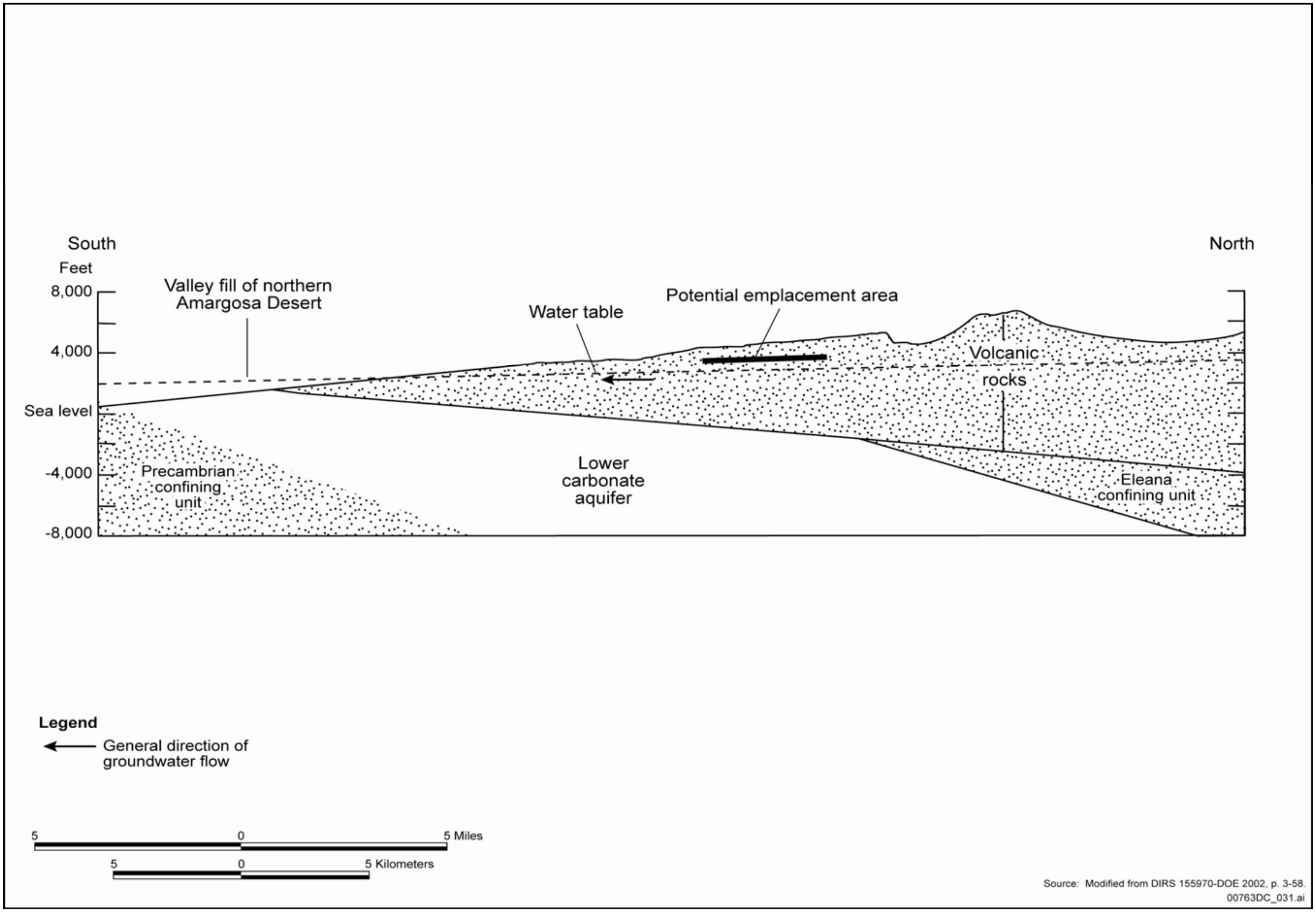


Figure 3-11. Cross section from northern Yucca Mountain to northern Amargosa Desert, showing generalized geology and the water table.

represents a regionally extensive system, though fragmented, that can transmit large amounts of groundwater when compartments are hydraulically connected.

Data from the few wells that penetrate the lower carbonate aquifer indicate that it has an upward gradient; that is, on well penetration, water rises in the well to an elevation above the aquifer. This occurred at a deep well near Yucca Mountain where the water level, or potentiometric head, of the carbonate aquifer was about 20 meters (66 feet) higher than the water level in the overlying volcanic aquifer. It also occurred in a well drilled for the Nye County program about 19 kilometers (12 miles) south of the repository site where the water rose 8 meters (26 feet) higher than the water in the overlying volcanic aquifer. Several other wells near Yucca Mountain that extend as deep as the confining unit at the base of the lower volcanic aquifer show higher potentiometric levels in that unit than in the overlying volcanic aquifers. This might be another indication of an upward hydraulic gradient in the carbonate aquifer.

Since completion of the Yucca Mountain FEIS, Inyo County installed a monitoring well to the carbonate aquifer. This well, in the southern Amargosa Desert in California, is about 50 kilometers (31 miles) south from the deep well near Yucca Mountain. Inyo County reported water in this well at an elevation 3.3 meters (almost 11 feet) higher than in an adjacent well [only 6 meters (20 feet) away] in the overlying alluvial aquifer (DIRS 185423-ICYMRAO n.d., pp. 4 to 8). The upward hydraulic gradient in the carbonate aquifer is important because it prevents water in the overlying volcanic aquifers of Yucca Mountain, and possibly in the overlying alluvial aquifers in the Amargosa Desert, from moving downward. This is significant in the assessment of the *postclosure* performance of the proposed repository (see Chapter 5 of this Repository SEIS) because it constrains the pathway by which *radionuclides* could move after repository-closure.

DOE has studied mineralogical data, isotopic data, and natural features at Yucca Mountain, as well as evidence of climate changes over the past few hundred thousand years, to evaluate how groundwater levels changed in the past and how they might change in the future. Based on this research, DOE concluded that the water table might have been as much as 85 meters (280 feet) above the present level beneath Yucca Mountain during the last 1 million years, which would have included climates cooler and wetter than those for the present (DIRS 177391-SNL 2007, pp. 6-82 and 6-83). Efforts to model the groundwater response to wetter climates have, in some cases, resulted in the prediction of higher water tables, including a simulated water table rise of 60 to 150 meters (200 to 490 feet) in a regional flow system model developed earlier in the Yucca Mountain Project (DIRS 169734-BSC 2004, pp. 8-105 and 8-106). However, DOE believes that limitations in this model, primarily due to its coarse (or large) numerical grid, appear to have resulted in overestimates of water table rise (DIRS 177391-SNL 2007, p. 6-83). In any case, both physical indicators of historic conditions and model projections of future wetter climates indicate that the repository horizon would remain well above maximum water tables.

The Yucca Mountain FEIS discussed opposing views on the historical water level at Yucca Mountain and on the level to which the water could rise in the future. One of the opposing views suggested that deposits of calcium carbonate and opaline silica in some rock fractures at Yucca Mountain could have been deposited by hydrothermal fluids from below that were driven upward by earthquakes or hydrothermal processes that could occur in the future. Another opposing view, presented several years later, looked at the presence of the carbonate-opal veinlets at Yucca Mountain and concluded that the water inclusions in the deposits were formed at elevated temperatures, which supported the conclusion they were formed by warm upwelling water rather than by precipitation moving downward.

In 1990, DOE convened a panel of experts that included members of the National Academy of Sciences to review the evidence of the first opposing view. The panel concluded that the mechanism suggested for causing water upwelling could not raise the water table more than a few tens of meters and that the carbonate-rich deposits in rock fractures were from surface-down processes (precipitation) rather than the opposite. In 1998, a second group of independent experts, including U.S. Geological Survey and university representatives, reviewed the second theory of warm upwelling. The group of independent experts disagreed with some of the central scientific conclusions put forth by the second opposing view. In this case, as reported in the Yucca Mountain FEIS, both parties agreed additional research was necessary to resolve the issue; DOE supported an independent investigation by the University of Nevada, Las Vegas, and invited the U.S. Geological Survey and the State of Nevada to participate.

Since the completion of the Yucca Mountain FEIS, the University of Nevada, Las Vegas reported on the results of its study (DIRS 182120-Wilson and Cline 2002, all; DIRS 182121-Wilson et al. 2002, all; DIRS 163589-Wilson et al. 2003, all). The study looked at 155 samples from tunnels in the Exploratory Studies Facility at Yucca Mountain and considered several different means to investigate how the carbonate-opal veinlets were deposited. It included the analysis of secondary mineral deposits and the isotope signatures of those deposits. It also included use of uranium-lead techniques to date the silica minerals associated with fluid inclusions. The researchers believed that the results supported a detailed time-temperature history of fluid migration through rock pores at Yucca Mountain during the past 8 to 9 million years (DIRS 182121-Wilson et al. 2002, p. 4). The conclusion of the study was that carbonate-opal veinlets were the result of descending meteoric water (that is, water infiltrating from above), not from the upwelling of hydrothermal fluids (DIRS 182120-Wilson and Cline 2002, p. 25; DIRS 182121-Wilson et al. 2002, p. 26).

An October 2003 letter (DIRS 181056-Swainston 2003, all) sent to the Nuclear Waste Technical Review Board by a lawyer who represented proponents of the upwelling fluids scenario included a review of the University of Nevada, Las Vegas report (DIRS 182120-Wilson and Cline 2002, all; DIRS 182121-Wilson et al. 2002, all). According to the letter, the scientists who proposed the opposing view disagreed with the conclusions in the University report and "are convinced, based on many lines of evidence, that the secondary minerals were deposited by hydrothermal fluids driven from deep beneath Yucca Mountain and that episodes of such deposition are recent in geologic time." A February 2004 letter of response from the Nuclear Waste Technical Review Board (DIRS 181239-Parizek 2004, all) indicated that the information provided "would not alter the Board's previous conclusion that the evidence presented does not make a credible case for the hypothesis of ongoing, intermittent hydrothermal activity at Yucca Mountain," but recognized that differences of opinion might still exist.

Hydrologic Properties of Rock. The Yucca Mountain FEIS provided definitions for the hydrologic properties of transmissivity, conductivity, and porosity and, in Table 3-15, listed typical values or ranges of values for the three aquifers and two interlying confining units at Yucca Mountain (DIRS 155970-DOE 2002, p. 3-62). The discussion presented some considerations in the interpretation or understanding of the values in the table. This included findings at Yucca Mountain that showed rock with the highest porosity often had low transmissivity. This is attributable to a condition in which the rock contains many voids that result in high porosity, but the voids are not interconnected and the rock is in an area of low fracturing. With low amounts of interconnected void spaces and few fracture seams, water pathways are limited and the transmissivity is low. Other factors to consider in understanding the values include the limited number of tests performed on the carbonate aquifer due to the limited number of wells that reach that depth and the ability to measure only apparent values from single boreholes; that is, the measured values are representative of a small area around the borehole, and might change significantly in the immediate area if water-bearing fractures are in the tested well zone.

Water Source and Movement. As reported in the Yucca Mountain FEIS, DOE has studied groundwater levels at Yucca Mountain for years and found them to be very stable. Excluding changes due to pumping, the observed fluctuations in groundwater level were attributed to natural phenomena such as barometric pressure changes and Earth tides; short-term fluctuations have been linked to apparent recharge events and earthquakes.

Hydrologists typically generate maps that show the elevation of the groundwater surface, also called the potentiometric surface, with contour lines of equal elevation. Lines perpendicular to the contour lines represent the direction of slope of the groundwater surface, which is the implied direction of groundwater flow. At Yucca Mountain, the potentiometric surface consists of three zones. On the west side of the mountain, the potentiometric surface slopes moderately to the southeast, dropping in elevation about 20 to 40 meters (66 to 130 feet) in 1 kilometer (0.6 mile). The east boundary of this zone is the Solitario Canyon fault on the west side of Yucca Mountain. The fault zone apparently impedes flow, and on its east side is the second zone where the water surface has a very gentle slope, dropping only 0.1 to 0.4 meter per kilometer (0.5 to 2 feet per mile). This zone of gentle slope underlies Yucca Mountain. The southeast direction of the slope is a local condition in the regional southward groundwater flow. The third zone is an area of steep slope in the potentiometric surface north of Yucca Mountain. In this zone, the groundwater appears to drop sharply toward the south; about 110 meters vertically over a horizontal distance of 1 kilometer (about 580 feet per mile), which generates a hydraulic gradient of 0.11 (DIRS 170009-BSC 2004, p. 6-20). The Yucca Mountain FEIS described possible reasons for this steep slope, but concluded that there were no obvious geologic reasons and that it was still under investigation. Figure 3-12 shows the potentiometric surface contours for the area of Yucca Mountain, which are consistent with the preceding discussion and which this discussion refers to as the Version A contours.

Since the completion of the Yucca Mountain FEIS, DOE investigations of this steep hydraulic gradient have continued, but the efforts have not reached an unequivocal explanation (DIRS 170009-BSC 2004, p. 6-21). DOE based the predictions of the groundwater elevation contours in the area of the steep gradient, to a large extent, on measured groundwater elevations in three different boreholes north of Yucca Mountain. These three boreholes (UE-25 WT 6, USW G-2, and USW WT-24) are within a circle about 1.6 kilometers (1 mile) in diameter (DIRS 170009-BSC 2004, p. 1-3). Two of the boreholes have measured water elevations notably higher than the one farthest to the south (USW WT-24). The Yucca Mountain FEIS identified a possible reason for the steep hydraulic gradient—that water in at least some of the boreholes in this area is perched water and not part of the regional water table. In pursuing this possibility, DOE has regenerated the potentiometric surface map (Version B) of the Yucca Mountain vicinity with the assumption that water in boreholes UE-25 WT 6 and USW G-2 is perched water (DIRS 170009-BSC 2004, p. 6-17); that is, of the three boreholes in the area immediately north of Yucca Mountain, DOE used only the water elevation measured in USW WT-24 along with other area data points in the development of the revised contours in this area. Version B (Figure 3-13) shows that, without the use of data from the two boreholes, the elevation contours at the north portion of Yucca Mountain have smoother curves and are slightly further apart than those in Figure 3-12. As a result of the more widely spaced contour lines, the hydraulic gradient in the area of the steep zone declines to 0.06 to 0.07. Possibly of more significance, DOE evaluated both the perched and nonperched scenarios in its groundwater model and found them to yield similar flow characteristics. This supports earlier findings of an expert panel that concluded that, whether the steep slope was due to perched water or not, it would

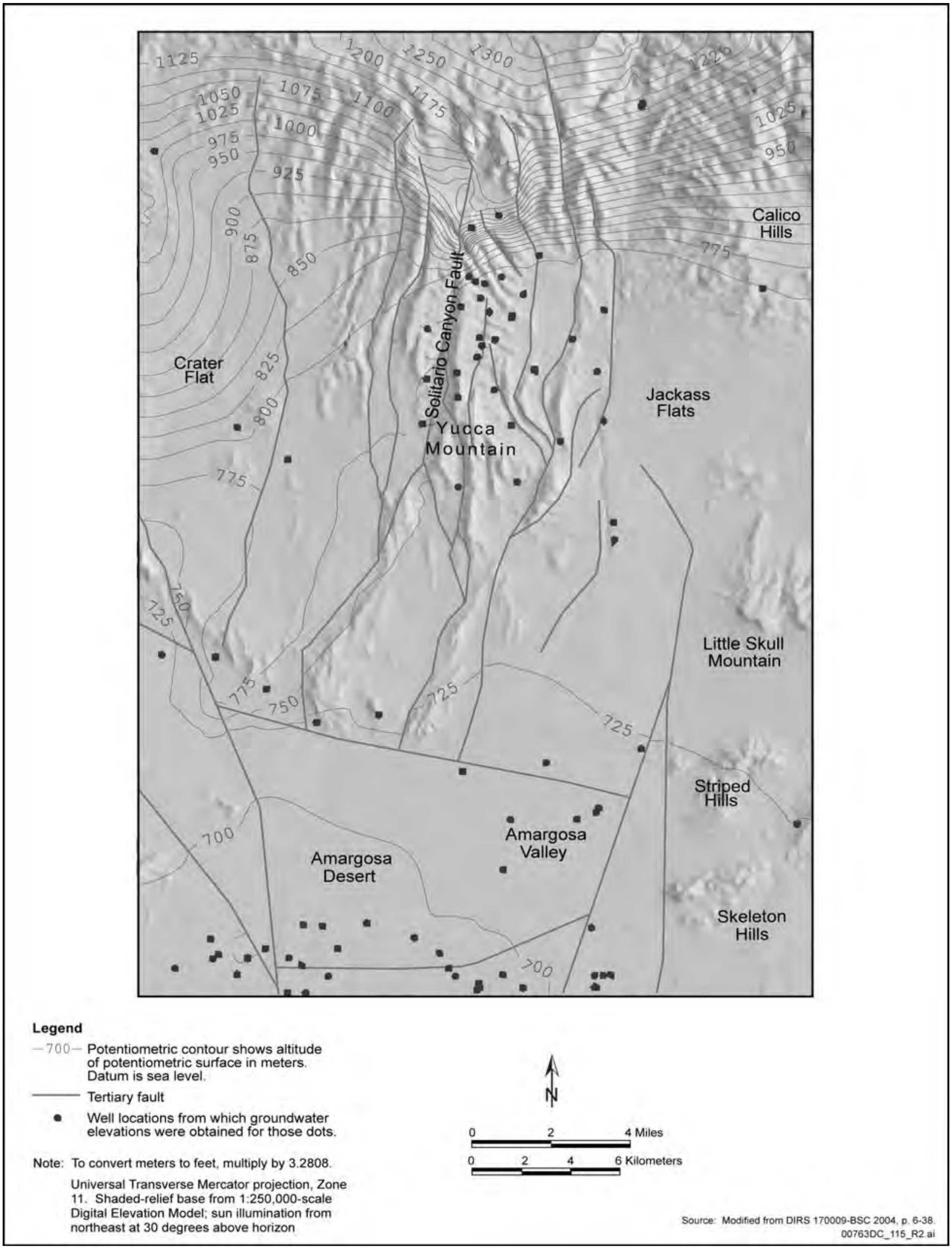


Figure 3-12. Original potentiometric surface map for the Yucca Mountain area (considering groundwater elevations in all applicable boreholes).

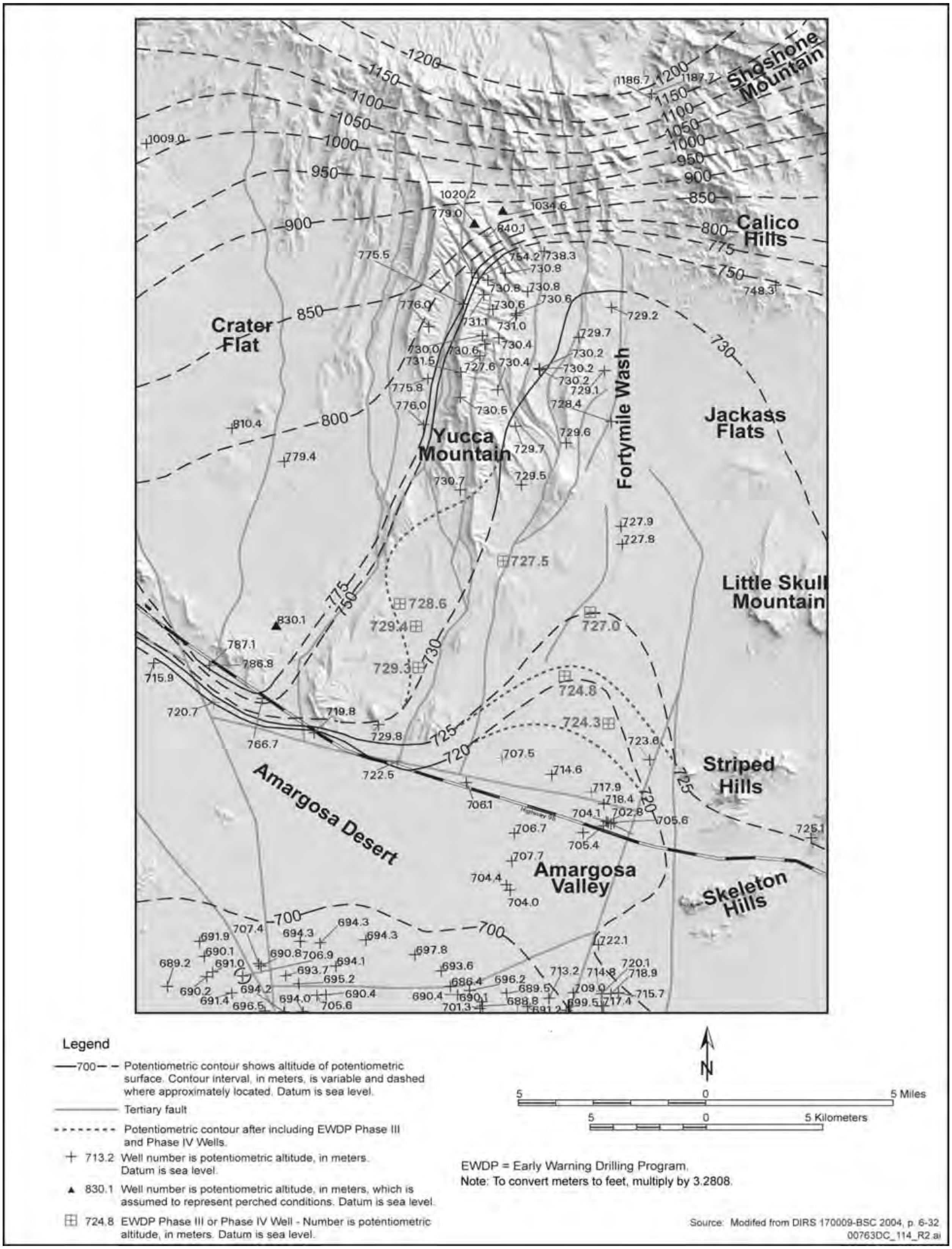


Figure 3-13. Revised potentiometric surface map for the Yucca Mountain area (excluding groundwater elevations from boreholes UE-25 WT 6 and USW G-2).

have no effect on repository performance (DIRS 170009-BSC 2004, p. 6-21). The lower central portion of Figure 3-13 shows several possible changes to contours as a result of recent findings from the Nye County drilling program.

The Yucca Mountain FEIS described an opposing view to the stability of groundwater levels at Yucca Mountain that suggested earthquakes in the area could cause substantial rises of the water table, and could even flood the repository. The FEIS also described the expert panel review of the information and theory behind this view and the conclusion of the panel that a rise of groundwater to the level of the repository was essentially improbable. DOE has received no additional support for this opposing view since it completed the FEIS.

Inflow to Volcanic Aquifers at Yucca Mountain. The Yucca Mountain FEIS described the four potential sources of inflow to the volcanic aquifers in the vicinity of Yucca Mountain: (1) lateral flow from volcanic aquifers north of Yucca Mountain, (2) recharge along Fortymile Wash from occasional stream flow, (3) precipitation at Yucca Mountain, and (4) upward flow from the underlying carbonate aquifer. DOE does not know the actual amounts of water inflow from these potential sources and cannot measure them on a large-scale basis, but it has developed estimates for incorporation into regional- and site-scale models of the unsaturated and saturated zones. According to these estimates, which are based on data collected and tests performed, the amount of inflow due to precipitation at Yucca Mountain is small in comparison with inflow from volcanic aquifers to the north, and it is less than estimates of recharge along the length of Fortymile Wash. The higher potentiometric surface of the carbonate aquifer in the area of Yucca Mountain would support inflow to the overlying volcanic aquifer where pathways existed. Based on hydrochemical analyses of the groundwater beneath Yucca Mountain, it appears a small amount (generally less than 5 percent) of the water in the volcanic aquifer can be attributed to upwelling from the carbonate aquifer (DIRS 177391-SNL 2007, Appendix A, p. A-164).

Outflow from Volcanic Aquifers at and near Yucca Mountain. The Yucca Mountain FEIS described the three pathways by which water might leave the volcanic aquifers in the vicinity of Yucca Mountain as (1) downgradient movement into other volcanic and alluvial aquifers in the Amargosa Desert, (2) downward movement into the carbonate aquifer (though evidence indicates this does not occur), and (3) upward movement into the unsaturated zone. The Yucca Mountain FEIS mentioned a fourth pathway, pumping of water from the aquifer. With the exception of pumping from wells, the actual amounts of water outflow along these pathways are unknown. Based on investigations of the area and the potentiometric surface of the groundwater, the pathway for groundwater beneath Yucca Mountain is southerly through volcanic aquifers before it encounters the alluvial aquifer of the Amargosa Desert.

Available data on the potentiometric head of the carbonate aquifer indicate that any movement of water between carbonate and volcanic aquifers in the area of Yucca Mountain would be upward. Upward movement of water to the unsaturated zone is the third pathway for water to leave the volcanic aquifer. However, based on collected data, DOE believes there is a net downward movement of water in the unsaturated zone.

Use. The Yucca Mountain FEIS described the historical use of groundwater in the immediate area of Yucca Mountain, which largely consisted of DOE water withdrawals. Two wells, J-12 and J-13, are in Jackass Flats (Hydrographic Area 227A) on the east side of Yucca Mountain and are the nearest production wells to the proposed repository site (DIRS 155970-DOE 2002, p. 3-65). DOE has used these wells to support water needs for Area 25 of the Nevada Test Site and the Yucca Mountain Project. The

Department has pumped groundwater from other wells in the immediate area in support of Yucca Mountain characterization activities, which include wells in Crater Flat on the west side of the mountain. For the most part, these withdrawals have been small. Exceptions were the relatively large volumes—up to 230,000 cubic meters (190 acre-feet) per year—that DOE pumped from the C-Well complex, also in Jackass Flats, as part of aquifer testing actions. Water from the C-Wells was reinjected as part of the testing. Table 3-16 of the Yucca Mountain FEIS summarized the quantities of water from J-12 and J-13 and from the C-Well complex for 1992 to 1997 and estimates for several years after 1997 (DIRS 155970-DOE 2002, p. 3-66). Since the completion of the Yucca Mountain FEIS, actual quantities of water pumped from Jackass Flats have dropped sharply. In 1997, the last year of record in Table 3-16 of the FEIS, about 420,000 cubic meters (340 acre-feet) of water were withdrawn from Jackass Flats. By 2000 and 2001, that number dropped to less than half the 1997 value to about 170,000 cubic meters (140 acre-feet) per year (DIRS 178692-La Camera et al. 2005, pp. 72 and 73; DIRS 181575-Wade 2000, all; DIRS 181576-Wade 2000, all; DIRS 181577-Wade 2000, all; DIRS 181578-Wade 2001, all; and DIRS 181580-Wade 2002, all). From 2002 to 2004, withdrawals dropped further, ranging from about 57,000 to 83,000 cubic meters (46 to 67 acre-feet) per year (DIRS 178692-La Camera et al. 2005, pp. 72 and 73; DIRS 178691-La Camera et al. 2006, p. 69; DIRS 181581-Wade 2003, all; DIRS 181582-Wade 2004, all; and DIRS 181583-Wade 2005, all). The large reductions in groundwater use are attributable to the reduction in water needs at the Yucca Mountain site as characterization activities ended and the project moved into licensing activities. Current water use at the site is only about 6,000 cubic meters (5 acre-feet) of water per year. (As noted above, the remaining groundwater withdrawals from Jackass Flats are attributable to Nevada Test Site needs.)

Table 3-17 of the Yucca Mountain FEIS summarized the results of long-term efforts by the U.S. Geological Survey to monitor changes in groundwater elevations in the vicinity of Yucca Mountain (DIRS 155970-DOE 2002, p. 3-67). The table listed water-level conditions in seven wells from 1992 to 1997 and compared them with median water levels in the same wells from measurements from 1985 to 1993 (DIRS 103283-La Camera et al. 1999, p. 84). Table 3-5 updates the data presented in the FEIS by including corresponding groundwater level monitoring results from 1998 through 2004. DOE used the same baseline water elevations it used on the Yucca Mountain FEIS to calculate the elevation differences. For example, the average groundwater elevation measured in well JF-1 during 2004 was 27 centimeters

Table 3-5. Differences between annual and baseline median groundwater elevations above sea level.

Baseline elevations[a]			Difference from baseline media (centimeters)[b]												
Well	Median (meters)[c]	Average deviation from median (centimeters)[b]	1992 to 1997[d]						1998 to 2004[e]						
JF-1	729.23	± 6	–3	0	–6	0	–6	–3	0	+6	+9	+15	+21	+24	+27
JF-2	729.11	± 9	+3	0	+3	+9	0	–3	0	+12	+18	+21	NA	+15	+18
JF-2a[f]	752.43	±12	0	+6	+12	+15	+21	+27	+43	+49	+67	+70	+70	+88	+85
J-13	728.47	± 6	–3	–3	–9	–6	–12	–12	–6	0	+6	+12	+12	+18	–3
J-11	732.19	± 3	0	0	+3	+6	+6	+12	+12	+6	+6	+12	+9	+12	+9
J-12	727.95	± 3	0	0	–3	–3	–9	–9	–9	0	+3	+6	+9	+15	+18
JF-3	727.95	± 3	NA	NA	–6	–6	–9	–9	–9	–3	+3	+6	+9	+15	+15

a. Source: DIRS 103283-La Camera et al. 1999, p. 84.
b. To convert centimeters to inches, multiply by 0.3937.
c. To convert meters to feet, multiply by 3.2808.
d. Source: DIRS 155970-DOE 2002, p. 3-67.
e. Source: DIRS 178691-La Camera et al. 2006, p. 71.
f. Well JF-2a is also known as UE-25 p#1, or P-1.
NA = Not available.

(11 inches) above the baseline elevation established for that well. Table 3-5 indicates a general increase in groundwater levels in all the wells beginning in 1998 to 1999. There were only a handful of instances in which the elevation in a well dropped below that reported in the previous year, so the increasing trend was relatively steady through the monitoring period from 1998 to 2004. This trend of increasing water levels probably is due either to the decrease in water use from the basin or to changes in recharge to the groundwater system (DIRS 178691-La Camera et al. 2006, p. 14), or a combination of both.

Saturated Zone Groundwater Quality. The groundwater sampling effort described in Section 3.1.4.2.1 included three groundwater wells in the vicinity of Yucca Mountain, which include production wells J-12 and J-13. As described in the Yucca Mountain FEIS, water samples from these three wells met primary drinking-water standards set at that time by the EPA for public drinking-water systems, but each well exceeded the secondary standard for fluoride and proposed primary standards for radon. Since the completion of the Yucca Mountain FEIS, the standard for radon is not yet in effect, but the EPA has lowered the primary drinking-water standard for arsenic to 0.01 milligram per liter. The reported values for the 1997 sampling of the three wells were 0.008, 0.009, and 0.011 milligrams per liter. The new standard for arsenic, effective January 23, 2006, requires treatment to less than 0.01 milligram per liter. DOE has installed and implemented an arsenic treatment system for the Yucca Mountain drinking-water system (DIRS 179878-BSC 2006, p. 7). Table 3-18 of the Yucca Mountain FEIS listed water chemistry data for groundwater in the volcanic and carbonate aquifers at Yucca Mountain (DIRS 155970-DOE 2002, p. 3-68). Water from the volcanic aquifer has a relatively dilute sodium-potassium-bicarbonate composition; water from the carbonate aquifer is quite different, with a more concentrated calcium-magnesium-bicarbonate composition. These characteristics are consistent with the different types of rock through which the water travels.

Table 3-19 of the Yucca Mountain FEIS listed radiological concentrations from sampling of groundwater in 1997 at and near Yucca Mountain (DIRS 155970-DOE 2002, p. 3-69). This sampling effort established a baseline for *radioactivity* in groundwater from the alluvial, volcanic, and carbonate aquifers. The radioactivity concentrations were below EPA *maximum contaminant levels* for public drinking-water systems, which include the value of 4 *millirem* per year set as the total body dose limit for beta- or gamma-emitting radionuclides. The discussion noted, however, that the groundwater would exceed proposed standards for radon. The information in Table 3-19 of the FEIS and the accompanying discussion are still valid and are incorporated here by reference. Table 3-19 of the FEIS listed sample results for total uranium, but indicated there was no associated drinking-water standard. Since the completion of the FEIS, EPA has established a maximum contaminant level of 30 micrograms (or 0.03 milligram) per liter for uranium in drinking water. The total uranium values in Table 3-19 of the FEIS are all below this level.

The Yucca Mountain FEIS discussed several studies on potential groundwater *contamination* from past nuclear weapons testing at the Nevada Test Site. DOE has detected radionuclide migration to groundwater. In general, the migration of tritium, a radionuclide that is transported in solution with water moving through the area, is limited to several kilometers. Less mobile radioactive constituents (generally those that do not go into solution or do not go into solution as completely and easily as tritium) have migrated no more than about 500 meters (1,600 feet). In one case, however, there is evidence of plutonium migration from a below-groundwater test at Pahute Mesa. Monitoring results indicate plutonium has moved at least 1.3 kilometers (0.8 mile) from the source in 28 years and might be due to the movement of very small particles called colloids. Area 25 of the Nevada Test Site, the location of Yucca Mountain and the proposed repository, was not an area of nuclear detonation testing, and DOE studies of contaminant migration from Nevada Test Site activities do not indicate that any contamination has reached the groundwater beneath Yucca Mountain. However, Pahute Mesa and Buckboard Mesa, which are areas where nuclear testing occurred (primarily at Pahute Mesa), are 40 kilometers (25 miles) and 30 kilometers (19 miles), respectively, north of Yucca Mountain. A single nuclear test with multiple detonations spaced in a row occurred in Area 30 of the Nevada Test Site (DIRS 101811-DOE 1996, p. 4-17) about 21 kilometers (13 miles) north of the repository site. The flow of groundwater from these areas could be to the south. Because of the distances, there is no reason to believe that contaminants could move as far as Yucca Mountain before repository-closure, with the possible exception of tritium. In addition, DOE modeling suggests that groundwater flow patterns from these test areas to the north skirt the Yucca Mountain area (DIRS 103021-DOE 1997, p. ES-28). This is similar to the conceptual model of groundwater flow from more recent U.S. Geological Survey efforts (Figure 3-8), which show that Pahute Mesa is in the dividing area between the Pahute Mesa-Oasis Valley Groundwater Basin and the Alkali Flat-Furnace Creek Groundwater Basin, the location of Yucca Mountain. The Survey model describes water from Pahute Mesa as contributing flow to the southwest through Oasis Valley (skirting Yucca Mountain) as well as to the south through the Fortymile Canyon Section (DIRS 173179-Belcher 2004, pp. 152 and 154). Chapter 8 of this Repository SEIS discusses the potential for long-term migration of radionuclides in the groundwater system to result in cumulative radiation impacts from nuclear testing and repository actions.

3.1.5 BIOLOGICAL RESOURCES AND SOILS

The region of influence for biological resources and soils is the area that contains all potential surface disturbances that would result from the Proposed Action and some additional area to evaluate local animal populations. This region is roughly equivalent to the analyzed land withdrawal area of about 600 square kilometers (150,000 acres). DOE has expanded the region of influence for biological resources and soils from that in the Yucca Mountain FEIS to include land proposed for an access road from U.S. Highway 95 and for construction of offsite facilities. This offsite area would include Bureau of Land Management lands between the southern boundary of the analyzed land withdrawal area and U.S. Highway 95 (Figure 3-1). The offsite area covers about 37 square kilometers (9,100 acres).

In the Yucca Mountain FEIS, DOE used available information and studies on plants and animals at the site of the proposed repository and the surrounding region to identify baseline conditions for biological resources. This information included land cover types, vegetation associations, and the distribution and abundance of plant and animal species in the region of influence and the broader region. The data suggested that the plants and animals in the Yucca Mountain region were typical of species in the Mojave and Great Basin deserts. As reported in the Yucca Mountain FEIS, DOE surveyed the region for naturally occurring wetlands and studied soil characteristics in the region, which included thickness, water-holding capacity, texture, and erosion hazard.

Beginning in 1982 with site investigation, DOE has conducted extensive field surveys to characterize the biological and soil resources in the vicinity of Yucca Mountain (DIRS 104593-CRWMS M&O 1999, all; DIRS 104592-CRWMS M&O 1999, all). DOE used the results of these studies to assess the impacts of site characterization in the Yucca Mountain FEIS analysis to understand and predict possible impacts from similar activities that would occur during repository construction and operations. For this Repository SEIS, DOE analyzed the results of field surveys and habitat data that have become available since completion of the Yucca Mountain FEIS. This Repository SEIS includes information from more recent lists of and surveys for special-status species and the results of a new land cover mapping effort.

3.1.5.1 Biological Resources

3.1.5.1.1 *Vegetation*

In the Yucca Mountain FEIS, DOE used data from two sources to describe land cover types in the analyzed land withdrawal area: a statewide classification and a detailed, field-validated classification of the area around the Yucca Mountain site. DOE has reassessed land cover in the region of influence using data from the *Southwest Regional Gap Analysis Project* (DIRS 174324-NatureServe 2004, all), which were not available at the completion of the FEIS and which describe land cover at a finer level of detail than previous land cover mapping efforts. In addition, the species composition results of field studies DOE performed in and near the analyzed land withdrawal area (conducted after the FEIS was completed, and as summarized in the *Rail Alignment* EIS) are consistent with the results in the Yucca Mountain FEIS and the results of subsequent analyses of Southwest Regional Gap Analysis Project land cover data.

Using previously defined *ecoregions* in the southwestern United States that are based on physical and biological similarities, the Southwest Regional Gap Analysis Project developed *mapping zones* to facilitate land cover delineation. By analyzing satellite imagery and field data, the Southwest Regional Gap Analysis Project classified geographic areas in each mapping zone based on land cover types and generated maps of land cover type occurrence. The project classified naturally vegetated land cover with an ecological systems classification and developed and described land cover types based on dominant vegetation, physical characteristics of the land, hydrology, and climate (DIRS 176369-Lowry et al. 2005, all; DIRS 173051-Comer et al. 2003, all). Ecological systems are recurring groups of biological communities in similar physical environments with similar dynamic ecological processes, such as fire or flooding. To identify land cover types in the region of influence, the project overlaid digital maps of the types in the mapping zones with a digital map of the repository region of influence.

SOUTHWEST REGIONAL GAP ANALYSIS PROJECT

This 2004 project was a multi-institutional effort to map and assess biodiversity for approximately 1.45 million square kilometers (560,000 square miles) in the southwestern United States. One task of this project was the development of a land cover map for the region.

Ecoregion:
A relatively discrete set of ecosystems characterized by certain plant communities or assemblages.

Mapping zones:
Biogeographically unique areas the Southwest Regional Gap Analysis Project derived from existing ecoregion maps using a combination of topographic and soil information, which it then truncated at state boundaries. Mapping zones are subunits of ecoregions.

The analyzed land withdrawal area is in the Mojave Desert ecoregion but, because it is near the southern boundary of the Great Basin Desert ecoregion, land cover types common to both deserts occur in the area. Whereas most of the analyzed land withdrawal area and all of the offsite area to the south are in the Mojave mapping zone, the northern portion of the analyzed land withdrawal area is in the Nellis mapping zone, which reflects the transition between the Mojave and Great Basin deserts. DOE identified 19 land cover types in the region of influence (Table 3-6). Plant communities at lower elevations are typical of the Mojave Desert, and communities at higher elevations, generally at the northern end of the analyzed land withdrawal area, are typical of the transition zone between the Mojave Desert and the cooler Great

Table 3-6. Land cover types in the region of influence.

Land cover type	Percent of region of influence	Description
Sonora-Mojave Creosotebush-White Bursage Desert Scrub	57	Occurs in broad valleys, lower washes, and low hills. Creosote bush (*Larrea tridendata*) and white bursage (*Ambrosia dumosa*) are typical dominants.
Mojave Mid-Elevation Mixed Desert Scrub	27	Common on lower foothill slopes in the transition zone into the southern Great Basin. Dominant species include blackbrush (*Coleogyne ramosissima*), Eastern Mojave (California) buckwheat (*Eriogonum fasciculatum*), Nevada jointfir (*Ephedra nevadensis*), spiny hopsage (*Grayia spinosa*), spiny menodora (*Menodora spinescens*), buck-horn cholla (*Cylindropuntia acanthocarpa*), big galleta (*Pleuraphis rigida*), Mexican bladdersage (*Salazaria mexicana*), Joshua tree (*Yucca brevifolia*), or Mojave yucca (*Yucca schidigera*).
Inter-Mountain Basins Semi-Desert Shrub Steppe	8.0	Occurs on alluvial fans and flats with moderate to deep soils. Common grasses include Indian ricegrass (*Achnatherum hymenoides*), blue grama (*Bouteloua gracilis*), saltgrass (*Distichlis spicata*), needle and thread (*Hesperostipa comata*), James' galleta (*Pleuraphis jamesii*), Sandberg bluegrass (*Poa secunda*), and alkali sacaton (*Sporobolus airoides*). Common shrubs include fourwing saltbush (*Atriplex canescens*), big sagebrush (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus* and *Ericameria* spp.), jointfir, broom snakeweed (*Gutierrezia sarothrae*), and winterfat (*Krascheninnikovia lanata*).
Sonora-Mojave mixed salt desert scrub	2.0	Occurs in saline basins in the Mojave Desert, often around playas. Typical vegetation includes saltbush species such as fourwing saltbush or cattle saltbush (*Atriplex polycarpa*) and other salt-tolerant species.
North American Warm Desert Volcanic Rockland	1.6	Restricted to barren and sparsely vegetated volcanic ground such as basalt lava and tuff. Scattered creosote bush, saltbush, or other desert shrubs are typical.
Great Basin Xeric Mixed Sagebrush Shrubland	1.4	Occurs on dry flats, alluvial fans, rolling hills, rocky hill slopes, saddles, and ridges of the Great Basin. Dominated by black sagebrush (*Artemisia nova*) or little sagebrush (*Artemisia arbuscula*), and can be accompanied by Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) or yellow rabbitbrush (*Chrysothamnus viscidiflorus*).
North American Warm Desert Bedrock Cliff and Outcrop	1.1	Occurs in foothills, includes barren to sparsely vegetated landscapes of steep cliff faces, narrow canyons, and smaller rock outcrops, including unstable scree and talus slopes typically below cliff faces. Species include desert and succulent species such as teddybear cholla (*Cylindropuntia bigelovii*).

Table 3-6. Land cover types in the region of influence (continued).

Land cover type	Percent of region of influence	Description
Inter-Mountain Basins Mixed Salt Desert Scrub	0.63	Occurs in saline desert basins and alluvial slopes. Vegetation includes one or more saltbush species such as shadscale saltbush (*Atriplex confertifolia*), fourwing saltbrush, or cattle saltbrush, accompanied by species such as Wyoming big sagebrush, yellow rabbitbrush, rubber rabbitbrush (*Ericameria nauseosa*), Nevada jointfir, spiny hopsage, winterfat, pale wolfberry (*Lycium pallidum*), or horsebrush (*Tetradymia* spp.).
Inter-Mountain Basins Cliff and Canyon	0.61	Occurs in foothills, includes barren and sparsely vegetated landscapes of steep cliff faces, narrow canyons, and smaller rock outcrops, including unstable scree and talus slopes typically below cliff faces. Widely scattered trees and shrubs include limber pine (*Pinus flexilis*), singleleaf pinyon (*Pinus monophylla*), juniper (*Juniperus* spp.), big sagebrush, antelope bitterbrush (*Purshia tridentata*), curl-leaf mountain mahogany (*Cercocarpus ledifolius*), jointfir, and other species often common in adjacent plant communities.
Inter-Mountain Basins Big Sagebrush Shrubland	0.57	Occurs in broad basins between mountain ranges and in foothills. Dominated by basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*), Wyoming big sagebrush, or both.
Great Basin Pinyon-Juniper Woodland	0.33	Occurs on warm dry sites on mountain slopes, mesas, plateaus, and ridges. Dominated by single leaf pinyon and Utah juniper (*Juniperus osteosperma*), or both.
North American Warm Desert Active and Stabilized Dune	0.23	Consists of unvegetated to sparsely vegetated sand dunes.
Inter-Mountain Basins Semi-Desert Grassland	Less than 0.1	Occurs on dry plains and mesas. Vegetation consists of very drought-resistant grasses and shrubs.
Inter-Mountain Basins Greasewood Flat	Less than 0.1	Occurs near drainages or in rings around playas. Dominated or at least accompanied by greasewood (*Sarcobatus vermiculatus*).
North American Warm Desert Playa	Less than 0.1	Consists of barren and sparsely vegetated playas. Vegetation is very salt-tolerant when present.
Invasive Annual Grassland	Less than 0.1	Consists of invasive grasses including red brome (*Bromus rubens*).
North American Warm Desert Lower Montane Riparian Woodland and Shrubland	Less than 0.1	Occurs in riparian corridors along perennial and seasonally intermittent streams. Vegetation is a mix of riparian trees and shrubs.
Inter-Mountain Basins Montane Sagebrush Steppe	Less than 0.1	Occurs on ridges and mountain slopes. Vegetation is typically dominated by sagebrush species.
North American Warm Desert Wash	Less than 0.1	Restricted to intermittently flooded washes. Vegetation composition is highly variable.

Sources: DIRS 174324-NatureServe 2004, all; DIRS 179926-SWReGAP n.d., all.

Basin Desert. Table 3-6 lists the *native species* of plants that are typical components of these land cover types.

In addition to shrubs and grasses, biological soil crusts are an important component to the Mojave and Great Basin *ecosystems*. Biological crusts consist of multiple species of lichen, moss, cyanobacteria, and algae that live on top of the soil surface, binding with soil particles and forming a cohesive mat or crust on the surface of dry landscapes (DIRS 181866-Belnap 2006, p. 1). Cyanobacteria are the dominant component of crusts in the Mojave Desert, while soil lichen and moss species tend to be limited. Biological crusts (if present) could play an important role in maintaining the health of some of the desert vegetation communities listed in Table 3-6, including but not limited to facilitating water infiltration, retaining soil moisture, and reducing soil loss from wind and water erosion (DIRS 181957-Kaltenecker and Wicklow-Howard 1994, pp. 3 to 8). Biological crusts are highly sensitive to surface disturbance and are easily destroyed. They probably occur in the region of influence in some areas where there has been no surface disturbance.

PLANT TERMS

Native species:
With respect to a particular ecosystem, a species that, other than as a result of an introduction, historically occurred or currently occurs in that ecosystem (Executive Order 13112).

Nonnative species:
A species found in an area where it has not historically been found.

Invasive species:
An alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health (Executive Order 13112).

Noxious weeds:
Any species of plant which is, or is likely to be, detrimental or destructive and difficult to control or eradicate (Nevada Revised Statutes 555.005).

About six *invasive species* commonly occur in the region of influence. These species are so prevalent and opportunistic that it is no longer practical or possible to eliminate them from the environment, although it is possible to control their spread into new areas. Some species often colonize areas that construction or traffic have disturbed. The most common include red brome (*Bromus rubens*), Russian thistle (*Salsola* spp.), tumble mustard (*Sisymbrium altissimum*), halogeton (*Halogeton glomeratus*), redstem stork's bill (*Erodium cicutarium*), and Arabian schismus (*Schismus arabicus*). Red brome is the most abundant *nonnative species* in the region of influence and the surrounding area. Approximately 20 other nonnative, invasive species could be present to a lesser degree; in many cases, these species have been or might have been eliminated in particular areas. None of these species is on the State of Nevada's *Noxious Weed* List (DIRS 174543-NDOA 2005, all).

3.1.5.1.2 *Wildlife*

This section summarizes, incorporates by reference, and updates Section 3.1.5.1.2 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, p. 3-72) for wildlife occurrence in the analyzed land withdrawal area and presents new information from studies and investigations that continued after completion of the Yucca Mountain FEIS. Thirty-six species of mammals are known to occur in and around Yucca Mountain. Rodents are the most abundant mammals, with 17 documented species. The most common rodents at Yucca Mountain are Merriam's kangaroo rats (*Dipodomys merriami*) and pocket mice, with long-tailed pocket mice (*Chaetodipus formosus*) at middle and higher elevations and little pocket mice (*Perognathus longimembris*) at lower elevations.

Other wildlife that occurs in the area includes:

- Three species of rabbit—desert cottontail (*Sylvilagus audubonii*), mountain cottontail (*Sylvilagus nuttallii*), and black-tailed jackrabbits (*Lepus californicus*);

- Seven carnivores—kit foxes (*Vulpes macrotis*) (formerly combined with *Vulpes velox*) and coyotes (*Canis latrans*) (the most common), long-tailed weasels (*Mustela frenata*), badgers (*Taxidea taxus*), western spotted skunks (*Spilogale gracilis*), bobcats (*Lynx rufus*), and mountain lions (*Puma concolor*);

- Two ungulates—mule deer (*Odocoileus hemionus*) and wild burros (*Equus asinus*); and

- Several species of bats.

There are no known wild horses at or near Yucca Mountain. As defined by Nevada Administrative Code 503.020 and 503.025, four species of game mammals occur in the analyzed land withdrawal area—desert cottontail, mountain cottontail, mule deer, and mountain lions—and there are two known species of furbearers—kit foxes and bobcats.

Twenty-seven known species of reptiles, including 12 species of lizards, 14 species of snakes, and the desert tortoise (*Gopherus agassizii*), occur at and near Yucca Mountain. The most abundant lizards are the side-blotched lizard (*Uta stansburiana*) and the western whiptail (*Cnemidophorus tigris*), and the most abundant snakes are the coachwhip (*Masticophis flagellum*) and the long-nosed snake (*Rhinocheilus lecontei*). The common chuckwalla (*Sauromalus ater*) (formerly *Sauromalus obesus*), the largest nonvenomous lizard in the United States, is locally common in some rocky areas in the region of influence. There are no known amphibians at Yucca Mountain.

Investigators have recorded more than 120 species of birds at Yucca Mountain and in the surrounding region, including 22 species that are believed to nest regularly in the area and 15 species of raptors (DIRS 104593-CRWMS M&O 1999, p. 3-10). Three species of game birds (Nevada Administrative Code 503.045) have been seen in the analyzed land withdrawal area: Gambel's quail (*Callipepla gambelii*), chukar (*Alectoris chukar*), and mourning dove (*Zenaida macroura*).

Because most of the habitat in the offsite area to the south is similar to the lower elevation portions of the analyzed land withdrawal area, many of the same species are likely to occur there, especially rodents, rabbits, and reptiles. In addition, the Bureau of Land Management has designated land in the Striped Hills near the eastern edge of this offsite area as winter habitat for desert bighorn sheep (*Ovis canadensis nelsoni*) (DIRS 103079-BLM 1998, Map 3-7).

3.1.5.1.3 *Special-Status Species*

This Repository SEIS considers the following special-status animal and plant species: (1) species that the U.S. Fish and Wildlife Service lists or proposes to list as endangered or threatened under the *Endangered Species Act*, as amended (16 U.S.C. 1531 et seq.) or species the Service has designated as species of concern under the Act; (2) species the Bureau of Land Management considers sensitive as designated by the Bureau's State Director in Nevada (DIRS 172900-BLM 2003, all); (3) flora the State of Nevada classifies as fully protected (Nevada Administrative Code 527); and (4) wild mammals, birds, fish, reptiles, and amphibians that the State of Nevada classifies as endangered, threatened, or sensitive (Nevada Administrative Code 503). This section summarizes, incorporates by reference, and updates Section 3.1.5.1.3 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-73 and 3-74).

SPECIAL-STATUS SPECIES

Endangered Species Act:

The Act classifies an **endangered species** as being in danger of extinction throughout all or a significant part of its range.

The Act classifies a **threatened species** as likely to become endangered in the foreseeable future.

The Secretary of the Interior designates **proposed species** for inclusion in the lists of threatened and endangered species.

Nevada Administrative Code 503 and 527:

The state designates special-status animal species as endangered, threatened, protected, and sensitive under Nevada Administrative Code 503. Fully protected plants that are declared to be critically endangered and threatened with extinction are protected under Nevada Administrative Code 527.

Bureau of Land Management:

The Bureau's State Director for Nevada designates **sensitive species**, which are in addition to the above special-status species.

One animal species at Yucca Mountain, the Mojave population of the desert tortoise, is a *threatened species* under the *Endangered Species Act*. Yucca Mountain is at the northern edge of the range of the desert tortoise, and the abundance of tortoises at Yucca Mountain is low or very low in comparison with other portions of its range (DIRS 155970-DOE 2002, p. 3-73). Since the completion of the Yucca Mountain FEIS, additional surveys covering approximately 1.3 square kilometers (320 acres) for desert tortoises and other special-status species have occurred in the Yucca Mountain area (DIRS 181672-Morton 2007, p. 1). Most of those surveys were in Midway Valley within about 2 kilometers (1.2 miles) of the Exploratory Studies Facility. Neither those surveys nor other work at Yucca Mountain have resulted in observations of other special-status species.

Since completion of the Yucca Mountain FEIS, DOE has examined an updated version of the Nevada Natural Heritage Program's element occurrence database to identify any previously undocumented observations of special-status species within the region of influence. Table 3-7 lists the documented special-status species within the region of influence and the authorities that protect them. The State of Nevada classifies all migratory birds as protected. In addition to these species, individual bald eagles (*Haliaeetus leucocephalus*) occasionally migrate through the region; this species is classified as endangered by the State of Nevada, and although recently removed from listing under the *Endangered Species Act*, the species is still protected under the federal *Bald and Golden Eagle Protection Act* and has been seen once at the Nevada Test Site (DIRS 155970-DOE 2002, p. 3-73). Bald eagles are rare in the region and have not been seen at Yucca Mountain.

3.1.5.1.4 *Wetlands*

This section summarizes, incorporates by reference, and updates Section 3.1.5.1.4 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, p. 3-74). As the FEIS reported, there are at present no naturally occurring wetlands at Yucca Mountain that would require regulation under Section 404 of the *Clean Water Act*, as amended (33 U.S.C. 1344 et seq.) (DIRS 155970-DOE 2002, p. 3-74). One manmade well

Table 3-7. Special-status species observed in the region of influence.

Common name (scientific name)	Status	Evaluation of potential for occurrence at Yucca Mountain[a]
	Birds[b]	
Golden eagle (*Aguila chrysaetos*)	BLM Sensitive	Present
Short-eared owl (*Asio flammeus*)	BLM Sensitive	Present
Long-eared owl (*Asio otus*)	BLM Sensitive	Present
Western burrowing owl *(Athene cunicularia hypugaea)*	BLM Sensitive	Present
Ferruginous hawk (*Buteo regalis*)	BLM Sensitive	Present
Swainson's hawk (*Buteo swainsoni*)	BLM Sensitive	Present
Prairie falcon (*Falco mexicanus*)	BLM Sensitive	Present
Loggerhead shrike *(Lanius ludovicianus)*	Nevada, BLM Sensitive	Present
Long-billed curlew (*Numenius americanus*)	BLM Sensitive	Rare
LeConte's thrasher (*Toxostoma lecontei)*	BLM Sensitive	Present
	Mammals	
Pallid bat (*Antrozous pallidus*)	Nevada Protected, BLM Sensitive	Common
Hoary bat (*Lasiurus cinereus*)	BLM Sensitive	Rare
California myotis (*Myotis californicus*) or Small-footed myotis (*Myotis ciliolabrum)*	BLM Sensitive	Common (The two species could not be confidently distinguished in the field.)
Fringed myotis (*Myotis thysanodes*)	Nevada Protected, BLM Sensitive	Rare
Long-legged myotis (*Myotis volans*)	BLM Sensitive	Rare
Western pipistrelle (*Pipistrellus hesperus)*	BLM Sensitive	Common
Brazilian free-tailed bat (*Tadarida brasiliensis*)	Nevada Protected, BLM Sensitive	Rare
	Reptiles	
Desert tortoise (*Gopherus agassizii)*	Federal Threatened, Nevada Threatened	Present
Western red-tailed skink (*Eumeces gilberti rubricaudatus*)	BLM Sensitive	Rare
Common chuckwalla (*Sauromalus ater*) (formerly *Sauromalus obesus*)	BLM Sensitive	Present
	Invertebrates	
Giuliani's dune scarab (*Pseudocotalpa giulianii*)	BLM Sensitive	Present, only in dune habitat south of Yucca Mountain.

Source: DIRS 181672-Morton 2007, p.1.

a. Common = known to be common in the region of influence; present = known to occur in the region of influence but at low abundance; rare = potentially occurs in the region of influence but very limited number of documented sightings.

b. The State of Nevada classifies all migratory birds as protected.

BLM = Bureau of Land Management.

pond in the analyzed land withdrawal area has riparian vegetation. Fortymile Wash and some of its tributaries could be classified as waters of the United States under the Act. In June 2007, the EPA and the U.S. Army Corps of Engineers released interim guidance that addresses the jurisdiction over waters of the United States in light of recent Supreme Court decisions (72 FR 31824, June 8, 2007). Based on this new guidance, it is less likely that the ephemeral washes and riverbeds in this area would be considered waters of the United States. For the proposed construction actions in these washes, the Corps of Engineers would have to determine the limits of jurisdiction under Section 404 of the *Clean Water Act*.

3.1.5.2 Soils

This section summarizes, incorporates by reference, and updates Section 3.1.5.2 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-74 to 3-76). DOE performed a soil survey in an 18-square-kilometer (4,400-acre) area around Midway Valley, which includes most of the areas where soil disturbances for the Proposed Action would occur, and performed a more general survey over the entire Yucca Mountain region (DIRS 104592-CRWMS M&O 1999, all). Both surveys identified only two *soil orders*, and the Midway Valley survey identified 17 *soil series* and seven *soil map units* (Table 3-8).

SOIL TERMS

Duripan:
A subsurface layer held together (cemented) by silica, usually containing other accessory cements.

Hydric:
Describes soils that are characterized by the presence of considerable moisture.

Indurated:
Hardened, as in a subsurface layer that has become hardened.

Petrocalcic:
A subsurface layer in which calcium carbonate or other carbonates have accumulated to the extent that the layer is cemented or indurated.

Prime farmland:
Land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops, and is available for these uses (urban areas are not eligible). It has the soil quality, growing season, and moisture supply necessary for the economic production of sustained high yields of crops when treated and managed (including water management) in accordance with acceptable farming methods (Farmland Protection Policy Act, as amended; 7 U.S.C. 4201 et seq.).

Soil map unit:
A conceptual group of one or more map delineations identified by the same name in a soil survey that represent similar landscape areas that consist of either (1) the same kind of component soils, with inclusions of minor or erratically dispersed soils, or (2) two or more kinds of component soils that might or might not occur together in various delineations but that have similar special use and management properties.

Soil order:
The broadest category of soil classification, identified by the presence or absence of diagnostic layers, or horizons, which have specific physical, chemical, and biological properties.

Soil series:
The lowest category of soil taxonomy with the most restrictive classification of soil properties.

None of these soils is *prime farmland*, and there are no *hydric* soils at Yucca Mountain. None of the soils at Yucca Mountain qualifies for groups one or two of the Natural Resources Conservation Service's wind erodibility classification, which means that these soils are not highly susceptible to wind erosion.

Yucca Mountain soils derive from underlying volcanic rocks and mixed alluvium that is mostly of volcanic origin, and in general have low water-holding capacities. DOE has sampled and analyzed

Table 3-8. Soil mapping units at Yucca Mountain.

Map unit	Percent	Geographic setting	Soil characteristics
Upspring-Zalda	11	Mountain tops and ridges. Soils on smooth, gently sloping ridge tops and shoulders and on nearly flat mesa tops. Rhyolite and tuffs are parent materials for both soil types.	Typically shallow (10 to 51 cm[a]) to bedrock or thin duripan over bedrock. Well to excessively drained, low available water-holding capacity, medium to rapid runoff potential, and slight erosion hazard.
Gabbvally-Downeyville-Talus	8	North-facing mountain side slopes. Talus (stone-sized rock) random throughout unit in long, narrow, vertically oriented accumulations.	Shallow (10 to 36 cm[a]) to bedrock. Permeability moderate to moderately rapid. Moderate to rapid runoff potential, well-drained, low available water-holding capacity, and moderate erosion hazard.
Upspring-Zalda-Longjim	27	Mountain side slopes. Soils on south, east, and west slopes, and on moderately sloping alluvial deposits below side slopes.	Shallow (10 to 51 cm[a]) to bedrock or thin duripan over bedrock. Well to excessively drained, moderately rapid to rapid permeability and runoff potential, very low available water-holding capacity, and slight erosion hazard.
Skelon-Aymate	22	Alluvial fan remnants. Soils on gently to strongly sloping summits and upper side slopes.	Moderately deep (51 to 102 cm[a]) to indurated duripan or petrocalcic layer with low to very low available water-holding capacity, moderately rapid permeability, slow runoff potential, and slight erosion hazard.
Strozi variant-Yermo-Bullfor	7	Alluvial fan remnants. Soils on gently to moderately sloping alluvial fan remnants and stream terraces adjacent to large drainages.	Moderately deep (51 to 102 cm[a]) to deep (102 cm). Well drained, rapid permeability, very low available water-holding capacity, slow runoff potential, and slight erosion hazard.
Jonnic variant-Strozi-Arizo	12	Dissected alluvial fan remnants. Soils formed in alluvium from mixed volcanic sources on fan summits, moderately sloping fan side slopes, and inset fans.	Moderately deep (36 to 43 cm[a]) to deep (more than 102 cm), sometimes over strongly cemented duripan. Slow or rapid permeability, slow or moderate runoff potential, very low available water-holding capacity, and slight erosion hazard.
Yermo-Arizo-Pinez	13	Inset fans and low alluvial side slopes in mountain canyons and drainages between fan remnants. Soils on moderately to strongly sloping inset fans near drainages, adjacent to lower fan remnants, and below foothills.	Deep (more than 102 cm[a]), sometimes over indurated duripan. Well drained, very low available water holding-capacity, moderately slow to rapid permeability, slow to medium runoff potential, and slight erosion hazard.

Source: DIRS 155970-DOE 2002, p. 3-75.
a. To convert cm to inches, multiply by 0.3937.
cm = centimeter.

surface soils for radiological constituents. The Department has maintained records of spills or releases of nonradioactive materials both to meet regulatory requirements and to provide a baseline for the Proposed Action. DOE's *Distribution of Natural and Man-Made Radionuclides in Soil and Biota at Yucca Mountain, Nevada* summarizes existing radiological conditions in soils from 98 surface samples from within 16 kilometers (9.9 miles) of the Exploratory Studies Facility (DIRS 146183-CRWMS M&O 1996, all). The results of that analysis, in comparison with other parts of the world, indicate average levels of naturally occurring uranium-238 decay products and above-average levels of naturally occurring potassium-40 and thorium-232 decay products. The higher-than-average values could be due to the origin of the soil at the site from tuffaceous igneous rocks. In addition, the studies detected small concentrations of strontium-90, cesium-137, and plutonium-239 from worldwide nuclear weapons testing.

3.1.6 CULTURAL RESOURCES

The region of influence for cultural resources includes the analyzed land withdrawal area, land that DOE has proposed for an access road from U.S. Highway 95, and land where DOE would construct offsite facilities. The Department would construct a portion of the proposed access road from U.S. Highway 95 on Bureau of Land Management land that Nye County currently controls. The analysis for this Repository SEIS assumed a location on Bureau of Land Management land near Gate 510 of the Nevada Test Site for construction of the offsite facilities. Federal agencies manage most of the land in the region. This section summarizes, incorporates by reference, and updates Section 3.1.6 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-76 to 3-82). In addition, these sections present environmental data that have become available since DOE completed the Yucca Mountain FEIS and that are pertinent to cultural resources and the associated impact analysis.

3.1.6.1 Archaeological and Historic Resources

The Yucca Mountain FEIS reported approximately 830 archaeological sites in the analyzed land withdrawal area, based on archaeological site file searches at the Desert Research Institute in Las Vegas and Reno, Nevada, and at the Harry Reid Center for Environmental Studies at the University of Nevada, Las Vegas. Most of these archaeological sites are small scatters of lithic (stone) artifacts that usually comprise fewer than 50 artifacts with few formal tools and no temporally or culturally diagnostic artifacts in the inventory. Temporally and culturally diagnostic artifacts can include projectile points and ceramic artifacts that can reference specific periods or cultural groups.

Since DOE completed the Yucca Mountain FEIS, it has refined the number of sites in the analyzed land withdrawal area to approximately 532 archaeological sites and 553 isolated artifacts (DIRS 172306-Rhode 2004, all). The change in number is due to the combination of some of the sites with the gathering of additional information that showed the sites were part of the same artifact complex. In addition, the revised number reflects the archaeological resources that recent investigations for the U.S. Highway 95 access road recorded. These 1,085 archaeological sites and isolated artifacts strictly pertain to the analyzed land withdrawal area of the Proposed Action. None of the archaeological sites has been listed on the *National Register of Historic Places*; DOE, in consultation with the Nevada State Historic Preservation Office, has determined that the large majority of sites and isolated artifacts are not eligible for inclusion in the *National Register*. The Department, in consultation with the Nevada State Historic Preservation Office, has recommended 232 archaeological sites for inclusion in the *National Register* and manages these sites accordingly. The site types in the analyzed land withdrawal area are temporary camps, extractive localities, processing localities, caches, stone tool manufacture stations, and historic sites.

Since the completion of the Yucca Mountain FEIS, there have been intensive surveys, assessments, and periodic monitoring to identify, characterize, and better evaluate cultural resources in the analyzed land withdrawal area. A draft programmatic agreement among DOE, the Advisory Council on Historic Preservation, and the Nevada State Historic Preservation Office has been prepared for cultural resources management related to activities that would be associated with development of a repository at Yucca Mountain. While this agreement is in ongoing negotiation among the concurring parties, DOE is abiding by Section 106 of the *National Historic Preservation Act of 1966* (16 U.S.C. 470) process.

3.1.6.2 American Indian Interests

3.1.6.2.1 *Yucca Mountain Project Native American Interaction Program*

In the Yucca Mountain FEIS, DOE discussed its program to consult and interact with tribes and organizations on the characterization of the Yucca Mountain site and the possible construction and operation of a repository. The Native American Interaction Program concentrates on the protection of cultural resources at Yucca Mountain and promotes a government-to-government relationship with tribes and organizations. Within this program, 17 tribes and organizations have formed the Consolidated Group of Tribes and Organizations, which consists of appointed tribal representatives who are responsible for presentation of their respective tribal concerns and perspectives to DOE. The Southern Paiute, Western Shoshone, and Owens Valley Paiute and Shoshone people from Arizona, California, Nevada, and Utah have cultural and historic ties to the Yucca Mountain area.

DOE held Tribal Update Meetings for members of the Consolidated Group of Tribes and Organizations between October 2004 and January 2005 (DIRS 174205-Kane et al. 2005, all). The Consolidated Group recommended additional studies to address eight issues of concern related to potential adverse impacts to the American Indian landscape. Additional recommendations involved increasing and ensuring consistent and effective communication between DOE and the Consolidated Group.

3.1.6.2.2 *American Indian Views of the Affected Environment*

The Yucca Mountain FEIS summarized American Indian views of the affected environment. In general, American Indians believe they are the original inhabitants of their homelands since the beginning of time. They assign meanings to places involved with their creation as a people, religious stories, burials, and important secular events. The traditional stories of the Southern Paiute, Western Shoshone, and Owens Valley Paiute and Shoshone peoples identify such places, including the Yucca Mountain region. The American Indian people believe cultural resources are not limited to the remains of native ancestors but include all natural resources and geologic formations in the region, such as plants and animals and natural landforms. Equally important are water resources and minerals. According to American Indian people, the Yucca Mountain region is part of the lands of the Southern Paiute, Western Shoshone, and Owens Valley Paiute and Shoshone peoples.

3.1.7 SOCIOECONOMICS

To define the existing conditions for the socioeconomic environment in the Yucca Mountain area for this Repository SEIS, DOE determined that it should base the region of influence on the distribution of potential residences of employees. At present, few Yucca Mountain Project employees work at the Yucca Mountain site. The Department would transfer most offsite Project positions to the Yucca Mountain site as the construction and operation of the repository began. Therefore, for this Repository SEIS, DOE used historical, rather than current, data to forecast the future residential distribution of Yucca Mountain

Project workers. This section summarizes, incorporates by reference, and updates Section 3.1.7 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-82 to 3-93) and provides new information, as applicable, from studies and investigations that continued after DOE completed the FEIS.

In 1994, when the total Yucca Mountain site employment was approximately 1,600 workers, about 98 percent of the workers, including those assigned to the Nevada Test Site location, lived in Clark and Nye counties. Since late 1995, Yucca Mountain site employment numbers have dropped significantly. DOE assumed that the historical pattern of residential distribution of onsite workers in 1994 reflects the projected residential distribution for the Proposed Action because 1994 is the most recent year in which onsite employment most nearly reflects expected employment for the Proposed Action. The migration patterns of Yucca Mountain Project workers who moved to Nevada from 1986 to March 2005 reinforce this expected pattern. Of the 3,866 individuals (1,740 workers and 2,126 dependents) who moved to Nevada as a direct result of Project employment, 3,808 chose to live in Clark County and 56 chose to live in Nye County, primarily in Pahrump and Mercury (DIRS 180788-BSC 2005, pp. 3-20 and 3-21). Therefore, DOE selected Clark and Nye counties as the region of influence for socioeconomic resources for this Repository SEIS (Figure 3-14). The Yucca Mountain FEIS included Lincoln County although less than 1 percent of the workforce lived in Lincoln County. Lincoln County is not a part of the Repository SEIS region of influence because so few Yucca Mountain Project workers lived there in 1994 and so few recent project migrants chose to live there. DOE recognizes that historical trends might not reflect future patterns and therefore presents an alternative residential distribution pattern in Appendix A of this Repository SEIS.

Clark County contains the cities of Las Vegas, Boulder City, Henderson, Mesquite, North Las Vegas, and other communities (DIRS 181749-Nevada State Demographer n.d., all). Based on a count of workers in a 1994 data report, 79 percent of the Yucca Mountain site workers lived in Clark County, and approximately 19 percent lived in Nye County (Table 3-9).

DOE used the Regional Economic Models, Inc. (REMI), economic-demographic forecasting computer model, *Policy Insight*®, Version 9 to estimate the baselines for population, employment, and three economic measures: Gross Regional Product, real disposable personal income, and state and local government spending. For this Repository SEIS, the REMI model projected the baselines from 2005 to 2067 for the two counties in the region of influence and for the State of Nevada. Table 3-10 lists the baseline information for the counties in the region of influence and for Nevada.

The version of the REMI model that DOE used for the Yucca Mountain FEIS contained historical data through 1997. DOE developed the baseline data for this Repository SEIS using REMI *Policy Insight* Version 9.0, which uses historical data through 2004 and updates DOE received from local and state sources. Employment and population estimates and projections incorporate data from the Nevada State Demographer's Office, Nevada Department of Employment, Training, and Rehabilitation, and the University of Nevada, Las Vegas Center for Business and Economic Research.

This section cites information, when available, from the Nevada State Demographer's Office and updates gathered by the U.S. Bureau of the Census. DOE developed the baselines with input from the State of Nevada and local sources. The Department used the baselines to project impacts to socioeconomic parameters, which include population and employment.

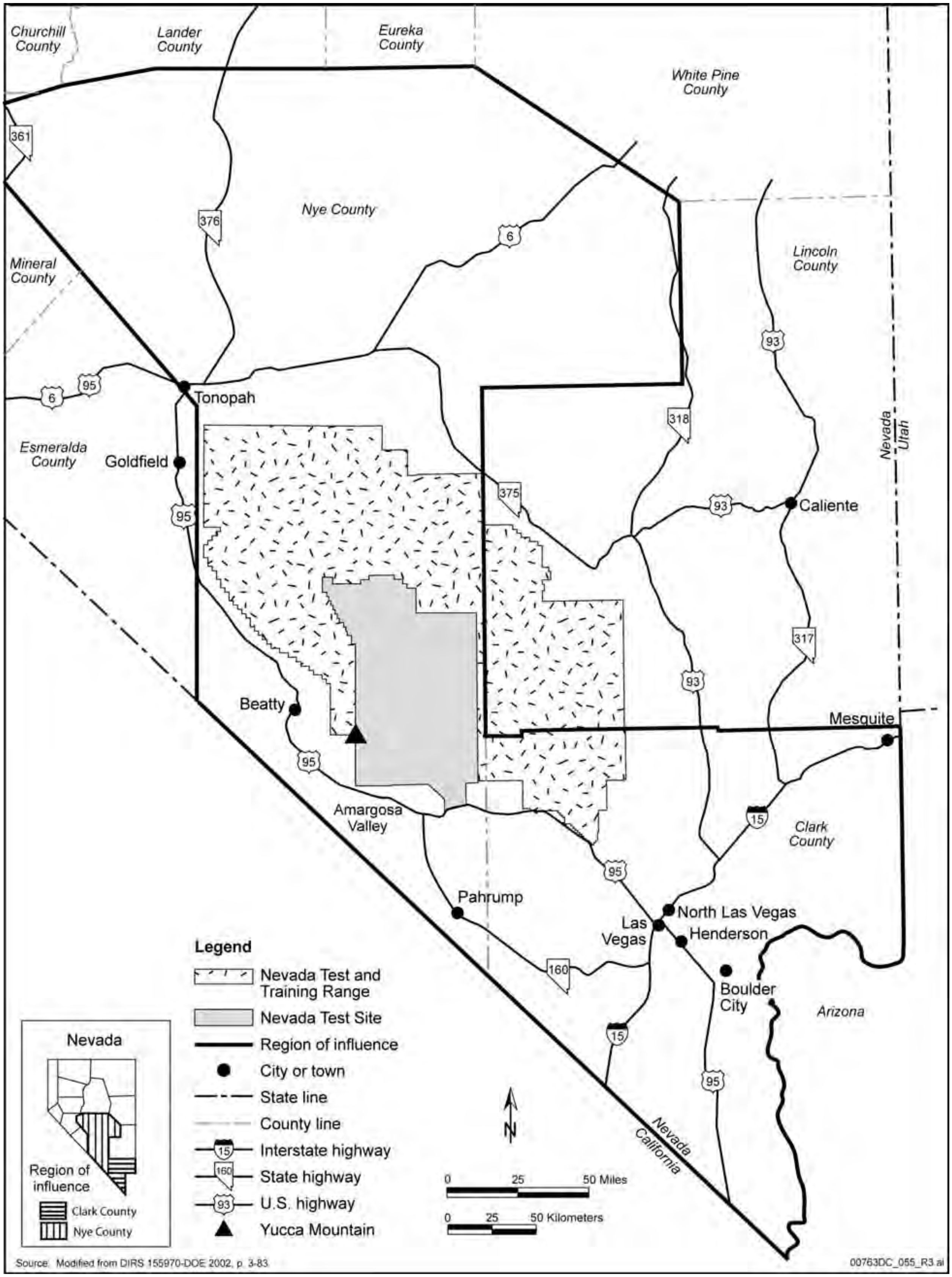


Figure 3-14. Socioeconomic region of influence for this Repository SEIS.

Table 3-9. Distribution by place of residence of Yucca Mountain site employees.

Place of residence	Onsite workers	Percent of total
Clark County	1,268	79
Nye County	308	19
Total region of influence	1,576	98
Outside region of influence	36	2
Total workers	1,612	100

Source: DIRS 104957-DOE 1994, p. 2-9.
Notes: Onsite Yucca Mountain Project employees worked either at the Yucca Mountain Repository or on the Nevada Test Site. All onsite workers were employed in Nye County.

3.1.7.1 Population

From 1990 to 2000, Nevada had a total growth of 64 percent (DIRS 174418-Nevada State Demographer n.d., all); the overall growth of the United States (DIRS 181012-Bureau of the Census 1990, all) was 13 percent. The population of the region of influence grew by 81 percent from 1990 to 2000, an average of almost 64,000 new residents annually. In 2000, the estimated population of the region of influence was about 1.43 million (DIRS 174418-Nevada State Demographer n.d., all).

In 2000, the population of Clark County was about 1.4 million people, which indicates an 81-percent growth rate during the 1990s (DIRS 174418-Nevada State Demographer n.d., all). Las Vegas, the county seat, is by far the largest population base, with about 480,000 residents in 2000. Boulder City had approximately 15,000 residents, Henderson had about 180,000 residents, Mesquite had 10,000 residents, and North Las Vegas had about 120,000 residents in the same year. By 2005, Las Vegas had a population of 570,000, Boulder City had 15,200, Henderson had 241,000, Mesquite had 16,000, and North Las Vegas had a population of 180,000.

In 2000, the population of Nye County was 33,000. As in Clark County, Nye County experienced 81-percent growth during the 1990s (DIRS 174418-Nevada State Demographer n.d., all). Today, Pahrump, the county's largest population center, is experiencing explosive growth, due primarily to in-migrating retirees and its proximity to Las Vegas. Pahrump had a population of about 24,000 people in 2000 and more than 33,000 in 2005. The county seat of Tonopah had about 2,900 residents in 2000.

Although the annual growth rate in the region of influence has slowed in the last 5 years from the extraordinary pace of the 1990s, the population should continue to grow at a rate greater than 4.6 percent a year, about four times the national average, in this decade (DIRS 178610-Bland 2007, all). Clark County will continue to lead the population growth in the foreseeable future in the region of influence.

The region of influence includes a number of incorporated cities and towns as well as unincorporated communities (Table 3-11). Clark County has five incorporated cities and numerous unincorporated but recognized communities. Nye County has no incorporated cities; the largest community is Pahrump.

Communities in Nye County are widely separated and often surrounded by lands that are federally owned or held in trust; these communities, therefore, tend to have economies that are distinct from one another. Clark County has a population density of about 67 persons per square kilometer (170 per square mile) (DIRS 173533-Bureau of the Census 2005, all) and Nye County about 0.69 person per square kilometer (1.8 per square mile) (DIRS 172310-Bureau of the Census 2004, all). Nevada has about 7.0 persons, on average, per square kilometer (18 per square mile). As reflected in the sparse population density for Nye

Table 3-10. Baseline values for population, employment, and economic variables, 2005 to 2067.

Variable	2005	2010	2015	2025	2035	2045	2067
Clark County							
Total population	1,820,000	2,260,000	2,650,000	3,170,000	3,540,000	3,950,000	5,000,000
Total employment	1,070,000	1,240,000	1,330,000	1,450,000	1,600,000	1,780,000	2,230,000
Spending by state and local governments (in billions of dollars)	6.5	8.5	11	13	16	18	23
Real disposable personal income (in billions of dollars)	55	69	80	100	125	157	208
Total Gross Regional Product (in billions of dollars)	87	110	132	173	225	291	394
Nye County							
Total population	41,000	52,000	61,000	73,000	84,000	97,000	131,000
Total employment	17,000	19,000	21,000	23,000	25,000	28,000	37,000
Spending by state and local governments (in billions of dollars)	0.16	0.20	0.25	0.32	0.39	0.47	0.64
Real disposable personal income (in billions of dollars)	1.0	1.3	1.4	1.8	2.2	2.8	4.0
Total Gross Regional Product (in billions of dollars)	1.1	1.3	1.6	2.1	2.7	3.5	5.0
All Nevada							
Total population	2,540,000	3,060,000	3,540,000	4,19,000	4,680,000	5,220,000	6,650,000
Total employment	1,520,000	1,720,000	1,830,000	2,000,000	2,180,000	2,410,000	3,030,000
Spending by state and local governments (in billions of dollars)	9.7	12	15	19	22	25	32
Real disposable personal income (in billions of dollars)	77	96	110	140	170	210	280
Total Gross Regional Product (in billions of dollars)	118	147	177	233	301	389	527

Source: DIRS 178610-Bland 2007, all.
Note: Values are in 2006 dollars.

Table 3-11. Population of incorporated Clark County cities and selected unincorporated towns in Nye County, 1991 to 2005.

Jurisdiction	1991	1995	2000	2005
Clark County				
Boulder City	13,000	14,100	14,900	15,200
Henderson	77,500	115,000	179,000	241,000
Las Vegas	290,000	367,000	482,000	570,000
Mesquite	2,520	5,170	10,100	16,400
North Las Vegas	53,500	78,300	118,000	180,000
Nye County				
Amargosa Valley	920	1,200	1,170	1,380
Beatty	1,800	1,900	1,150	1,000
Pahrump	8,800	15,000	24,200	33,200
Tonopah	3,600	3,400	2,830	2,610

Source: DIRS 180794-Nevada State Demographer’s Office 2006, all
Note: Population numbers have been rounded to three significant figures.

County, the region of influence consists of a metropolitan concentration in the Las Vegas area, with spotty occupancy in the remainder of the region. The Federal Government manages more than 85 percent of the land in Nevada (DIRS 181638-NDCNR n.d., all). Cities in metropolitan Clark County are well connected via established road systems and proximity to one another, but major population centers in Nye County, such as Pahrump and Tonopah, are almost 270 kilometers (170 miles) apart. Transportation systems must often weave around federally held lands with restricted access.

The population growth in the State of Nevada and Clark County should exceed average national trends through 2067. The population growth in Clark County should grow more moderately through this decade and then slow to about 1.4 percent annually through 2067 (DIRS 178610-Bland 2007, all). Clark County will continue to house approximately 97 percent of the population in the region of influence. Nye County should grow at an accelerated rate, with an average annual increase of approximately 2 percent (DIRS 178610-Bland 2007, all) through 2067. Figure 3-15 shows estimated populations for the region of influence and the State of Nevada, projected to 2065.

3.1.7.2 Employment

In the region of influence, Clark County has the larger economy. In 2006, the estimated employment was 920,000; this constituted 98 percent of the regional employment and about 71 percent of the state employment. During the same year, Nye County had an employment base of approximately 13,000 (DIRS 178610-Bland 2007, all). Clark County should continue to lead employment growth in the region of influence (DIRS 180734-NDETR 2007, all). The Leisure and Hospitality sector, which includes casinos, hotels, gaming, eating and drinking establishments, and amusement and recreation facilities, is the largest employment sector in Clark County, with 30 percent of the employment in June 2006 (DIRS 180712-NDETR 2006, all). The Professional and Business sector and Leisure and Hospitality sector are the largest employment sectors in the Nye County economy. In June 2006, these services comprised 40 percent of Nye County’s employment. Retail trade made up an additional 14 percent (DIRS 180712-NDETR 2006, all).

Las Vegas, in Clark County, has one of the fastest growing economies in the country. The Leisure and Hospitality industry drives this rapid growth. For each new hotel room, an employment multiplier effect creates an estimated 2.5 direct and indirect (composite) jobs. Despite an inventory of more than

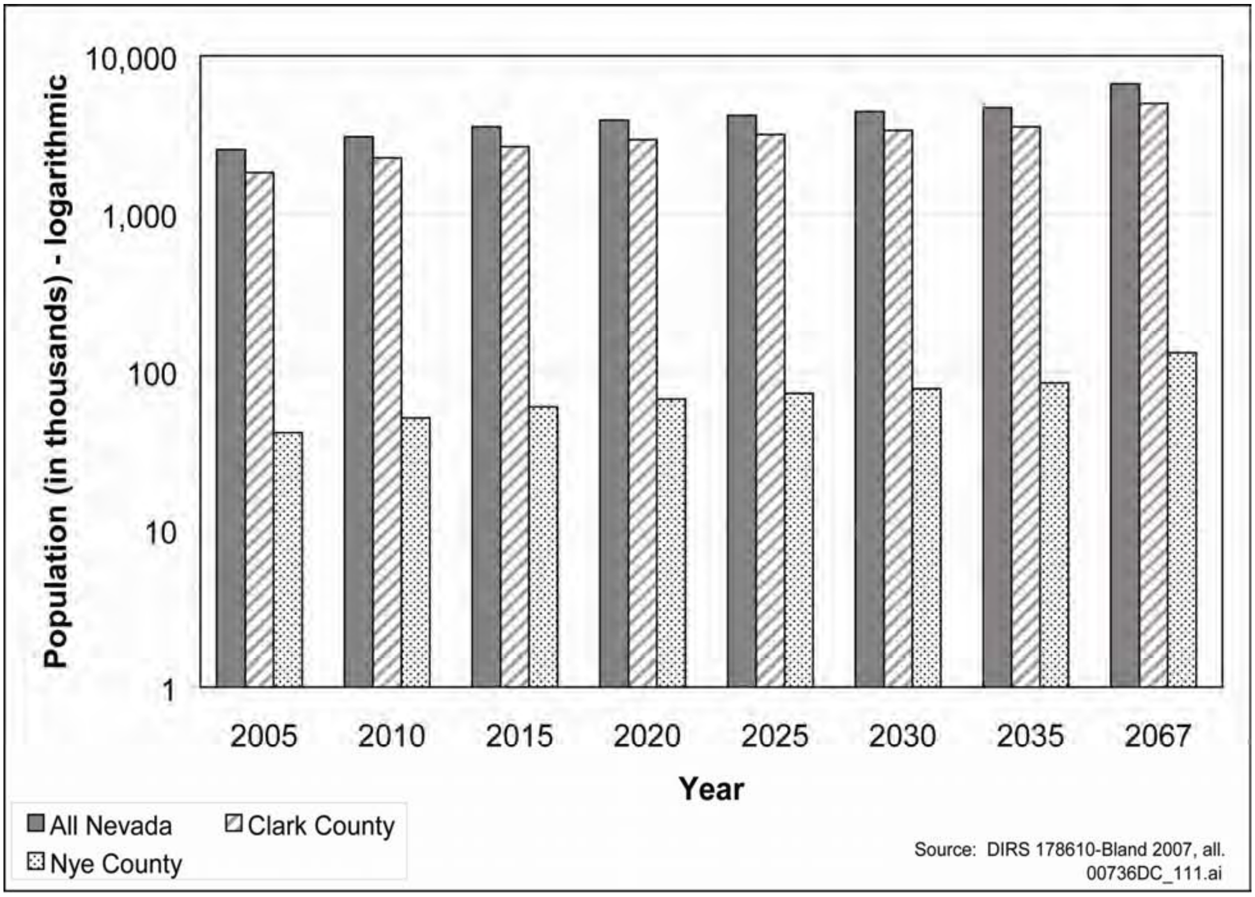


Figure 3-15. Estimated populations for the counties in the region of influence and the State of Nevada, projected to 2067.

130,000 rooms in December 2006, hotels consistently operate at 90-percent occupancy, reaching 95 percent on weekends (DIRS 180713-LVCVA 2006, all).

Hundreds of new jobs are added to the regional economy each month, and many job seekers have come to the area (primarily Clark County). Clark County has maintained a low unemployment rate near state and national averages. In January 2007, Clark County and Nye County had unemployment rates of 4.7 and 6.9 percent, respectively. The average in the State of Nevada was about 4.9 percent; the nationwide unemployment rate for the same period was about 4.6 percent (DIRS 180734-NDETR 2007, all).

In March 2005, an average of about 2,200 workers (210 on the site and 2,000 off) worked on the Yucca Mountain Project. By early 2007, the average number of onsite workers had fallen to fewer than 50. Most offsite workers, those primarily involved with engineering, licensing, project support, safety analysis, and related project support functions, worked in the Las Vegas area (DIRS 180788-BSC 2005, p. 3-12).

Projected employment in the region of influence broadly reflects population trends. The number of jobs in Clark County should reach approximately 2.2 million in 2067 (DIRS 178610-Bland 2007, all), up from 1.1 million in 2005. Clark County will host 98 percent of the employment opportunities in the region of influence. Nye County will add approximately 20,000 additional jobs by 2067 to the base of 17,000 in 2005 (DIRS 178610-Bland 2007, all).

In 2006, Clark County had 19 employers that maintained a payroll with at least 3,500 workers; the Clark County School District led with 30,000 to 39,999 workers, and the Clark County government was second with 10,000 to 19,999 workers. Many casinos in the county employed more than 3,500 workers. In the private sector, Bechtel Nevada Corporation led employers in Nye County with 1,000 to 1,499 workers, Nye County School District employed 900 to 999, and Round Mountain Gold Corporation employed at least 700 workers (DIRS 181180-NDETR 2006, all).

The 2005 per-capita income in Clark County was approximately $34,980, which is near the state's average of about $35,744. The per-capita income in Nye County was $28,761 (DIRS 180951-BEA 2007, all). The United States average per-capita income for the same period was $34,471 (DIRS 180952-BEA 2007, all).

3.1.7.3 Payments-Equal-to-Taxes Provision

An issue of interest is the DOE Payments-Equal-to-Taxes specified by the *Nuclear Waste Policy Act*, as amended (NWPA) (42 U.S.C. 10101 et seq.). DOE acquired data from the Yucca Mountain Project organizations that purchase or acquire property for use in Nevada, have employees in Nevada, or use property in Nevada. These organizations include federal agencies, national laboratories, and private firms. Not all of these organizations have a federal exemption, so they pay the appropriate taxes. The purchases (sales and use tax), employees (business tax), and property (property or possessory use taxes) of the Project organizations that exercise a federal exemption are subject to the Payments-Equal-To-Taxes provision (DIRS 156763-YMP 2001, all).

At present, DOE makes Payments-Equal-to-Taxes to the State of Nevada, Nye County, and Clark County. The amounts paid to the state and to Clark County are formula-driven, but DOE and Nye County periodically negotiate (DIRS 181181-TischlerBise 2005, all) (Table 3-12). In Nye County, Payments-Equal-to-Taxes from the Yucca Mountain Project are a major revenue source. In 2005, Nye County had budgeted expenditures of approximately $28.29 million. In the same year, Payments-Equal-to-Taxes payments to the county totaled $10.5 million. These payments do not automatically increase with growth.

Table 3-12. DOE Payments-Equal-To-Taxes for the Yucca Mountain Project, 2004 through 2007 (in dollars).

Jurisdiction	2004	2005	2006	2007	Total
State of Nevada	860,000	960,000	743,000	718,000	3,281,000
Nye County	10,250,000	10,500,000	10,750,000	11,000,000	42,500,000
Clark County	152,000	134,000	122,000	65,000	473,000
Total	11,262,000	11,594,000	11,615,000	11,783,000	46,254,000

Source: DIRS 181001-Lupton 2007, all.

3.1.7.4 Housing

As in much of the nation, the sale of new and existing homes in the Las Vegas area slowed in early 2007 and prices dropped. The greater Las Vegas area should experience a decline in home prices of almost 9 percent in the next year (DIRS 180999-Money 2007, all). New home sales were down 44 percent in the first quarter of 2007 in comparison with the first quarter of 2006 (DIRS 181013-SNHBA 2007, all).

The housing inventory in Clark County in 2005 was about 720,000 units, which consisted of 440,000 single-family units, 240,000 multifamily units, and 35,000 mobile homes or other units. The occupancy rate was 89 percent during 2005. The average household size was 2.7 persons (DIRS 180738-Bureau of the Census 2005, all). The median value of a Clark County house or condominium in 2005 was $289,000, up from $140,000 in 2000. The median value of a house or condominium in the State of Nevada was nearly the same in 2005, $283,000.

In 2006, 36,000 new homes and 42,000 existing homes were sold (DIRS 180955-Smith 2007, all). In 2006, the median price of a new home was about $330,000, and the median price of an existing home was about $290,000 (DIRS 181013-SNHBA 2007, all). These sale prices are above the national median prices of $250,000 and $220,000 for new and existing homes, respectively (DIRS 181014-NAHB 2007, all).

The housing inventory in Nye County in 2000 was about 16,000 units, which consisted of 6,400 single-family units, 1,000 multifamily units, and 8,500 mobile homes or other units. The occupancy rate was 84 percent during 2000. The median value of houses and condominiums was about $122,100, or about 88 percent of the median value of a house in Clark County. Median rents in Nye County were $541 per month, about 76 percent of the median rent in Clark County. The average household size was 2.4 persons. The 2000 housing inventory in Pahrump was about 12,000 housing units of which 5,000 were single-family units, 6,200 were multifamily units, and 480 were mobile homes or other units (DIRS 181016-City-Data 2007, all). Nye County is attractive to home buyers because it is within commuting distance to metropolitan Las Vegas and has less expensive housing. Pahrump should be attractive to new workers because of its proximity to the Yucca Mountain site. The 2005 median value of a house or condominium in Pahrump was $117,000 (DIRS 181016-City-Data 2007, all). New home prices in Nye County continue to escalate as build-to-suit land with water rights becomes increasingly scarce. Although unincorporated, Pahrump is in the Pahrump Regional Planning District, which has adopted a land use plan and zoning regulations to guide future development. However, existing *infrastructure* systems are strained and inadequate. Rental unit vacancy rates are approaching zero.

Nye County purchased almost 61 acres near the current Gate 510 access road to the Nevada Test Site from the Bureau of Land Management to develop a science and technology business park. The park is the first phase of a proposed master development that will encourage a live-work community lifestyle in the town of Amargosa Valley.

The Pahrump Regional Planning District, which includes Nye County, Pahrump, and portions of the Nye County School District, has determined that the county's current revenue structure cannot adequately provide the current level of services to current residents. Current assessments on residential land uses are not paying their way and generate net deficits to the county. New residents would cause additional net deficits under the existing revenue structure (DIRS 181181-TischlerBise 2005, all).

3.1.7.5 Public Services

3.1.7.5.1 *Education*

In the 2005–2006 school year, the region of influence comprised approximately 270 public elementary and middle schools, 46 public high schools, and 31 alternative and special education schools (DIRS 181156-MGT 2006, p. 11-3; DIRS 181158-NDE n.d., all; DIRS 181159-NDE n.d., all). The Clark County School District expects to build about 180 new schools by 2018 to accommodate population growth (DIRS 181156-MGT 2006, p. 5-10). The average pupil-to-teacher ratio in the 2005–2006 school year was about 26 to 1 in kindergarten and 22 to 1 in all grades first to eighth; the national pupil-to-teacher ratio was about 19 to 1 for elementary schools and 15 to 1 for secondary schools (DIRS 181160-NDE n.d., all). During the 2005–2006 school year, Clark County had about 320 schools and nearly 294,000 students (Table 3-13). Enrollment in Clark County schools tends to be very large, with several high schools serving more than 3,000 students each. During the same period, Nye County had

Table 3-13. Enrollment by school district and grade level, for the 1996–1997 through 2005–2006 school years.

Jurisdiction	1996–1997[a,b]	2000–2001[a,c]	2005–2006[d]
Clark County			
Prekindergarten	1,100	1,100	1,880
Kindergarten	15,000	19,000	22,343
Elementary (grades 1 to 6)	90,000	120,000	141,429
Secondary (grades 7 to 12)	73,000	94,000	127,943
District totals[e]	179,000	232,000	293,961[f]
Nye County			
Prekindergarten	43	54	101
Kindergarten	370	360	403
Elementary (grades 1 to 6)	2,300	2,500	2,849
Secondary (grades 7 to 12)	2,200	2,300	2,870
District totals[e]	4,970	5,290	6,223[f]

a. Enrollment numbers by category rounded to two significant figures and district totals rounded to three significant figures for the 1996–1997 and 2000–2001 school years.
b. Source: DIRS 157146-NDE 2001, all.
c. Source: DIRS 155820-NDE 2001, all.
d. Source: DIRS 181169-NDE 2007, all.
e. Totals might differ from sums due to rounding.
f. Figures include students in ungraded situations.

approximately 6,200 students in 17 schools spread over about 47,000 square kilometers (18,000 square miles), which vary in size from an enrollment of 10 students in Duckwater Elementary school to nearly 1,300 students in Pahrump High School (DIRS 181161-NDE n.d., all). Nye County school officials report that all schools in the county are at capacity and that those in Pahrump exceed design capacity. A new elementary school is scheduled to open in fall 2008, and a new high school within 2 years of that in Pahrump. The balance of the county has opted to use modular units to accommodate the growth (DIRS 181182-Nye County School District 2007, all).

3.1.7.5.2 *Health Care*

Most health care services in the region of influence are in Clark County, particularly in the Las Vegas area. In January 2007, Clark County had 13 accredited general medical and surgical hospitals (DIRS 181162-AHA 2006, all) and several specialized care facilities. Several major health care providers have proposed new hospitals or expansions of existing facilities and are awaiting various governmental approval processes. Although Nye County has one unaffiliated (that is, with the American Hospital Association or Joint Commission on Accreditation of Healthcare Organizations) accredited hospital in Tonopah, most people in the southern part of the county use local clinics or go to hospitals in metropolitan Las Vegas. The very recently opened 24-bed critical care Desert View Medical Center in Pahrump has emergency room service available 24 hours a day, 7 days a week (DIRS 181162-AHA 2006, all). Table 3-14 lists hospital use in the region of influence.

Table 3-14. Hospital use by county in the region of influence, 1995 to 2006.

Jurisdiction	1995[a]	2000[b]	2006[c]
Clark County			
Population	1,000,000	1,380,000	1,900,000
Average number of beds	2,100	2,600	3,100
Beds per 1,000 residents	2.2	1.9	1.6
Patient days	530,000	NA	NA
Nye County			
Population	24,000	32,000	43,600
Average number of beds	21	42	44[d]
Beds per 1,000 residents	0.86	1.3	1.0
Patient days	1,900	NA	NA

a. Source: DIRS 103451-Rodefer et al. n.d., pp. 214 to 216.
b. Source: DIRS 155872-Bureau of the Census 2000, County totals.
c. Source: DIRS 181162-AHA 2006, all.
d. Does not include the 24-bed Desert View Hospital, which opened in April 2006.
NA = Not available.

Medical services are available at the Nevada Test Site for Yucca Mountain Project personnel; Section 3.1.7.5 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, p. 3-92) describes these services.

3.1.7.5.3 *Law Enforcement*

The Las Vegas Metropolitan Police Department is responsible for law enforcement in Clark County, with the exceptions of the cities of North Las Vegas, Henderson, Boulder City, and Mesquite, which have their own departments. The Las Vegas police department is the largest law enforcement agency in Nevada; in the 2004 to 2005 reporting period, the department had approximately 3,400 employees, including 2,250 commissioned officers—a ratio of 1.7 commissioned officers per 1,000 residents (DIRS 181163-LVMPD 2006, all). In 2005, the Nye County Sheriff’s office had 141 employees, including 102 commissioned officers—a ratio of 2.5 commissioned officers per 1,000 residents. In comparison, the national officer-to-population ratio is 3.0 commissioned officers per 1,000 residents (DIRS 181167-FBI 2006, all; DIRS 181168-FBI 2005, all).

3.1.7.5.4 *Fire Protection*

A combination of fire departments that use career, part-time, and volunteer personnel provides protection in the region of influence; these include the Clark County, Las Vegas, and North Las Vegas fire departments and several other city, county, and military departments. No single state or national agency gathers and categorizes information about fire suppression activities, services, and personnel in the region of influence. In January 2007, the Clark County Fire Department had about 685 paid and 350 volunteer firefighters (DIRS 181170-CCFD 2006, all). The department responded to about 111,000 incidents in 2006 from 20 stations (DIRS 181186-Nevada State Fire Marshal 2006, all). The Las Vegas Fire Department had about 560 employees reported in 2005 (DIRS 185193-USFA 2008, all). The department responded to about 78,500 calls in 2006 (DIRS 181186-Nevada State Fire Marshal 2006, all) from 16 stations (DIRS 181646-CCFD 2005, all). In January 2006, the North Las Vegas Fire Department had 147 employees (DIRS 181171-Las Vegas Sun 2006, all) and answered 20,100 calls from seven stations (DIRS 181646-CCFD 2005, all). The Henderson Fire Department responded to 21,500 calls (DIRS 181186-Nevada State Fire Marshal 2006, all) from nine stations (DIRS 181646-CCFD 2005, all). Information for the Boulder City Fire Department was not available. The national average is 3.8 firefighters (paid and volunteer) per 1,000 residents (DIRS 181176-NFPA 2005, all).

In 2007, Clark County met fire suppression needs primarily with career firefighters. According to the U.S. Fire Administration, the Clark County Fire Department had about 614 career and 350 volunteer firefighters (DIRS 185193-USFA 2008, all). Indian Springs, a part of the Clark County Fire Department, had 21 volunteers and 2 stations. The Clark County Fire Department responded to about 111,000 incidents in 2006 (DIRS 181186-Nevada State Fire Marshal 2006, all) from about 25 stations (DIRS 185193-USFA 2008, all). The Las Vegas Fire Department had about 550 career firefighters (DIRS 185193-USFA 2008, all). The department responded to about 78,500 calls in 2006 (DIRS 181186-Nevada State Fire Marshal 2006, all) from 16 stations (DIRS 185193-USFA 2008, all). In 2007, the North Las Vegas Fire Department had 141 career firefighters and responded from 7 stations (DIRS 185193-USFA 2008, all). In 2006, the department answered 20,100 calls (DIRS 181646-CCFD 2005, all). In 2006, the Henderson Fire Department responded to 21,500 calls (DIRS 181186-Nevada State Fire Marshal 2006, all). In 2007, the department had 185 career firefighters responding from 9 stations (DIRS 185193-USFA 2008, all). The Boulder City Fire Department had 18 career firefighters responding from 1 station in 2007. The Nellis Air Force Base had 105 firefighters operating from 4 stations (DIRS 185193-USFA 2008, all). The national average is 3.8 firefighters (paid and volunteer) per 1,000 residents (DIRS 181176-NFPA 2005, all).

In 2007, Nye County met fire suppression needs primarily with volunteers from the communities in the county. The Pahrump Valley Fire Department has career, part-time, and volunteer personnel. The department answered 155 calls in 2006 (DIRS 181186-Nevada State Fire Marshal 2006, all). The Nevada Test Site reported 26 fire calls. None of the eight all-volunteer departments reported calls to the State Fire Marshall in 2006, although the Nye County Fire Protection District Department responded to 31 calls. Nye County is hampered by its rural nature and size; assistance from mutual aid departments is often an hour away. Many conventional developed neighborhoods in the county lack fire hydrants. Most of the Town of Pahrump is outside the nationally recommended radius of 5 kilometers (3 miles) to achieve a 4- to 5-minute response time (DIRS 181184-Pahrump Valley Fire Rescue Service 2004, p. 6). DOE did not determine conventional resident-to-firefighter ratios because the large geographical area of the two counties distorts meaningful mutual aid and response time comparisons.

3.1.8 OCCUPATIONAL AND PUBLIC HEALTH AND SAFETY

The public health and safety region of influence consists of members of the public who reside within an 84-kilometer (52-mile) radius of the geologic repository operations area. The region of influence includes parts of Nye, Clark, Lincoln, and Esmeralda counties in Nevada and Inyo County in California. DOE estimated the baseline population in this area in 2003 as 33,000 (DIRS 181663-Morton 2007, all); the population is mostly in small communities in the southern and western portions of the 84-kilometer radius (Figure 3-16). The baselines in this Repository SEIS incorporate population estimates and projections from the Nevada State Demographer’s Office and the Center for Business and Economic Research at the University of Nevada, Las Vegas. The occupational health and safety region of influence includes workers at the repository and potentially affected workers at nearby Nevada Test Site facilities. This section summarizes, incorporates by reference, and updates Section 3.1.8 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-93 to 3-101).

In the Draft Repository SEIS, this region of influence was referred to as having an 80-kilometer (50-mile) radius. Because of the actual alignment of the concentric rings on the grid in Figure 3-16, the distance from the proposed repository location to the outer ring is 84 kilometers (52 miles). For this Final

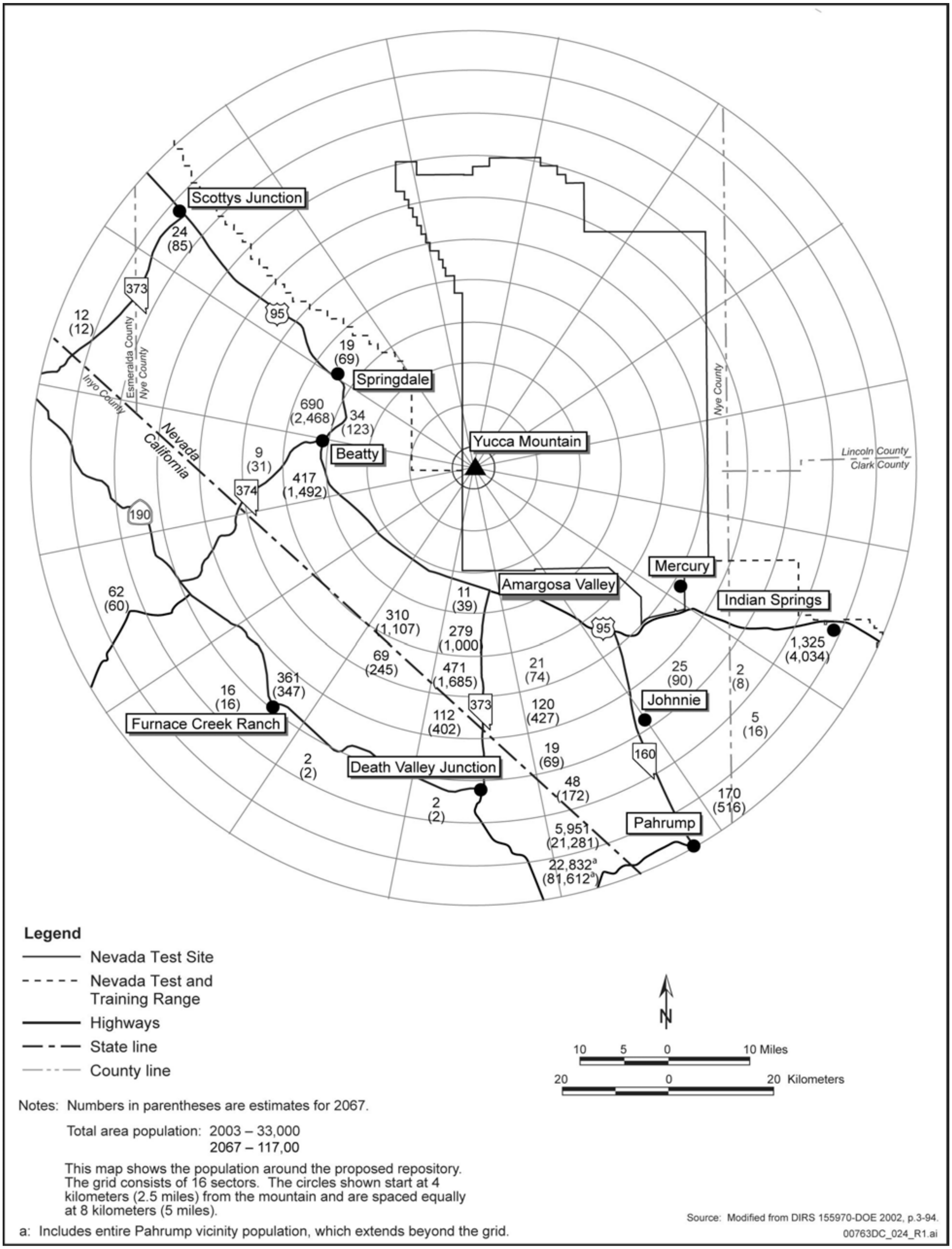


Figure 3-16. Population distribution within 84 kilometers (52 miles) of the proposed repository, 2003 estimations (2067 projections).

Repository SEIS, the region of influence is referred to as an 84-kilometer radius. The estimated population within each grid cell has not changed from the Draft Repository SEIS.

3.1.8.1 Radiation Sources in the Environment

Radiation levels from background sources in the environment provide a basis for comparison with radiation from manmade sources. Background radiation derives from cosmic and cosmogenic sources, external terrestrial sources, radon in homes, and internally deposited radionuclides. The Yucca Mountain FEIS contains more detail about types of radiation.

The effect of radiation on people depends on the kind of radiation exposure (*alpha* and *beta particles*, and *x-rays* and *gamma rays*), the total amount of exposed tissue, and the duration of the exposure. The representative annual external doses for the region of influence range from a low of about 100 millirem at the town of Amargosa Valley to a high of 150 millirem at Beatty from terrestrial sources and cosmic and cosmogenic radiation. Internally deposited radionuclides contribute an additional 40 millirem per year, mainly from potassium-40, and doses from radon and its short-lived progeny add another 200 millirem per year. Therefore, the total dose from all background sources in the region of influence ranges from 340 to 390 millirem per year. This background dose varies by location and is slightly higher than the U.S. average, which is about 300 millirem per year.

Radiation can cause a variety of adverse health effects in people. The following discussion is an overview of a common method for estimation of the effects of radiation exposure; Appendix D of this Repository SEIS contains more detailed information. At low doses, the most important adverse health effect for estimation of the consequences of environmental and occupational radiation exposures (which typically are low) is the potential inducement of *cancers* that can lead to death in later years. This effect is referred to as latent because the cancer might not be the cause of death and because cancer can take years to develop.

The collective dose to an exposed population is the sum of the estimated doses to each member of the exposed population. This is referred to as a *population dose*, which is measured in person-rem. For example, if 1,000 people each received a dose of 0.001 *rem*, the population dose would be 1 person-rem (1,000 persons multiplied by 0.001 rem equals 1 person-rem). The same population dose (1 person-rem) would result if 500 people each received a dose of 0.002 rem (500 persons multiplied by 0.002 rem equals 1 person-rem).

As recommended by the Interagency Steering Committee on Radiation Standards, this Repository SEIS uses a conversion factor of 0.0006 *latent cancer fatality* per person-rem, for both workers and the public, to estimate the radiological impacts of repository operations (DIRS 174559-Lawrence 2002, p. 2). The factor is higher than those the Yucca Mountain FEIS used, which were 0.0004 and 0.0005 latent cancer fatality per person-rem for workers and the public, respectively (DIRS 155970-DOE 2002, p. 3-97).

As stated in the Yucca Mountain FEIS, these concepts can be used to estimate the effects of exposure to radiation. For example, if 100,000 people each were exposed only to background radiation (0.3 rem per year), an estimated 18 latent cancer fatalities could occur as a result of 1 year of exposure (100,000 persons multiplied by 0.3 rem per year multiplied by 0.0006 latent cancer fatality per person-rem equals 18 latent cancer fatalities).

TERMS USED IN RADIATION DOSE ASSESSMENT

Curie:
A unit of radioactivity equal to 37 billion disintegrations per second; also a quantity of any nuclide or mixture of nuclides having 1 curie of radioactivity.

Picocurie per liter (or gram):
A unit of concentration measure that describes the amount of radioactivity (in picocuries) in volume (or mass) of a given substance [typically, air or water (by volume) or soil (by mass)]. A picocurie is one-trillionth of a curie.

Rad:
A unit of absorbed radiation dose in terms of energy. One rad equals 100 ergs of energy absorbed per gram of tissue. (The word derives from radiation absorbed dose.)

Rem:
The unit of effective dose equivalent from ionizing radiation to the human body. It is an expression of the amount of radiation to which a person has been exposed. The effective dose equivalent in rem is equal to the absorbed dose in rad multiplied by quality and weighting factors that are necessary because biological effects can vary both by the type of radiation (even of the same deposited energy) and by the specific tissue exposed. (The word derives from roentgen equivalent in man.)

Millirem:
One one-thousandth (0.001) of a rem.

Total effective dose equivalent:
Often generically referred to simply as dose, it is an expression of the radiation dose received by an individual from external radiation and from radionuclides internally deposited in the body. All doses presented in this Repository SEIS are in terms of total effective dose equivalent.

Latent cancer fatality:
A death that results from cancer that exposure to ionizing radiation caused. There typically is a latent period between the time of the radiation exposure and the time the cancer cells become active.

Solid cancer:
Solid cancers include all malignant neoplasms other than those of the lymphatic and hematopoietic tissue (DIRS 181250-National Research Council 2006, p. 377).

Calculations of the number of latent cancer fatalities due to radiation exposure do not normally yield whole numbers and, especially in environmental applications, can yield numbers less than 1. For example, if 100,000 people each were exposed to a total dose of only 1 millirem (0.001 rem), the population dose would be 100 person-rem, and the corresponding estimated number of latent cancer fatalities would be 0.06 (100,000 persons multiplied by 0.001 rem multiplied by 0.0006 latent cancer fatality per person-rem equals 0.06 latent cancer fatality).

The estimated average number of deaths that could result if many different groups of 100,000 people received the same exposure is 0.06. In most groups, nobody (zero people) would incur a latent cancer fatality from the 1-millirem dose each member received. In a small fraction of the groups, 1 latent cancer fatality would result; in exceptionally few groups, 2 or more latent cancer fatalities would occur. The average number of deaths over all the groups would be 0.06 latent cancer fatality per 100,000 (just as the average of 0, 0, 0, and 1 is 0.25). The most likely outcome is no latent cancer fatalities in any of the different groups.

To aid in decisionmaking, DOE has applied these same concepts to estimate the effects of radiation exposure on a single individual. Consider the effects, for example, of exposure to background radiation over a lifetime. The probability of a latent cancer fatality that corresponds to a single individual's exposure to 0.3 rem per year over a (presumed) 70-year lifetime is:

$$\text{Probability of a latent cancer fatality} = 1 \text{ person} \times 0.3 \text{ rem per year} \times 70 \text{ years} \times 0.0006 \text{ latent cancer fatality per person-rem}$$
$$= 0.013 \text{ probability of a latent cancer fatality}$$

This is a statistical average; that is, the estimated effect of background radiation exposure on the exposed individual would produce a 1.3-percent chance that the individual would incur a latent cancer fatality. For comparison purposes, statistics from the Centers for Disease Control and Prevention indicate that 24 percent of all deaths in the State of Nevada during 1998 were attributable to cancer from all causes (DIRS 153066-Murphy 2000, p. 83).

3.1.8.2 Radiation Environment at the Yucca Mountain Site

Environmental radiation at the Yucca Mountain site consists of natural background radiation from cosmic and terrestrial sources, past nuclear testing activities, and radon releases from activities at the Exploratory Studies Facility. The Yucca Mountain FEIS detailed the radiation exposure rates from these sources and the existing radiological environments in the region of influence. Table 3-15 summarizes major radiation sources and associated doses.

Table 3-15. Major sources of radiation exposure at Yucca Mountain.

Sources of exposure	Dose rate (per year)
Natural background radiation	
Cosmic and terrestrial radiation at Yucca Mountain ridge	160 millirem
ESF operations	
Median external dose rate to ESF workers	40 millirem
Average inhalation dose rate to ESF workers from radon and decay products	40 millirem
Annual dose to an individual 20 kilometers (12 miles) south of the ESF from exposure to ESF radon releases	< 0.1 millirem
Annual dose to the population within 84 kilometers (52 miles) of the repository from exposure to ESF radon releases	10 person-rem
Radiation doses from past nuclear testing activities at Nevada Test Site	
Maximum annual dose to an individual in Springdale, Nevada, 14 kilometers (9 miles) north of Beatty	0.12 millirem
Annual dose to the population within 84 kilometers of the Nevada Test Site	0.38 person-rem

Source: DIRS 155970-DOE 2002, pp. 3-98 to 3-100.
ESF = Exploratory Studies Facility.

3.1.8.3 Health-Related Mineral Issues Identified During Site Characterization

Certain minerals known to present a potential risk to worker health are present in the volcanic rocks at Yucca Mountain. The risks generally are related to potential exposure caused by inhalation of airborne particulates (dust). These minerals include crystalline silica (silica dioxide) and *erionite* and have been determined by the International Agency for Research on Cancer to be known human *carcinogens*. The National Institute of Health, U.S. Department of Human Services, has included silica and erionite on its list of "Known to be Human Carcinogens" report that was provided to Congress (DIRS 176678-DOE 2006, p. 6-12). Crystalline silica comes in several forms that include quartz, tridymite, and cristobalite. Prolonged exposure to silica dust can result in the formation of scar tissue in the lungs. This scar tissue can reduce overall lung capacity. DOE performs evaluations of airborne crystalline silica at Yucca Mountain during routine operations and tunneling. The repository host rock has cristobalite content that ranges from 18 to 28 percent (DIRS 104523-CRWMS M&O 1999, p. 4-81). The American Conference of Governmental Industrial Hygienists has established *threshold limit values* for various forms of crystalline silica. Further, the World Health Organization has listed crystalline silica as a carcinogen.

Underground mechanical excavation produces dust when the rock is broken loose. Dust is also generated when the broken rock is transferred to railcars, conveyors, or a storage pile, and can also be generated by wind erosion of excavated rock storage piles. Excavation activities during past activities at Yucca Mountain have resulted in some exceedences of crystalline silica threshold limit values at specific work locations. In these cases, workers at these locations are required to wear respirators to mitigate occupational exposures.

Erionite is an uncommon zeolite mineral that forms wool-like fibrous masses. The International Agency for Research on Cancer recognized erionite as a human carcinogen in 1987 (DIRS 103278-IARC 1987, all). Even at low concentrations, erionite is believed to be a potent carcinogen, capable of causing mesothelioma, a form of lung cancer. As a result of its apparent carcinogenicity, erionite may pose a risk if encountered in quantity during underground construction. However, based on geologic studies to characterize the repository horizon, erionite appears to be absent or rare at the proposed repository depth and location, so most operations have not been affected. During excavation activities, DOE performs continuous monitoring of the geologic strata. If erionite is encountered, the area is sealed off and remediated. During the initial tunneling operations in the mid-1990s, one vein of erionite was encountered. This vein was only a few millimeters wide and was in the far south region of the exhaust tunnel and not in the main repository horizon. In subsequent studies, only minor traces of erionite have been found in the repository horizon (DIRS 176678-DOE 2006, p. 6-12).

A number of other minerals present at Yucca Mountain might have associated health risks if prolonged exposures occur. These minerals include the zeolite group minerals mordenite (which is fibrous), clinoptilolite, heulandite, and phillipsite. Even though these are not classified as known human carcinogens, the measures implemented to mitigate occupational risk from silica (including dust suppression, air filters, and personal protective gear) also protect workers from exposure to other minerals.

In January 2004, DOE announced a Silicosis Medical Screening Program for Yucca Mountain tunnel workers who were involved in tunneling and underground operations between 1992 and 2004. The DOE Office of Civilian Radioactive Waste Management and the University of Cincinnati mailed 6,228 informative letters, postcards, and invitations to affected individuals to participate in the screening program. A total of 978 persons responded to the mailings, 551 completed a work history interview, and 414 of those interviewed underwent a medical examination. The final report from the University of Cincinnati diagnosed two cases of silicosis. Both cases were found in the screening examination, although one case previously had been diagnosed and reported as medical history. These cases of silicosis cannot be attributed solely to exposure at Yucca Mountain because both workers had a long history of working in occupations that were dusty and likely to contain silica dust. The average age of the two confirmed silicosis cases was 70 years, the average time working in mining or tunneling occupations was 30 years, and the average time working at Yucca Mountain was 5 years (DIRS 181251-OCRWM 2007, all). Compensation coverage for DOE employees exposed to silica is defined in the *Energy Employees Occupational Illness Compensation Program Act*, which is administered by the U.S. Department of Labor.

3.1.8.4 Industrial Health and Safety Impacts During Past Construction Activities

During past activities related to construction at Yucca Mountain, health and safety impacts to workers resulted from common industrial hazards (such as tripping and falling). The categories of worker impacts include *recordable incidents*, lost workdays, and fatalities. Recordable incidents or cases are occupational injuries or occupation-related illnesses that result in (1) a fatality, regardless of the time between the injury or the onset of the illness and death; (2) *lost workday cases* (nonfatal); and (3) incidents that result in the transfer of a worker to another job, termination of employment, medical treatment, loss of consciousness, or restriction of motion during work activities.

To date, activities at Yucca Mountain have had no *involved worker* fatalities. DOE has compiled statistics for the other types of health and safety impacts in accordance with the regulations of the Occupational Safety and Health Administration (29 CFR Part 1904). These statistics cover the 30-month period from the fourth quarter of 1994 through the first quarter of 1997. DOE selected this period because there was high onsite work activity during which the tunnel boring machine was in operation in the Exploratory Studies Facility. Table 3-16 lists the industrial health and safety loss statistics for industry, general construction, general mining, and Yucca Mountain for the construction period for the Exploratory Studies Facility. The table also lists current industrial health and safety loss statistics. DOE expects these statistics to be representative for the types of activities that would occur during the construction of the surface facilities and the development of the emplacement drifts.

Table 3-16. Health and safety statistics for total industry, general construction, general mining, and Yucca Mountain, 1997 and 2005.[a]

Rates	Total industry	General construction	General mining	Yucca Mountain experience for involved workers
1997 total recordable cases	7.1[b]	9.5[b]	5.9[b]	6.8
2005 total recordable cases	4.6[c]	6.3[c]	4.1[c]	0
1997 lost workday cases	3.3[b]	4.4[b]	3.7[b]	4.8
2005 lost workday cases	2.4[c]	3.4[c]	2.7[c]	0

a. Based on 100 full-time equivalent worker years or 200,000 worker hours.
b. Data for 1997 for the period of excavation of the Exploratory Studies Facility (DIRS 148091-BLS 1998, all).
c. Data for 2005 (DIRS 179131-BLS 2006, all).

3.1.9 NOISE AND VIBRATION

The region of influence for noise and vibration includes the Yucca Mountain site and existing and future residences to the south in the town of Amargosa Valley. This section discusses the affected environment in terms of noise sources and levels, regulatory standards, and vibration, and it summarizes and incorporates by reference Section 3.1.9 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-101 to 3-104).

3.1.9.1 Noise Sources and Levels

Yucca Mountain is in a quiet desert environment where natural phenomena such as wind, rain, and wildlife account for most background noise. Average day-night sound-level values range from 22 *A-weighted decibels (dBA)* on calm days to 38 dBA on windy days. Manmade noise levels at the Yucca Mountain Exploratory Studies Facility were consistent with noise levels near industrial operations, which range from 44 to 72 dBA. The nearest housing to Yucca Mountain is in the town of Amargosa Valley about 22 kilometers (14 miles) to the south. The estimated sound level in the town of Amargosa Valley ranges from 45 to 55 dBA.

NOISE AND VIBRATION TERMS

A-weighted decibels (dBA):
A measurement of sound that approximates the sensitivity of the human ear, which is used to characterize the intensity or loudness of sound.

Day-night average sound level:
The energy average of the A-weighted sound levels over a 24 hour period. It includes an adjustment factor for noise between 10 p.m. and 7 a.m. to account for the greater sensitivity of most people to noise during the night.

Vibration velocity decibels (VdB):
Vibration velocity in decibels with respect to 1 microinch per second. A measurement of root-mean-square velocity for the evaluation of ground vibration as an average or smoothed vibration amplitude on a logarithmic scale.

3.1.9.2 Regulatory Standards

With the exception of prohibitions of nuisance noise, neither the State of Nevada nor local governments have established numerical noise standards. Nevertheless, many federal agencies use *day-night average sound levels* as guidelines for land use compatibility and to assess the impacts of noise on people. As required, DOE has a hearing protection program in place that includes monitoring of noise levels in worker areas. Engineering controls are the primary methods of noise suppression, and the plan requires supplemental hearing protection when noise levels exceed safe levels.

Sound levels that cause annoyance vary greatly by individual and background conditions. The threshold for hearing hazard, which depends on the frequency of the sound, ranges from around 65 *decibels* at a frequency of 4,000 hertz to about 88 decibels at 125 and 8,000 hertz. These threshold levels assume continuous exposure for periods of hours. High risk for hearing loss occurs at 120 dBA and can result from exposures as brief as seconds to minutes.

3.1.9.3 Vibration

Many natural phenomena such as wave action on beaches, strong winds, and earthquakes, as well as human activities such as construction, transportation, and military activities, cause ground vibration. Background vibration almost always exists to some degree, and levels are generally higher in large cities than in rural communities.

A typical background level of ground vibration is 52 *vibration velocity decibels* (VdB) with respect to 1 microinch per second, and the human threshold for the perception of ground vibration is 65 VdB. There are three ground vibration impacts of general concern: human annoyance, damage to buildings, and interference with vibration-sensitive activities.

Background levels for ground vibration at the Yucca Mountain site are low. Other than site maintenance activities, there is a lack of the classic manmade sources of ground vibration.

3.1.10 AESTHETICS

Visual resources, with nighttime darkness as a component, include the natural and manmade physical features that give a particular landscape its character and value as an environmental factor. The region of influence for aesthetics includes the approximate boundary of the analyzed land withdrawal area, an area west of the boundary where ventilation stacks could be seen, and the area south of the boundary where DOE would construct the access road from U.S. Highway 95 and several offsite facilities. This section summarizes, incorporates by reference, and updates Section 3.1.10 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-104 to 3-106).

The Yucca Mountain region consists of unpopulated to sparsely populated desert and rural lands. Because much of Yucca Mountain is on the Nevada Test Site and the Nevada Test and Training Range, both with restricted public access, the public can see Yucca Mountain only from portions of U.S. Highway 95 near the intersection of State Route 373.

The Bureau of Land Management assigns visual resource values to lands that it manages. The Bureau classification of visual resource values involves assessment of visual resources and assignment of one of four *visual resource management classes* based on three factors: scenic quality, visual sensitivity, and distance from travel routes or observation points. Class I represents the highest visual values, and Class IV represents the lowest. Each visual resource class has an associated management objective that defines permissible land uses and developments. Table 3-17 describes the Bureau of Land Management objectives for visual resource classes.

The Bureau of Land Management has classified a portion of the analyzed land withdrawal area, with characteristics fairly common to the region, as Class IV and the remainder as Class III. The land to the west of the site consists of Class III and Class IV lands. The lands south of the analyzed land withdrawal area boundary, where DOE would construct the access road from U.S. Highway 95, the Marshalling Yard and Warehouse, Sample Management Facility, Offsite Training Facility, and temporary accommodations for construction workers, are Class III. Land on the Nevada Test Site is not under Bureau of Land Management jurisdiction but, using the Bureau's methods, DOE has assigned these lands as Class IV. Figure 3-17 shows the visual resource classifications.

Nighttime darkness in the Yucca Mountain region is a valued component of the solitude experience many people seek and greatly enhances astronomy and stargazing activities. Existing or potential sources of nighttime light in this area include the towns of Beatty and Amargosa Valley between Death Valley National Park and the Yucca Mountain site, the community of Pahrump slightly east of the park, and particularly Las Vegas farther to the east. Current lighting at the Yucca Mountain site is similar to or less than lighting at other work areas on the Nevada Test Site and represents a minor contribution to the area's sources of nighttime lighting.

Table 3-17. Bureau of Land Management visual resource management classes and objectives.

Visual resource class	Objective	Acceptable changes to land
Class I	Preserve the existing character of the landscape.	Provides for natural ecological changes but does not preclude limited management activity. Changes to the land must be small and must not attract attention.
Class II	Retain the existing character of the landscape.	Management activities may be seen but should not attract the attention of the casual observer. Changes must repeat the basic elements of form, line, color, and texture of the predominant natural features of the characteristic landscape.
Class III	Partially retain the existing character of the landscape.	Management activities may attract attention but may not dominate the view of the casual observer. Changes should repeat the basic elements in the predominant natural features of the characteristic landscape.
Class IV	Provide for management activities that require major modifications of the existing character of the landscape.	Management activities may dominate the view and be the major focus of viewer attention. An attempt should be made to minimize the impact of activities through location, minimal disturbance, and repeating the basic elements.

Source: DIRS 101505-BLM 1986, Section V.B.

3.1.11 UTILITIES, ENERGY, AND SITE SERVICES

The region of influence for potential impacts to utilities, energy supplies, and site services comprises those public and private resources on which DOE would draw to support the Proposed Action. These resources are in Nye, Clark, and Lincoln counties in Nevada. Utilities include water and sewer services, energy supplies include electric power and fossil fuel, and site services include security, medical, and fire protection. This section summarizes, incorporates by reference, and updates Section 3.1.11 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-106 to 3-110) and presents new information DOE has accumulated since it completed the FEIS.

3.1.11.1 Utilities

The Proposed Action could affect water and sewer utilities through project-related increases in population and the associated increases in water demand and sewage production. Based on historical residency patterns, DOE anticipates that the majority of project-related increases in population would occur in Clark and Nye counties (DIRS 155970-DOE 2002, p. 3-82).

3.1.11.1.1 *Water*

The Southern Nevada Water Authority is a cooperative agency that was formed in 1991 to address southern Nevada’s regional water needs. It is the wholesale water provider to municipal water agencies in the Las Vegas Valley and Boulder City. It supplies water to the communities of Boulder City, Henderson, Las Vegas, North Las Vegas, Laughlin, and portions of unincorporated Clark County (DIRS 181261-SNWA n.d., p. v). Southern Nevada gets nearly 90 percent of its water supply from the Colorado River and the remaining 10 percent from groundwater. To meet growing water demands, the Southern

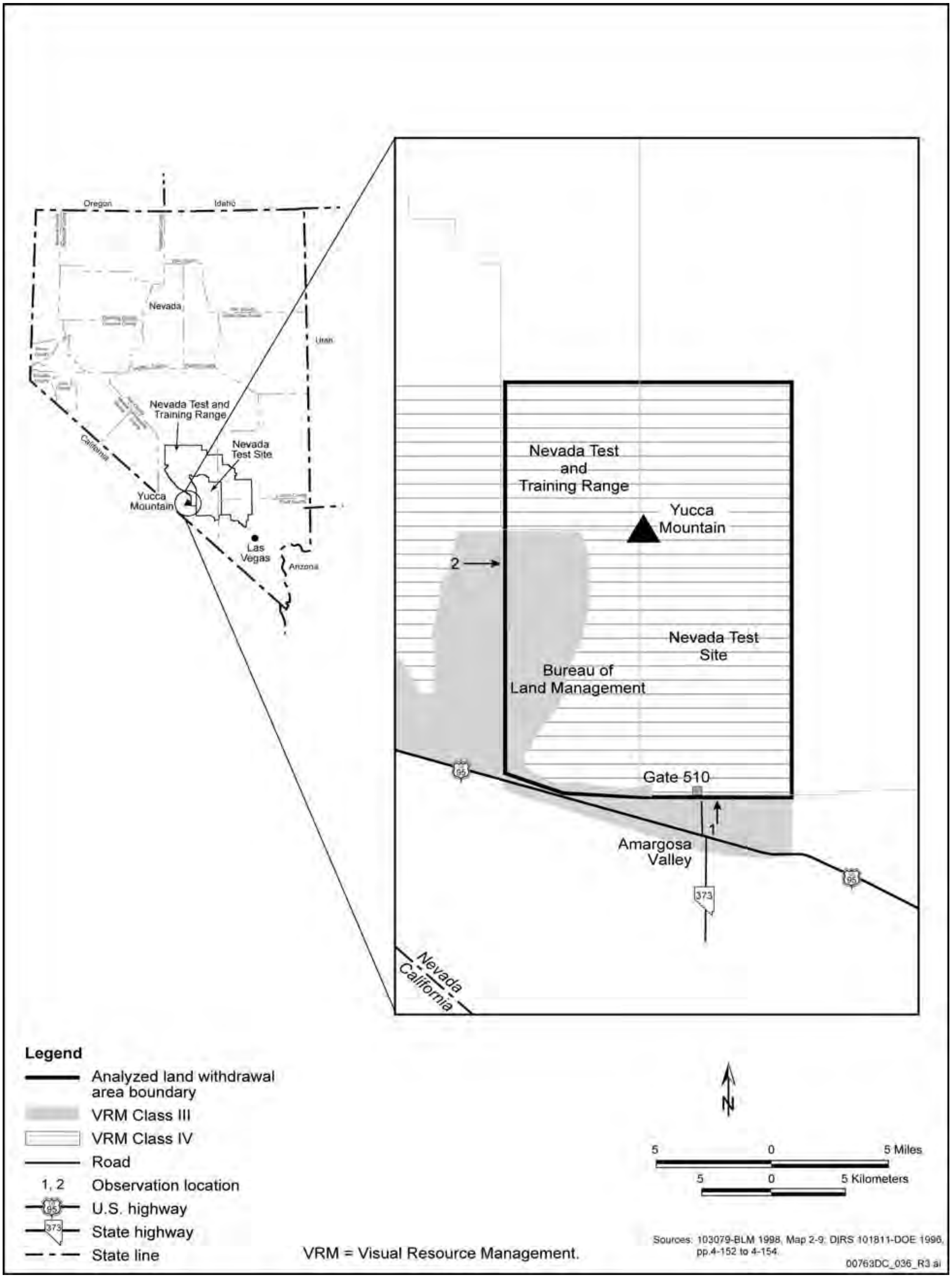


Figure 3-17. Visual Resource Management classifications near Yucca Mountain.

Nevada Water Authority is upgrading current facilities and installing new facilities. In 2002, the Authority completed a second water intake system at Lake Mead; and it has scheduled a third for completion in 2011. The Southern Nevada Water Authority is identifying new water resources and developing a portfolio of resource options to help meet potential future demands. The portfolio includes both Colorado River water options (such as apportionments, water banks, and water exchanges) and in-state, non-Colorado River water options (such as Las Vegas Valley groundwater rights, shallow groundwater, surface-water rights, and groundwater rights in other portions of Clark County as well as Lincoln, White Pine, and Nye counties) (DIRS 181261-SNWA n.d., pp. v and vi).

In southern Nye County, the location of the proposed repository, groundwater is the only source of water. Total groundwater use in Nye County in 2000 was approximately 125 million cubic meters (101,000 acre-feet) (DIRS 173226-Buqo 2004, p. 47). Historically, nearly 80 percent of Nye County's annual groundwater withdrawal is for agricultural irrigation and only 7 percent is for domestic purposes (including public supplies). Mining uses an additional 9 percent, public use and losses use 2 percent, livestock use 1 percent, and commercial activities use 1 percent (DIRS 173226-Buqo 2004, p. 41).

Since completion of the Yucca Mountain FEIS, a new water supply and demand evaluation has become available for Nye County (DIRS 173226-Buqo 2004, all). The evaluation indicated that Beatty (Oasis Valley Hydrographic Area) has adequate water rights and wells to meet projected future demands. A water connection moratorium that was in effect in 1996 ended after another well (the former Barrick Gold Well EW-4) came on line. The only significant water issues in Beatty are the naturally occurring levels of arsenic and fluoride in the groundwater and the water treatment that could be necessary to reduce those levels (DIRS 173226-Buqo 2004, p. 85). In the Amargosa Desert Hydrographic Area, the existing groundwater rights of 31 million cubic meters (25,000 acre-feet) (DIRS 182821-Converse Consultants 2005, p. 100) exceed the published perennial yield of 30 million cubic meters (24,000 acre-feet). However, actual water use in the basin is far less and has not exceeded 20 million cubic meters (16,000 acre-feet). Existing groundwater sources would be adequate for anticipated needs (DIRS 173226-Buqo 2004, pp. 80 to 83). Although activities at Yucca Mountain would not require the use of water from the Pahrump Valley Hydrographic Area, project-related population increases could cause increased water use in the hydrographic area. The total groundwater that was pumped from the Pahrump Valley Hydrographic Area in 2000 was about 28 million cubic meters (23,000 acre-feet), which was the lowest demand since 1993 because of a decrease in water pumped for irrigation. This is about 21 percent higher than the upper end of estimates of the perennial yield of that hydrographic area, which ranges from 15 million to 23 million cubic meters (12,000 to 19,000 acre-feet). Water consumption in the Pahrump Valley results from approximately 8,700 domestic water wells; nearly 300 irrigation wells; and 254 municipal, commercial, and industrial wells (DIRS 173226-Buqo 2004, p. 89). Drilling continues at a rate of over 400 wells a year. With projected population increases, the annual demand for water could be about 99 million cubic meters (80,000 acre-feet) by 2050 (DIRS 173226-Buqo 2004, p. 95). Possible alternatives for meeting the projected future water shortfalls in the Pahrump Valley include a managed overdraft of the basin by optimizing the locations of new wells, development of the carbonate aquifer that underlies the basin, importation of water from other basins, and administrative actions such as conservation (DIRS 173226-Buqo 2004, pp. 57 to 59). In 2007, the Nevada Legislature passed a measure enacting the Nye County Water District. The District is empowered to manage water within the boundaries of Nye County in a manner similar to that of the Southern Nevada Water Authority in Clark County.

3.1.11.1.2 *Sewer*

Wastewater treatment in the Las Vegas Valley occurs in facilities of the City of Las Vegas (which also serves the City of North Las Vegas), Boulder City, Henderson, and the Clark County Water Reclamation District (DIRS 181261-SNWA n.d., p. v). The District serves portions of unincorporated Clark County and the communities of Blue Diamond, Indian Springs, Laughlin, Overton, and Searchlight (DIRS 181264-CCWRD n.d., all). Although other small wastewater treatment facilities might service parts of Clark County outside the populous areas of the Las Vegas Valley, septic systems provide the primary means of treatment in these outlying areas, particularly for private residences.

Most communities in southern Nye County rely primarily on septic systems or small communal wastewater treatment systems, with the exception of Beatty, which has municipal sewer service. Pahrump has no communitywide wastewater treatment system, although the formation of a sanitary district in the Pahrump area has been investigated to provide an area-wide solution for sanitary sewer service (DIRS 181265-Tri-Core Engineering 2005, all). Nye County is developing a service plan for the Pahrump Regional Planning District, which is the first required step in the formation of a sanitary sewer district.

3.1.11.2 Energy

3.1.11.2.1 *Electric Power*

The Yucca Mountain FEIS described the distributors that supply electric power in the region of influence: Nevada Power Company, Valley Electric Association, and Lincoln County Power District No. 1.

Nevada Power Company supplies electricity to southern Nevada in a corridor from southern Clark County that includes Las Vegas, North Las Vegas, Henderson, and Laughlin, to the Nevada Test Site in Nye County. The power sources were approximately 39 percent company-generated and 61 percent purchased power in 2005. In 2005, Nevada Power Company sold 21 million megawatt-hours to its 770,000 customers, and the peak load was the highest ever at just under 5,600 megawatts. The company has an annual customer growth rate of approximately 6 percent, the highest of any electric utility in the country (DIRS 172302-Nevada Power Company 2004, all). It forecasts a 2.1-percent average rate of growth in peak demand from 2007 through 2026, when it should reach an anticipated level of about 9,400 megawatts (DIRS 185100-Gecol 2007, p. 33). To keep pace with demands for electricity, Nevada Power Company must build more substations and transmission and distribution facilities each year. It added a 1,160-megawatt generating station and a 75-megawatt unit in early 2006 (DIRS 181270-Nevada Power Company 2006, all). The completion of several other projects, which include the first two phases of the Centennial project (a transmission line and substation construction project) and the ongoing construction at existing power plants, should ensure an adequate supply of electric power for the next several years (DIRS 173383-Nevada State Office of Energy 2005, p. 34). A projected shortfall between demand and available resources could occur after 2011, which will require the future addition of resources to maintain resource adequacy and ensure system reliability (DIRS 185100-Gecol 2007, pp. 34 to 38).

The Valley Electric Association distributes power to southern Nye County, which includes Pahrump, Amargosa Valley, Beatty, and the Nevada Test Site. The Western Area Power Administration allocates Valley Electric Association a portion of the lower-cost hydroelectric power from the Colorado River dams. However, the combination of increased demand and low water levels has decreased the hydroelectric power share to only 20 percent of Valley Electric Association's total electricity resources. The private market supplements power to meet the demands of association members. The costs of purchased power represent 62 percent of the total expenses of the cooperative. The amount of energy that Valley Electric Association sells annually to its members almost tripled in the 11 years from 1985 through 1995. The annual sales of energy increased by another 100 million kilowatt-hours between 1995 and 2005. In 2005, Valley Electric Association sold approximately 400 million kilowatt-hours to its 19,000 members. The association invested more than $4.3 million in 2005 in new plant facilities and system improvements to ensure continued reliable service to its members (DIRS 181273-VEA n.d., all).

Lincoln County Power District No. 1 is a general-improvement district with headquarters in Caselton, Nevada, that serves approximately 820 customers. It supplies more than 72,000 megawatt-hours per year (DIRS 173383-Nevada State Office of Energy 2005, p. 40).

The Nevada Test Site power grid provides transmission of electric power for ongoing operations at Yucca Mountain. At present, two commercial utility companies own transmission lines that supply electricity to the Nevada Test Site (Figure 3-18). The description of the existing Test Site power supply incorporates by reference Section 3.1.11.2 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, p. 108).

Table 3-18 lists the historical electricity use (partially estimated) for ongoing Yucca Mountain operations for 1995 through 2000. Annual power use and peak demand declined and stabilized at a level lower than the 1997 values due to the decline of site activity after 1997. From 1995 through 1997, Yucca Mountain ongoing operations accounted for about 15 to 20 percent of the electric power the Nevada Test Site used.

3.1.11.2.2 *Fossil Fuel*

Tanker trucks deliver fossil fuels (heating oil, propane, diesel, gasoline, and kerosene) to the Nevada Test Site and the Yucca Mountain site from readily available supplies in southern Nevada. Since 2002, when Congress and the President designated the site as suitable for a repository, consumption of fossil fuels by the Yucca Mountain Project has declined in step with the reduction in site characterization activities.

The fossil-fuel system in the region of influence, the State of Nevada, has sufficient capacity to meet normal Nevada demands. However, the isolation of Nevada cities and the limited number of pipelines that provide service to the state can make the system marginally reliable (DIRS 173383-Nevada State Office of Energy 2005, p. 69).

3.1.11.3 Site Services

DOE has established a support infrastructure to provide emergency services to the Yucca Mountain Project. The *Yucca Mountain Project Emergency Management Plan* describes emergency planning, preparedness, and response (DIRS 167254-DOE 2003, all). The Yucca Mountain Project cooperates with the Nevada Test Site in such areas as training, emergency drills, and exercises to provide full emergency preparedness capability. In addition, the Yucca Mountain Project trains and maintains an underground rescue team. The Nevada Test Site provides support for the Yucca Mountain security program, fire protection, and medical services. The Nye County Sheriff's Department provides traffic enforcement and has authority for civil disturbances. The Yucca Mountain Project has access to a Flight for Life helicopter that can transport two victims to a trauma center in Las Vegas, Nevada.

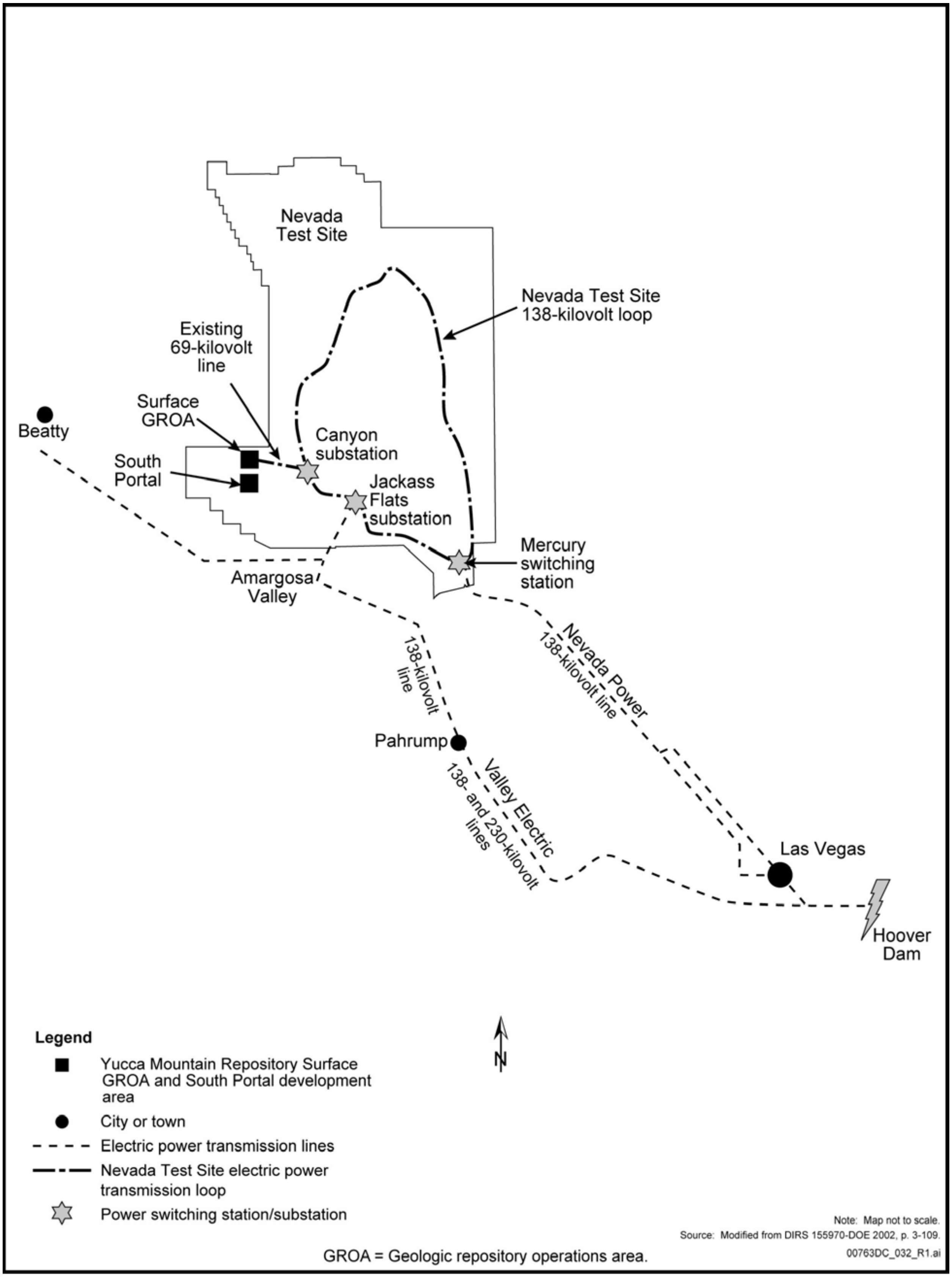


Figure 3-18. Existing Nevada Test Site electric power supply.

Table 3-18. Electric power use for the Exploratory Studies Facility and Field Operations Center.

Fiscal year[a]	Consumption (megawatt-hours)	Peak (megawatts)
1995	9,800	3.5
1996	19,000	4.9
1997	23,000	5.3
1998[b]	21,000[b]	4.2[b]
1999[b]	17,000[b]	4.2[b]
2000[b]	8,700[b]	4.2[b]

Source: DIRS 155970-DOE 2002, p. 108.

a. Before 1995, Yucca Mountain Project power was not separately metered.

b. Estimated.

3.1.12 WASTE AND HAZARDOUS MATERIALS

This section summarizes, incorporates by reference, and updates as appropriate Section 3.1.12 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-110 to 3-312). This section discusses changes in the plans for treatment and disposal of waste and the management of hazardous materials at the proposed repository since the completion of the Yucca Mountain FEIS, and it reevaluates the capacities of regional facilities that could receive waste from Yucca Mountain.

The region of influence for waste and hazardous materials consists of on- and offsite areas, including landfills and hazardous and radioactive waste processing and disposal sites, in which DOE would dispose of waste it generated under the Proposed Action. At present, the types of waste the Yucca Mountain Project generates are *solid waste* and construction debris, oil-contaminated debris, hazardous waste, *sanitary sewage*, and wastewater.

3.1.12.1 Solid Waste

DOE disposes of solid waste from the Yucca Mountain Project in landfills on the Nevada Test Site in Areas 23 and 9. Both landfill capacities and their estimated operational life spans have not changed since the completion of the Yucca Mountain FEIS. Although DOE currently disposes of solid waste at the Nevada Test Site, it could send such waste to other locations on the Test Site or in the analyzed land withdrawal area, or to nearby municipal solid waste landfills. In addition to the landfills on the Test Site, there are 20 operating municipal solid waste landfills including four *industrial waste* landfills in Nevada (DIRS 184969-NDEP 2007, Appendix 3). Since 2002, the total capacity of landfills in Nevada has increased from 150 million cubic meters (200 million cubic yards) to 1.1 billion cubic meters (1.4 billion cubic yards).

Although DOE could dispose of solid waste throughout the state, the landfills that would be the most likely to receive waste from Yucca Mountain are those in Nye, Lincoln, Clark, and Esmeralda counties. Of those landfills, the Apex Regional landfill in Clark County is the largest municipal landfill and receives over half of the waste disposed of in Nevada, averaging over 10,000 metric tons (11,000 tons) of solid waste per day. Based on current waste disposal rates and remaining lifespan estimates from the Nevada Division of Environmental Protection, the Apex Regional landfill has a total of approximately 144 remaining life years left and a total capacity of about 661 million cubic meters (865 million cubic yards).

In addition, DOE transports recyclable materials from site maintenance activities off the site for recycling. Recyclable materials include paper, cardboard, aluminum cans, scrap metal, used oil, used antifreeze, and lead-acid batteries.

3.1.12.2 Hazardous Waste Disposal Facilities

> **HAZARDOUS WASTE**
>
> Waste designated as hazardous by Environmental Protection Agency (EPA) or State of Nevada regulations. Hazardous waste, defined under the Resource Conservation and Recovery Act, is waste that poses a potential hazard to human health or the environment when improperly treated, stored, or disposed of. Hazardous wastes appear on special EPA lists or possess at least one of the following characteristics: ignitability, corrosivity, toxicity, or reactivity. Hazardous waste streams from the repository could include certain used rags and wipes contaminated with solvents.

DOE currently contracts with permitted hazardous waste vendors to ship hazardous waste from the Yucca Mountain site to offsite treatment, storage, and disposal facilities that handle waste under the provisions of the *Resource Conservation and Recovery Act*, as amended (42 U.S.C. 6901 et seq.). Although commercial companies that collect hazardous waste for processing and disposal could use facilities throughout the country, DOE considered only the currently available hazardous waste facilities in the western United States. Estimates for the western states place the hazardous waste disposal capacity as high as 50 times the demand for landfills and seven times the demand for incineration until at least 2013. There are currently three hazardous waste treatment, storage, and disposal facilities in Nevada. The American Ecology Treatment and Disposal Site in the town of Beatty treats and disposes of hazardous wastes, nonhazardous industrial wastes, and wastes that contain polychlorinated biphenyls. Safety-Kleen Systems operates a hazardous waste treatment, storage, and disposal facility in North Las Vegas and Phillip Services Corporation operates a similar facility in the City of Fernley.

DOE sends recyclable hazardous wastes, such as solvents, corrosives, and fuels, to appropriate facilities for recycling.

3.1.12.3 Wastewater

DOE uses a septic system to treat and dispose of sanitary sewage at the Yucca Mountain site. The system design can handle a daily flow of about 76 cubic meters (20,000 gallons) (DIRS 102599-CRWMS M&O 1998, p. 64).

3.1.12.4 Existing Low-Level Radioactive Waste Disposal Facilities

> **AGREEMENT STATE**
>
> A state that reaches an agreement with the Nuclear Regulatory Commission to assume regulatory authority to license and regulate radioactive materials.

At present, the Yucca Mountain Project does not generate *low-level radioactive waste*, but it would during repository operations. This section describes only those facilities that currently receive low-level radioactive waste in the United States, but DOE has not committed to a disposal location for such waste. Low-level radioactive waste disposal occurs at a DOE low-level waste disposal site, sites in *Agreement States*, or NRC-licensed sites. The Nevada Test Site is one of the nation's approved sites for the disposal of low-level waste. Only DOE and U.S. Department of Defense generators may ship waste for disposal at the

Test Site. The Radioactive Waste Acceptance Program at the Nevada Test Site ensures safe disposal operation by requiring waste generators to meet strict waste acceptance criteria before *shipment* and disposal (DIRS 181748-DOE 2006, all).

In addition to the Nevada Test Site, there are three existing commercial low-level radioactive waste disposal facilities in the United States: EnergySolutions Barnwell Operations in Barnwell, South Carolina; U.S. Ecology in Richland, Washington; and EnergySolutions Clive Operations in Clive, Utah. These facilities are in Agreement States and accept waste from all or parts of the nation. The NRC evaluates Agreement State programs every 2 to 4 years to ensure consistency in the nation's materials and safety programs. There are current or anticipated limitations associated with these three commercial disposal sites. EnergySolutions Barnwell Operations is scheduled to be closed to out-of-state waste in 2008; U.S. Ecology generally accepts waste only from sites in the regional compact that includes the State of Washington; and EnergySolutions Clive Operations is licensed to accept only Class A wastes. The regional compact that includes Washington has a contract for receiving low-level waste from the regional compact that includes Nevada but, if Barnwell closes, the U.S. Ecology facility would be the only licensed commercial facility available for disposal of Class B and C low-level waste.

3.1.12.5 Materials Management

DOE has programs and procedures in place for the Yucca Mountain Project to procure and manage hazardous and nonhazardous materials (DIRS 104842-YMP 1996, all). By using these programs, DOE minimizes health and environmental hazards of hazardous materials at the Yucca Mountain site. DOE would continue the use of the programs throughout repository operations.

The *Nevada Combined Agency Hazardous Material Facility Report* (DIRS 181526-Spence 2007, all) from the Nevada State Fire Marshal's Office lists the hazardous materials that meet or exceed the thresholds for storage of hazardous materials that the state and the federal *Emergency Planning and Community Right-to-Know Act*, as amended (42 U.S.C. 1001 et seq.) have established.

3.1.13 ENVIRONMENTAL JUSTICE

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, directs federal agencies to "promote nondiscrimination in Federal programs substantially affecting human health and the environment, and provide *minority* and low-income communities access to public information on, and an opportunity for public participation in, matters relating to human health or the environment." Executive Order 12898 also directs agencies to identify and consider disproportionately high and adverse human health or environmental impacts of their actions on minority and low-income communities and American Indian tribes, as well as provide opportunities for community input to the *National Environmental Policy Act*, as amended (NEPA; 42 U.S.C. 4321 et seq.) process, which includes input on potential effects and *mitigation* measures. Executive Order 12898 and its associated implementing guidance establish the framework for characterization of the affected environment for

ENVIRONMENTAL JUSTICE TERMS

Minority:
Hispanic, Black, Asian/Pacific Islander, American Indian/Eskimo, Aleut, and other nonwhite person.

Low income:
Below the poverty level as defined by the U.S. Bureau of the Census.

environmental justice. Section 3.1.6.2 of this Repository SEIS discusses the ties of American Indians to cultural characteristics or historic resources in the area.

This section summarizes and incorporates by reference Section 3.1.13 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-112 to 3-118) and describes the minority and low-income populations in the region of influence for the Yucca Mountain Repository that could experience disproportionately high and adverse human health or environmental effects from the Proposed Action. The analysis considered minority and poverty data in relation to the smallest census areas for which information was available. The analysis used block data for identification of minority areas and block group data for low-income areas.

The regions of influence for environmental justice in this Repository SEIS vary with resource area and correspond to the region of influence for each resource area. DOE analyzed U.S. Bureau of the Census block data for minority populations and block group data for low-income populations partly or completely within the regions of influence where the percentages of minority or low-income residents were meaningfully greater than average.

On August 24, 2004, the NRC issued the *Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions* (69 FR 52040-52048, August 24, 2004). The policy statement recommends examination of an 80-kilometer (50-mile) radius for licensing and regulatory actions involving power *reactors.* After identification of the impacted area, the policy statement recommends identification of potentially affected low-income and minority communities. Under current NRC staff guidance, an agency identifies a minority or low-income community by comparing the percentage of minority or low-income population in the county (or parish) and the state. If the percentage in the impacted area significantly exceeds the state or county percentage for either the minority or low-income population, the policy calls for consideration of environmental justice in greater detail. NRC staff guidance defines “significantly” to be 20 percentage points. As an alternative, if either the minority or low-income population percentage in the impacted area exceeds 50 percent, the policy calls for consideration of environmental justice matters in greater detail. DOE employed the NRC policy for this Repository SEIS.

3.1.13.1 State of Nevada

This Repository SEIS uses minority and poverty data from the 2000 Census, which indicates that minority persons comprised 35 percent of the population in Nevada. Figure 3-19 shows the 2000 Census blocks in which the minority population equaled or exceeded 50 percent within the 80-kilometer (50-mile)-radius around Yucca Mountain. About 11 percent of the people of Nevada were living in poverty. The poverty threshold in the 2000 Census for a family of four was a 1999 income of $17,603.

3.1.13.2 Clark County

In 2000, the minority population of Clark County was approximately 40 percent of the total population. Several census blocks in the region of influence had minority populations equal to or greater than 50 percent. In Clark County, 11 percent of the population was living in poverty. There were four block groups in Clark County within or intersected by the 80-kilometer (50-mile)-radius around Yucca Mountain. Block group poverty levels ranged from 0 to approximately 11 percent. No block group exceeded 31 percent.

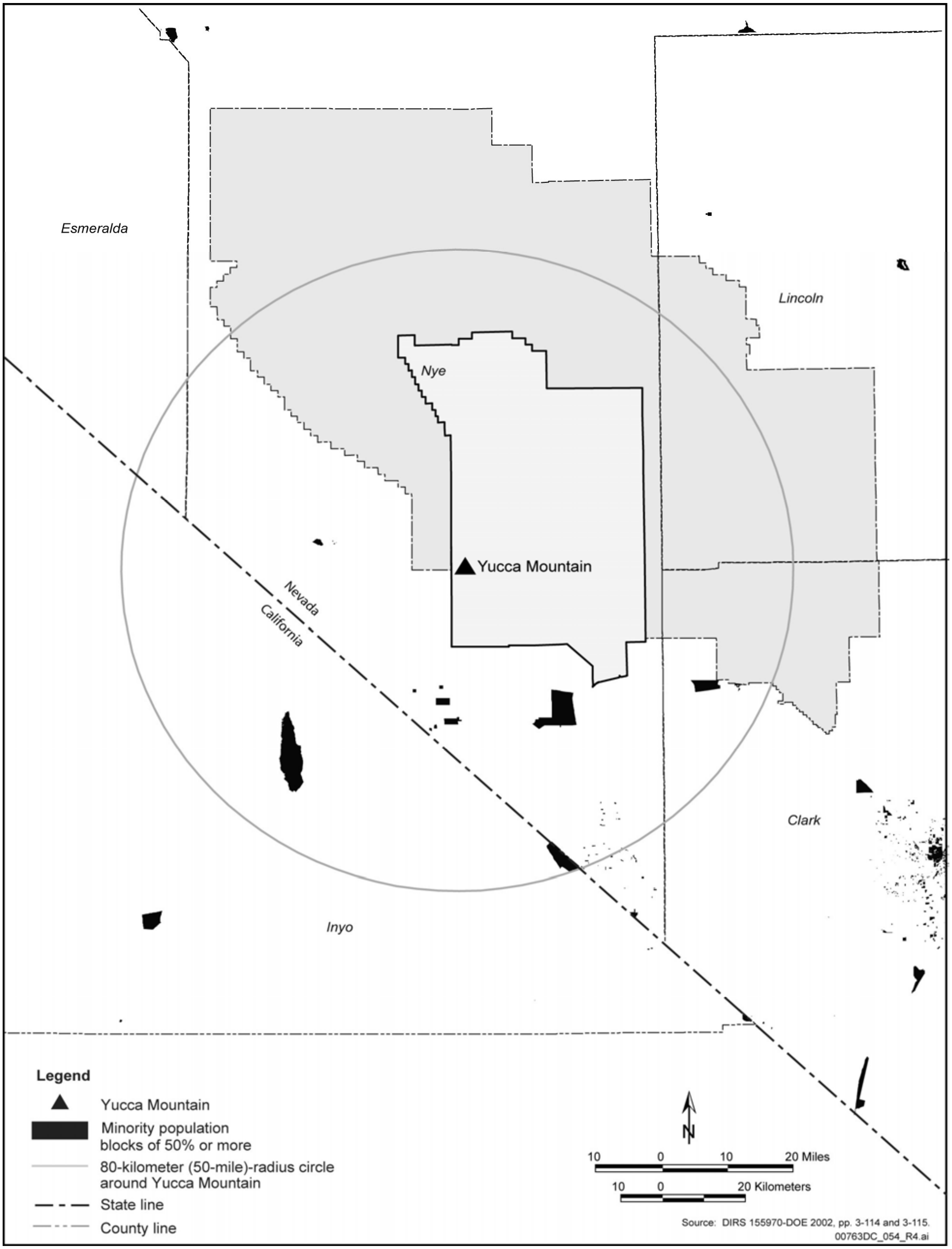


Figure 3-19. 2000 Census blocks with minority populations of 50 percent or more within the 80-kilometer (50-mile)-radius circle.

3.1.13.3 Nye County

Based on the 2000 Census, the minority population of Nye County was approximately 15 percent. Several census blocks in the region of influence had a minority population of 50 percent or more. Approximately 11 percent of the Nye County population was living in poverty. Fifteen block groups in Nye County were within or intersected the 80-kilometer (50-mile)-radius around Yucca Mountain. Block-group poverty levels ranged from approximately 1 to 20 percent. No block group exceeded 31 percent.

3.1.13.4 Inyo County, California

In 2000, the minority population of California was approximately 40 percent. The minority population of Inyo County was approximately 20 percent. Several census blocks within the 80-kilometer (50-mile) radius have a minority population of 50 percent or more. About 14 percent of the people of California were living in poverty. One block group near Stewart Valley lies partly within the affected area. Approximately 13 percent of the Inyo County block groups were low-income. The percentage of low-income residents would have to be 34 percent in the Inyo County block group to be meaningfully greater than average.

3.2 Affected Environment Related to Transportation

To assess the potential impacts of its transportation-related activities, DOE must characterize baseline environmental conditions. Section 3.2.1 provides baseline information about national transportation, and it summarizes, incorporates by reference, and updates Section 3.2.1 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-119 to 3-121). Section 3.2.2 incorporates Chapter 3, Sections 3.2 and 3.3 of the Rail Alignment EIS for baseline conditions for construction and operation of a railroad in Nevada. Section 3.2.3 reports recent data on traffic conditions in the Yucca Mountain region.

3.2.1 NATIONAL TRANSPORTATION

The loading and shipping of spent nuclear fuel and high-level radioactive waste would occur at 72 commercial and 4 DOE sites in 34 states. DOE would transport most of these materials to the Yucca Mountain site by rail and the remainder by *overweight trucks*. Trains would travel on existing *railroads* to a point in Nevada from which DOE would construct a new railroad to Yucca Mountain, as the Rail Alignment EIS explains. Trucks would travel on existing highways. DOE would use *heavy-haul trucks* for short-distance transport of spent nuclear fuel from some generator sites to nearby railheads.

The national transportation of spent nuclear fuel and high-level radioactive waste (which would include transportation in Nevada to a point of departure for the Caliente or Mina rail corridor) would use existing highways and railroads and would represent a small fraction of the existing national highway (0.0002 percent of truck miles per year) and railroad traffic (0.006 percent of railcar miles per year) (DIRS 181280-DOT 2006, all; DIRS 181282-AAR 2006, all). Because there would be no new land acquisition or construction to accommodate national transportation, this Repository SEIS focuses on potential impacts to human health and safety and the potential for *accidents* along the national transportation routes.

The region of influence for public health and safety along existing transportation routes is 800 meters (0.5 mile) from the centerline of the transportation rights-of-way and from the boundary of railyards for *incident-free* (nonaccident) conditions. The region of influence extends to 80 kilometers (50 miles) to address potential human health and safety impacts from accident scenarios.

For this Repository SEIS, DOE used the TRAGIS computer program (DIRS 181276-Johnson and Michelhaugh 2003, all) to derive representative highway and rail routes for transportation of spent nuclear fuel and high-level radioactive waste for use in the analysis of health and safety impacts. TRAGIS based the estimated population densities along routes on the 2000 Census. TRAGIS identified highway routes from commercial and DOE generator sites to the proposed repository that would meet U.S. Department of Transportation regulations; no corresponding federal regulations constrain the routing of rail shipments. The analysis used population densities along the highway and rail routes to estimate human health impacts and consequences of transportation. Except in Nevada, the analysis based projected growth in populations along routes on Bureau of the Census forecasts of state populations to 2067. For routes in Nevada, DOE used 2000 Census data to develop an initial estimate of the populations within 800 meters (0.5 mile) along highways, commercial rail lines, and the potential rail *alignments* in the Caliente and Mina rail corridors. The analysis accounted for growth in populations along Nevada routes by using forecasts of population growth in Nevada counties from the REMI computer program. The analysis used population growth forecasts from Clark County, Nye County, and the Nevada State Demographer and data for each county from the 2000 Census to estimate populations in Nevada in 2067.

Appendix G describes the representative routes that DOE used for analysis in this Repository SEIS. The Department would make actual transportation mode and routing decisions on a route-specific basis during the transportation planning process, if there was a decision to build a repository at Yucca Mountain. The following sections discuss transportation routes for rail, legal-weight highway, and heavy-haul highway shipments from generator sites.

3.2.1.1 Rail Transportation Routes

In most cases, rail transportation of spent nuclear fuel and high-level radioactive waste would originate with shortline rail carriers that provide service to the commercial and DOE sites. At rail yards near the sites, dedicated rail shipments would switch from shortline carriers to national mainline railroads. Figure 2-11 in Chapter 2 shows the representative rail routes that DOE analyzed and could use for shipments to Nevada. This network has about 230,000 kilometers (140,000 miles) of track that link the nation's major population centers and industrial, agricultural, energy, and mineral resources (DIRS 181282-AAR 2006, p. 3). With the exception of shortline regional railroads that serve the commercial and DOE sites, cross-country shipments would move on mainline railroads. Appendix G describes the representative rail routes.

3.2.1.2 Highway Transportation Routes

Highway transportation of spent nuclear fuel and high-level radioactive waste to the Yucca Mountain site would use local highways near the commercial and DOE sites and near Yucca Mountain, Interstate Highways, Interstate bypasses around metropolitan areas, and preferred routes designated by state routing agencies where applicable. Figure 2-12 in Chapter 2 shows the representative truck routes that DOE analyzed and could use for shipments to Nevada. DOE calculated population density distributions along the routes to support calculations of risk to human health.

USE OF REPRESENTATIVE ROUTES IN IMPACT ANALYSIS

At this time, before receipt of a construction authorization for the repository and years before a possible first shipment, DOE has not identified the actual routes it would use to ship spent nuclear fuel and high-level radioactive waste to Yucca Mountain. However, the highway and rail routes that DOE used for analysis in this Repository SEIS are representative of routes that it could use. The highway routes conform to U.S. Department of Transportation regulations (49 CFR 397.101). These regulations, which the Department of Transportation developed for Highway Route-Controlled Quantities of Radioactive Materials, require such shipments to use preferred routes that would reduce the time in transit. A preferred route is an Interstate System highway, bypass, beltway, or an alternative route designated by a state routing agency. Alternative routes can be designated by states and tribes under U.S. Department of Transportation regulations (49 CFR 397.103) that require consideration of the overall risk to the public and prior consultation with local jurisdictions and other states. Federal regulations do not restrict the routing of spent nuclear fuel and high-level radioactive waste shipments by rail. However, for this analysis and to be consistent with rail industry practice, DOE assumed routes for rail shipments by giving priority to the use of rail lines that have the most rail traffic, (which are the best maintained and have the highest quality track), giving priority to originating railroads, minimizing the number of interchanges between railroads, and minimizing the travel distance.

3.2.1.3 Heavy-Haul Truck Routes

For generator sites that do not have direct rail service, DOE would transport spent nuclear fuel on heavy-haul trucks to nearby railheads. Heavy-haul trucks would use local highways to carry the spent nuclear fuel to a nearby railhead for transfer to railcars for transport to Nevada.

3.2.2 TRANSPORTATION IN NEVADA

Chapter 3, Sections 3.2 and 3.3, of the Rail Alignment EIS present information about the affected environment related to the construction and operation of a railroad in Nevada. This Repository SEIS incorporates by reference Sections 3.2 and 3.3 of the Rail Alignment EIS.

3.2.3 TRAFFIC IN THE YUCCA MOUNTAIN REGION

Main roads near Yucca Mountain are generally two-lane highways with very little daily traffic. Table 3-19 lists average daily traffic volumes along primary roads in the region of influence in 2005 (DIRS 178749-NDOT n.d., all). These traffic volumes indicate that roadways near the Yucca Mountain site rarely experience congestion. The *Highway Capacity Manual 2000* defines the levels of service, which is an industry standard for traffic engineering (DIRS 176524-Transportation Research Board 2001, all). The manual defines six levels of service that reflect the level of traffic congestion and qualify the operating conditions of a roadway. The six levels range from A to F, as best (free flow, little delay) to worst (congestion, long delays). Factors that influence the operation of a roadway or intersection include speed, delay, travel time, freedom to maneuver, traffic interruptions, comfort, convenience, and safety.

The Highway Capacity Manual describes the levels of service as follows:

- Level of service A describes completely free-flow conditions. Individual drivers are virtually unaffected by the presence of other vehicles in the traffic stream.

Table 3-19. Average daily traffic counts in southern Nevada, 2005.

Roadway and location of traffic count station	Vehicles per day	Level of service
U.S. Highway 95, 0.3 kilometer (0.19 mile) north of State Route 373 (Nye County)	2,600	B
U.S. Highway 95, 2.4 kilometers (1.5 miles) south of State Route 373 (Nye County)	2,900	B
State Route 373, 0.8 kilometer (0.5 mile) south of U.S. Highway 95 (Nye County)	560	A
U.S. Highway 95, 6.4 kilometers (4.0 miles) north of the Mercury interchange (Nye County)	3,200	B
State Route 160, 0.2 kilometer (0.1 mile) south of U.S. Highway 95 (Nye County)	990	A

Source: DIRS 178749-NDOT n.d., all.

- Level of service B also indicates free flow, but the presence of other vehicles becomes more noticeable. Freedom to select desired speeds is relatively unaffected, but there is a slight decline in the freedom to maneuver within the traffic stream from level of service A.

- Level of service C is in the range of stable flow, but marks the beginning of the range of flow in which operation of individual drivers becomes significantly affected by interactions with others in the traffic stream. The selection of speed is now affected by others and maneuvering requires substantial vigilance on the part of the driver.

- Level of service D represents high density but stable flow. Speed and freedom to maneuver are severely restricted, and the driver experiences a generally poor level of comfort and convenience.

- Level of service E represents operating conditions at or near capacity. All speeds are reduced to a low but relatively uniform value.

- Level of service F indicates a breakdown of traffic flow or stop-and-go traffic. This condition exists wherever the amount of traffic approaching a point exceeds the amount that can cross the point. Backups form behind such locations. Operations within the backups are characterized by stop-and-go waves, and they are extremely unstable.

The Manual generally considers levels of service A, B, and C to be good operating conditions in which motorists experience minor or tolerable delays of service. As Table 3-19 indicates, the roads in the vicinity of Yucca Mountain are level of service A or B.

Most roads in metropolitan Clark County have levels of service that reflect congestion. The most congested area is the U.S. 93, U.S. 95, I-515, and I-15 interchanges, which are known locally as the “Spaghetti Bowl.” The Spaghetti Bowl area is at level of service F during peak hours (DIRS 155779-DOE 1999, p. 3-1).

3.3 Affected Environment at Commercial and DOE Sites

DOE analyzed the impacts for the *No-Action Alternative* of not constructing and operating a geologic repository at Yucca Mountain. The Department assumed that spent nuclear fuel and high-level radioactive waste would remain at commercial and DOE sites throughout the United States. Because neither the No-Action Alternative nor the environmental baseline conditions at the generator sites have changed significantly, DOE has neither updated the affected environment nor reanalyzed the No-Action Alternative for this Repository SEIS. This section summarizes and incorporates by reference Section 3.3

of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-183 to 3-194), which included baseline environmental factors at commercial and DOE sites such as land use requirements, radiological effluents, worker and offsite populations, and occupational and public radiation doses. These factors provided a basis for comparison of impacts between the Proposed Action and the No-Action Alternative in the Yucca Mountain FEIS.

3.3.1 SITE ENVIRONMENTAL FACTORS

3.3.1.1 Commercial Sites

The Yucca Mountain FEIS presented general site environmental factors for the 72 commercial nuclear power plant sites in the contiguous United States. Nuclear power plants typically are on flat to rolling countryside in wooded or agricultural areas. Site areas range from 0.34 to 120 square kilometers (0.13 to 46 square miles).

The average permanent staff at a nuclear power plant ranges from 800 to 2,400 workers. In addition, many temporary workers are necessary for tasks that occur during refueling and maintenance outages. In rural communities, this temporary employment can have a substantial effect on the local economy. Nuclear power plants represent investments of several billion dollars each, which generates tax revenue and often enables higher quality and more extensive public services.

Nuclear power plants release small amounts of radioactive materials to the environment through atmospheric and aquatic pathways. Releases to the atmosphere consist of noble gases, tritium, isotopes of iodine, and cesium. Radioactive effluents that sites release to aquatic pathways consist primarily of *fission* and activation products such as isotopes of cesium and cobalt. Sites monitor these materials carefully before and during effluent releases to comply with the licensed release limits.

Commercial sites routinely report worker occupational radiation exposures. The data indicate most of the radiation dose to workers is from external radiation rather than internal exposure to inhaled or ingested radioactive material from the operation of the *nuclear reactor*. In 1999, the total collective occupational dose for all operating commercial reactors was almost 14,000 person-rem. DOE based this collective dose on data from 114,000 monitored personnel. Of these monitored workers, about half had no measurable dose.

The Yucca Mountain FEIS listed and discussed radiation exposures to the public at commercial sites. In 1992, the estimated total population doses for populations living within 80 kilometers (50 miles) of operating nuclear power reactors were 32 person-rem by waterborne pathways and 15 person-rem by airborne pathways. Estimated population dose commitments from both pathways varied widely among the sites.

3.3.1.2 DOE Sites

The Yucca Mountain FEIS presented general site environmental factors for five DOE sites at which spent nuclear fuel and high-level radioactive waste exist. The environmental factors were land use, socioeconomics, and occupational radiation exposure. Large expanses of federally owned land surround and buffer the public from potential effects at three DOE sites—the Hanford Site, Idaho National Laboratory, and Savannah River Site. The Fort St. Vrain Independent Spent Nuclear Fuel Installation in

Colorado and the West Valley Demonstration Project in New York are on much smaller tracts with nearby lands having low density and mostly agricultural and residential land uses.

Based on their large employment bases, the Hanford Site, Idaho National Laboratory, and Savannah River Site represent a substantial portion of local workforces. In addition to base employment, DOE sites contribute to the local economy through the creation of *indirect employment* and through the local purchase of goods and services.

The Yucca Mountain FEIS discussed occupational radiation exposures for workers at the DOE sites. For the five DOE sites, the 1999 total collective dose for workers was about 380 person-rem. There were almost 6,000 individuals with measurable doses, and the average annual dose was about 60 millirem per person. The Fort St. Vrain site reported no measurable doses for 1999. In the Yucca Mountain FEIS, DOE estimated the collective doses for populations who lived within 80 kilometers (50 miles) of the five DOE sites. In 1999, the total estimated offsite population dose was about 7.1 person-rem. About 2.5 million people received this dose; the average was about 0.003 millirem per person, which is a very small fraction of the annual dose from natural background radiation of about 300 millirem in the United States.

3.3.2 REGIONAL ENVIRONMENTAL FACTORS

DOE used a regional approach that divided the continental United States into five regions (Figure 3-20) to analyze the No-Action Alternative in the Yucca Mountain FEIS. The affected environment for each region includes the inventory of spent nuclear fuel and high-level radioactive waste in the region, climatic parameters, groundwater flow times, affected waterways (rivers), river flow, and the identification of populations that depend on drinking water from those waterways. The use of these regional environmental factors resulted in representative values that are not susceptible to short-term or frequent fluctuations but instead evolve over long periods (decades). As a consequence, the regional factors would not be different from those in the Yucca Mountain FEIS. Tables 3-20 through 3-23 provide the regional environmental factors from the FEIS that DOE used in the No-Action Alternative analyses.

Precipitation, rain days, wet days, and temperature are important climatic parameters to material degradation times and rates of release. Table 3-21 lists the regional values for each parameter along with precipitation chemistry (pH, chloride anions, and sulfate anions). Most of the radioactivity and metals from degraded material would seep into the groundwater and flow with it to surface outcrops, rivers, or streams. Table 3-22 lists the ranges of groundwater flow times in each region. The analysis calculated these ranges as the estimated times in years that it takes for groundwater, and separately for contaminants in the groundwater, to reach the surface-water resource nearest to each site at which people could obtain drinking water. The range is the shortest and longest flow time, depending on the site. Most of the estimated population dose for the No-Action Alternative would be a result of drinking contaminated surface water. Table 3-23 lists the number of people who would use the public drinking water systems that degradation of radioactive materials could affect.

Figure 3-20. Commercial and DOE sites in each No-Action Alternative analysis region.

Table 3-20. Proposed Action quantities of spent nuclear fuel (*metric tons of heavy metal*) and canisters of high-level radioactive waste in each geographic region.[a]

Region	Commercial spent nuclear fuel	DOE spent nuclear fuel	High-level radioactive waste
1	16,800	0	300
2	18,900	30	6,000
3	14,700	0	0
4	7,200	0	0
5	5,400	2,300	2,000
Totals	63,000	2,300	8,300

Source: DIRS 155970-DOE 2002, p. 3-191.
a. Totals might differ from sums due to rounding.

Table 3-21. Regional environmental parameters.

Region	Precipitation rate (centimeters per year)[a]	Percent rain days (per year)	Percent wet days (per year)	pH	Precipitation chemistry: Chloride anions (weight percent)	Precipitation chemistry: Sulfate anions (weight percent)	Average temperature (°C)[b]
1	110	30	31	4.4	6.9×10^{-5}	1.5×10^{-4}	11
2	130	29	54	4.7	3.9×10^{-5}	9.0×10^{-5}	17
3	80	33	42	4.7	1.6×10^{-5}	2.4×10^{-4}	10
4	110	31	49	4.6	3.5×10^{-5}	1.1×10^{-4}	17
5	30	24	24	5.3	2.1×10^{-5}	2.5×10^{-5}	13

Source: DIRS 155970-DOE 2002, p. 3-192.
a. To convert centimeters to inches, multiply by 0.3937.
b. To convert °C to °F, add 17.78 and then multiply by 1.8.
°C = degrees Celsius. °F = degrees Fahrenheit.

Table 3-22. Ranges of flow time (years) for groundwater and contaminants in the unsaturated and saturated zones in each region.

Region	Contaminant K_d[a,b] (milliliters per gram)	Unsaturated zone: Water flow time	Unsaturated zone: Contaminant flow time	Saturated zone: Groundwater flow time	Saturated zone: Contaminant flow time	Total contaminant flow time
1	0 – 100	0.7 – 4.4	0.4 – 2,100	0.3 – 56	10 – 5,000	10 – 6,000
2	10 – 250	0.6 – 10	35 – 5,000	3.3 – 250	11 – 310,000	460 – 310,000
3	10 – 250	0.5 – 14	32 – 1,500	1.3 – 410	9 – 44,000	65 – 45,000
4	10 – 100	0.2 – 7.1	110 – 2,300	3.9 – 960	300 – 520,000	460 – 520,000
5	0 – 10	0.9 – 73	14 – 4,700	1.7 – 170	0 – 25,000	200 – 26,000

Source: DIRS 155970-DOE 2002, p. 3-192.
a. K_d = equilibrium adsorption coefficient.
b. The K_d would be 0 if there were no soil at the site.

Table 3-23. Public drinking water systems and the populations that use them in the five regions.

Region	Drinking water systems	Population
1	85	10,000,000
2	150	5,600,000
3	150	12,000,000
4	95	600,000
5	6	2,800,000
Totals	486	31,000,000

Source: DIRS 155970-DOE 2002, p. 3-194.

REFERENCES

181282	AAR 2006	AAR (Association of American Railroads) 2006. *Railroad Facts.* 2006 Edition. Washington, D.C.: Association of American Railroads. TIC: 259612.
181162	AHA 2006	AHA (American Hospital Association) 2006. *AHA Guide to the Health Care Field.* 2007 Edition. Chicago, Illinois: Health Forum. TIC: 259357.
103071	ANS 1992	ANS (American Nuclear Society) 1992. *American National Standard for Determining Design Basis Flooding at Power Reactors Sites.* ANSI/ANS-2.8-1992. La Grange Park, Illinois: American Nuclear Society. TIC: 236034.
180951	BEA 2007	BEA (Bureau of Economic Analysis) 2007. "Nevada Per Capita Personal Income." *Regional Economic Accounts.* Table CA1-3. Washington, D.C.: U.S. Department of Commerce, Bureau of Economic Analysis. Accessed May 11, 2007. ACC: MOL.20070613.0007. URL: http://www.bea.gov/regional/reis/drill.cfm
180952	BEA 2007	BEA (Bureau of Economic Analysis) 2007. "United States Per Capita Personal Income." *Regional Economic Accounts.* Table CA1-3. Washington, D.C.: U.S. Department of Commerce, Bureau of Economic Analysis. Accessed May 11, 2007. ACC: MOL.20070613.0008. URL: http://www.bea.gov/regiona/reis/drill.cfm
173179	Belcher 2004	Belcher, W.R. 2004. *Death Valley Regional Ground-Water Flow System, Nevada and California - Hydrogeologic Framework and Transient Ground-Water Flow Model.* Scientific Investigations Report 2004-5205. Reston, Virginia: U.S. Geological Survey. ACC: MOL.20050323.0070.
181866	Belnap 2006	Belnap, J. 2006. "The Potential Roles of Biological Soil Crusts in Dryland Hydrologic Cycles." *Hydrological Processes, 20,* 3159-3178. New York, New York: Wiley InterScience. ACC: MOL.20070721.0100.
178610	Bland 2007	Bland, J. 2007. "Baseline: REMI Policy Insight Version 9, Last History Year 2004." E-mail from J. Bland to E. Gorsem, January 10, 2007, with attachment. ACC: MOL.20070119.0084.

101505	BLM 1986	BLM (Bureau of Land Management) 1986. *Visual Resource Inventory.* BLM Manual Handbook 8410-1. Washington, D.C.: U.S. Bureau of Land Management. ACC: MOL.20010730.0378.
103079	BLM 1998	BLM (Bureau of Land Management) 1998. *Proposed Las Vegas Resource Management Plan and Final Environmental Impact Statement.* Three volumes. Las Vegas, Nevada: Bureau of Land Management. ACC: MOL.20010724.0319.
176043	BLM 1998	BLM (Bureau of Land Management) 1998. *Record of Decision for the Approved Las Vegas Resource Management Plan and Final Environmental Impact Statement.* Las Vegas, Nevada: Bureau of Land Management, Las Vegas Field Office. ACC: MOL.20060313.0209.
172900	BLM 2003	BLM (Bureau of Land Management) 2003. *Nevada BLM Sensitive Species.* Las Vegas, Nevada: Bureau of Land Management. ACC: MOL.20050516.0552.
184655	BLM 2007	BLM (Bureau of Land Management) 2007. *Right-of-Way Grant N-47748 Issued.* N-47748. Las Vegas, Nevada: Bureau of Land Management. ACC: MOL.20071227.0033.
148091	BLS 1998	BLS (Bureau of Labor Statistics) 1998. "Safety & Health Statistics, Table 1. Incidence Rates of Nonfatal Occupational Injuries and Illnesses by Selected Industries and Case Types, 1997." Washington, D.C.: U.S. Department of Commerce. Accessed December 18, 1998. ACC: MOL.20010721.0025. URL: http://stats.bls.gov/news.release/osh.t01.htm
179131	BLS 2006	BLS (Bureau of Labor Statistics) 2006. "Table 1. Incidence Rates of Nonfatal Occupational Injuries and Illnesses by Industry and by Case Types, 2005." *Occupational Injuries and Illnesses (Annual).* Washington, D.C.: U.S. Department of Labor, Bureau of Labor Statistics. Accessed February 13, 2007. ACC: MOL.20070220.0267. URL: http://stats.bls.gov/news.release/osh.toc.htm
181688	Bowlby 2007	Bowlby, B. 2007. "Repository and Nye County Land Info." E-mail from B. Bowlby to J. Rivers, June 13, 2007, with attachment. ACC: MOL.20070712.0060; MOL.20070809.0080.
169734	BSC 2004	BSC (Bechtel SAIC Company) 2004. *Yucca Mountain Site Description.* TDR-CRW-GS-000001 Rev 02 ICN 01. Two volumes. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20040504.0008.

169989	BSC 2004	BSC (Bechtel SAIC Company) 2004. *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada.* ANL-MGR-GS-000001 Rev 02. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20041015.0002; DOC.20050718.0007.
170002	BSC 2004	BSC (Bechtel SAIC Company) 2004. *Future Climate Analysis.* ANL-NBS-GS-000008 Rev 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20040908.0005.
170009	BSC 2004	BSC (Bechtel SAIC Company) 2004. *Water-Level Data Analysis for the Saturated Zone Site-Scale Flow and Transport Model.* ANL-NBS-HS-000034 Rev 02. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20041012.0002; DOC.20050214.0002.
180788	BSC 2005	BSC (Bechtel SAIC Company) 2005. *Yucca Mountain Project Socioeconomic Monitoring Program Employment Data Report October 2004 through March 2005.* TDR-MGR-EV-000052 Rev 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20060306.0257.
179489	BSC 2006	BSC (Bechtel SAIC Company) 2006. *Chlorine-36 Validation Study at Yucca Mountain, Nevada.* TDR-NBS-HS-000017 Rev 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20060829.0002.
179878	BSC 2006	BSC (Bechtel SAIC Company) 2006. *Public Water System Operation and Maintenance Manual.* ESF-BSC-PRWS-MECH-0021 Rev 00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: SIT.20060501.0001.
179641	BSC 2007	BSC (Bechtel SAIC Company) 2007. *Project Design Criteria Document.* 000-3DR-MGR0-00100-000-007. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20071016.0005; ENG.20071108.0001; ENG.20080305.0002; ENG.20080305.0011; ENG.20080305.0012; ENG.20071220.0003; ENG.20080107.0001; ENG.20080107.0002; ENG.20080107.0016; ENG.20080107.0017; ENG.20080131.0006; ENG.20080306.0009; ENG.20080313.0004.
181770	BSC 2007	BSC (Bechtel SAIC Company) 2007. *Identification of Aircraft Hazards.* 000-30R-WHS0-00100-000-008. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070705.0002.
182591	BSC 2007	BSC (Bechtel SAIC Company) 2007. *Local Meteorology of Yucca Mountain, Nevada, 1994-2006.* TDR-MGR-MM-000002 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070905.0008.

184494	BSC 2007	BSC (Bechtel SAIC Company) 2007. *Seismic Analysis and Design Approach Document*. 000-30R-MGR0-02000-000-001. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20071220.0029; ENG.20080310.0015.
184497	BSC 2007	BSC (Bechtel SAIC Company) 2007. *RF Heating and Cooling Load Calculation (Tertiary Non-ITS).* 200-M8C-VCT0-00400-000-00C. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20071218.0014; ENG.20080103.0003; ENG.20080116.0001.
173226	Buqo 2004	Buqo, T.S. 2004. *Nye County Water Resources Plan.* Pahrump, Nevada: Nye County, Department of Natural Resources and Federal Facilities. ACC: MOL.20050418.0041.
181012	Bureau of the Census 1990	Bureau of the Census 1990. "1990 Population and Housing Unit Counts: United States, Table 4." *Selected Historical Decennial Census Population and Housing Counts, Urban and Rural Populations.* Washington, D.C.: U.S. Bureau of the Census. Accessed May 23, 2007. ACC: MOL.20070712.0033; MOL.20070918.0104.
155872	Bureau of the Census 2000	Bureau of the Census 2000. "Census 2000 Redistricting Data (Public Law 94-171) Summary File." *2000 Census of Population and Housing, Technical Documentation.* Washington, D.C.: U.S. Department of Commerce, Bureau of the Census. ACC: MOL.20011009.0041.
172310	Bureau of the Census 2004	Bureau of the Census 2004. "Nevada QuickFacts, Nye County, Nevada." Washington, D.C.: Bureau of the Census. Accessed September 28, 2004. ACC: MOL.20041122.0211. URL: http://quickfacts.census.gov/qfd/states/32/32023.html
173533	Bureau of the Census 2005	Bureau of the Census 2005. "Nevada QuickFacts, Clark County, Nevada." Washington, D.C.: Bureau of Census. Accessed April 7, 2005. ACC: MOL.20050505.0098. URL: http://quickfacts.census.gov/qfd/states/32/32003.html
180738	Bureau of the Census 2005	Bureau of the Census 2005. "Clark County, Nevada, 2005 American Community Survey, Data Profile Highlights." *Clark County, Nevada - Fact Sheet - American FactFinder.* Washington, D.C.: U.S. Bureau of the Census. Accessed May 23, 2007. ACC: MOL.20070712.0032. URL: http://factfinder.census.gov/servlet/ACSSAFFFacts?_event=Search&_lang=en&_sse=on&_state=04000US32&_county=Clark%20County

179903	California Air Resources Board 2006	California Air Resources Board 2006. "Ambient Air Quality Standards." *Air Resources Board.* Sacramento, California: Department of the California Environmental Protection Agency. Accessed March 21, 2007. ACC: MOL.20070613.0034. URL: http://www.arb.ca.gov/research/aaqs/aaqs.htm
148102	Cappaert et al. v. United States 1976	*Cappaert et al.. v. United States*, 426 U.S. 128; 96 S. Ct. 2026. Decided June 7, 1976. TIC: 243576.
181646	CCFD 2005	CCFD (Clark County Fire Department) 2005. "Complete List of Fire Stations." *General.* Las Vegas, Nevada: Clark County Fire Department. Accessed June 29, 2007. ACC: MOL.20070718.0054. ACC: MOL.20070718.0054. URL: http://fire.co.clark.nv.us/(S(5mrqe3554bdwef55mg5bzaqo))/ List.aspx
181170	CCFD 2006	CCFD (Clark County Fire Department) 2006. "Quick look at 2005 statistics." Las Vegas, Nevada: Clark County Fire Department. Accessed May 11, 2007. ACC: MOL.20070718.0053. URL: http://fire.co.clark.nv.us/(S(0noa5pz5a2agul55j053dpjv))/Facts.aspx
181264	CCWRD n.d.	CCWRD (Clark County Water Reclamation District) n.d. "Who Is the CCWRD?" Las Vegas, Nevada: Clark County Water Reclamation District. Accessed December 28, 2006. ACC: MOL.20070718.0057. URL: http://www.cleanwaterteam.com/whoisccwrd.html
181016	City-Data 2007	City-Data 2007. "Pahrump, NV Houses and Residents." Flossmoor, Illinois: Advameg, Inc. Accessed May 23, 2007. TIC: 259640. URL: http://www.city-data.com/housing/houses-Pahrump-Nevada.html
173051	Comer et al. 2003	Comer, P.; Faber-Langendoen, D.; Evans, R.; Gawler, S.; Josse, C.; Kittel, G.; Menard, S.; Pyne, M.; Reid, M.; Schulz, K.; Snow, K.; and Teague, J. 2003. *Ecological Systems of the United States, A Working Class Classification of the U.S. Terrestrial Systems.* Arlington, Virginia: NatureServe. TIC: 257146.
182821	Converse Consultants 2005	Converse Consultants 2005. *Water Resources Assessment Report, Task 3.4, Rev. 0.* Converse Project No. 04-33110-01. Las Vegas, Nevada: Converse Consultants. ACC: ENG.20070614.0005.
185128	Coppersmith 2008	Coppersmith. K. 2008. "Re: Questions on Strain Rates at Yucca Mountain - for Final SEIS." Email from K. Coppersmith to K. Davis, February 21, 2008, with attachment. ACC: MOL.20080317.0050.

104828	Covay 1997	Covay, K. 1997. "Water-Quality Data Collected May 6-15, 1997, by the U.S. Geological Survey at Eight Selected Well and Spring Sites Near Yucca Mountain." Letter from K. Covay (USGS) to W. Dixon (DOE/YMSCO), October 6, 1997, with enclosures. ACC: MOL.19981013.0007.
146183	CRWMS M&O 1996	CRWMS M&O 1996. *Distribution of Natural and Man-Made Radionuclides in Soil and Biota at Yucca Mountain, Nevada.* Rev 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990218.0217.
102599	CRWMS M&O 1998	CRWMS M&O 1998. *Site Gas/Liquid Systems Technical Report.* BCBC00000-01717-5705-00001 Rev 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980501.0178.
103731	CRWMS M&O 1998	CRWMS M&O 1998. *Probabilistic Seismic Hazard Analyses for Fault Displacement and Vibratory Ground Motion at Yucca Mountain, Nevada.* Milestone SP32IM3, September 23, 1998. Three volumes. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19981207.0393.
104523	CRWMS M&O 1999	CRWMS M&O 1999. *Engineering File - Subsurface Repository.* BCA000000-01717-5705-00005 Rev 02 DCN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990621.0157; MOL.19990615.0230.
104592	CRWMS M&O 1999	CRWMS M&O 1999. *Environmental Baseline File for Soils.* B00000000-01717-5700-00007 Rev 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990302.0180.
104593	CRWMS M&O 1999	CRWMS M&O 1999. *Environmental Baseline File for Biological Resources.* B00000000-01717-5700-00009 Rev 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990302.0181; MOL.19990330.0560.
179968	DeBurle 2006	DeBurle, M.A. 2006. "Re: Class II General Air Quality Operation Permit Renewal, #AP9199-0573.02, FIN #A0023." Letter from M.A. DeBurle (NDEP) to W.J. Arthur, III (DOE/OCRWM), August 8, 2006, 0814065554, MAD/tu, with enclosure. ACC: MOL.20070316.0087.

104957	DOE 1994	DOE (U.S. Department of Energy) 1994. *Yucca Mountain Site Characterization Project Socioeconomic Monitoring Program 1994 U.S. Department of Energy/Nevada Employee Survey Data Report, Executive Summary.* Las Vegas, Nevada: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.19950518.0077.
101811	DOE 1996	DOE (U.S. Department of Energy) 1996. *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada.* DOE/EIS-0243. Las Vegas, Nevada: U.S. Department of Energy, Nevada Operations Office. ACC: MOL.20010727.0190; MOL.20010727.0191.
103021	DOE 1997	DOE (U.S. Department of Energy) 1997. *Regional Groundwater Flow and Tritium Transport Modeling and Risk Assessment of the Underground Test Area, Nevada Test Site, Nevada.* DOE/NV-477. Las Vegas, Nevada: U.S. Department of Energy. ACC: MOL.20010731.0303.
155779	DOE 1999	DOE (U.S. Department of Energy) 1999. *Intermodal and Highway Transportation of Low-Level Radioactive Waste to the Nevada Test Site, Volume 1.* DOE/NV-544-Vol. I. Las Vegas, Nevada: U.S. Department of Energy, Nevada Operations Office. ACC: MOL.20011009.0006.
155970	DOE 2002	DOE (U.S. Department of Energy) 2002. *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada.* DOE/EIS-0250F. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20020524.0314; MOL.20020524.0315; MOL.20020524.0316; MOL.20020524.0317; MOL.20020524.0318; MOL.20020524.0319; MOL.20020524.0320.
167254	DOE 2003	DOE (U.S. Department of Energy) 2003. *Emergency Management Plan.* PLN-CRW-EM-000001 Rev 01 ICN 03. Las Vegas, Nevada: U.S. Department of Energy, Office of Repository Development. ACC: DOC.20031215.0002.
176678	DOE 2006	DOE (U.S. Department of Energy) 2006. *Yucca Mountain Project Critical Decision-1 Preliminary Hazards Analysis.* TDR-MGR-RL-000004, Rev. 02. Las Vegas, Nevada: U.S. Department of Energy, Office of Repository Development. ACC: ENG.20060403.0010.

181748	DOE 2006	DOE (U.S. Department of Energy) 2006. *Low-Level Waste ... at the Nevada Test Site.* DOE/NV--657-Rev 3. Las Vegas, Nevada: U.S. Department of Energy, National Nuclear Security Administration. ACC: MOL.20070712.0052.
181572	DOE 2007	DOE (U.S. Department of Energy) 2007. *Preclosure Seismic Design and Performance Demonstration Methodology for a Geologic Repository at Yucca Mountain Topical Report.* YMP/TR-003-NP, Rev. 5. Las Vegas, Nevada: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: DOC.20070625.0013.
185301	DOE 2008	DOE (U.S. Department of Energy) 2008. *Yucca Mountain Repository License Application.* DOE/RW-0573, Rev. 0. Las Vegas, Nevada: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20080501.0021; MOL.20080501.0023.
185209	Domm 2008	Domm, J. 2008. "Air Force Concurrence for Renewal of the Yucca Mountain Right-of-Way N-48602." Letter from J. Domm (USAF) to Mr. Chatterton (BLM), March 6, 2008, with attachment. ACC: MOL.20080307.0001.
181280	DOT 2006	DOT (U.S. Department of Transportation) 2006. *Freight in America.* Washington, D.C.: U.S. Department of Transportation, Research and Innovative Technology Administration. ACC: MOL.20070712.0049.
181491	EPA 2007	EPA (U.S. Environmental Protection Agency) 2007. "National Ambient Air Quality Standards (NAAQS)." Washington, D.C.: U.S. Environmental Protection Agency. Accessed June 20, 2007. ACC: MOL.20070712.0037. URL: http://www.epa.gov/air/criteria.html
182869	FAA 2007	FAA (Federal Aviation Administration) 2007. "Chapter 3, Section 4, Special Use Airspace." *Federal Aviation Administration Aeronautical Information Manual, Includes Change 1, 2, and 3.* Washington, D.C.: Federal Aviation Administration. Accessed September 5, 2007. ACC: MOL.20070913.0512. URL: http://www.faa.gov/airports_airtraffic/air_traffic/publications/ATpubs/AIM/chap3toc.htm
181167	FBI 2006	FBI (Federal Bureau of Investigation) 2006. "Table 70, Full-Time Law Enforcement Employees," *Crime in the United States 2005.* Washington, D.C.: Federal Bureau of Investigation. Accessed September 13, 2007. ACC: MOL.20070918.0105. URL: http://www.fbi.gov/ucr/05cius/data/table_70.html

181168	FBI 2006	FBI (Federal Bureau of Investigation) 2006. "Table 80, Nevada, Full-Time Law Enforcement Employees," *Crime in the United States 2005.* Clarksburg, West Virginia: Federal Bureau of Investigation, Criminal Justice Information Services Division. Accessed May 30, 2007. ACC: MOL.20070712.0031. URL: http://www.fbi.gov/ucr/05cius/data/table_80_nv.html
177754	Finsterle and Seol 2006	Finsterle, S. and Seol, Y. 2006. *Preliminary Evaluation of Seepage Observations from the ESF South Ramp Using the Drift Seepage Abstraction Model.* Albuquerque, New Mexico: Sandia National Laboratories. ACC: MOL.20060510.0330.
185100	Gecol 2007	Gecol, H. 2007. *Status of Energy in Nevada, Report to Governor Gibbons and Legislature.* Carson City, Nevada: State of Nevada, Nevada State Office of Energy. ACC: MOL.20080304.0035.
182345	Giampaoli 2007	Giampaoli, M.C. 2007. *Yucca Mountain Project Gateway Area Concept Plan.* Pahrump, Nevada: Nuclear Waste Repository Project Office, Nye County, Nevada. ACC: MOL.20070712.0048.
180378	Hill and Blewitt 2006	Hill, E.M. and Blewitt, G. 2006. "Testing for Fault Activity at Yucca Mountain, Nevada, Using Independent GPS Results from the BARGEN Network." *Geophysical Research Letters, 33,* (L14302), 1-5. Washington, D.C.: American Geophysical Union. TIC: 259570.
103278	IARC 1987	IARC (International Agency for Research on Cancer) 1987. *Silica and Some Silicates.* IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Volume 42. Lyon, France: International Agency for Research on Cancer. TIC: 226502.
173525	ICC 2003	ICC (International Code Council) 2003. *International Building Code 2000, with Errata to the 2000 International Building Code.* Falls Church, Virginia: International Code Council. TIC: 251054; 257198.
185423	ICYMRAO n.d.	ICYMRAO (Inyo County Yucca Mountain Repository Assessment Office) n.d. "Death Valley Lower Carbonate Aquifer Monitoring Program Wells Down Gradient of the Proposed Yucca Mountain Nuclear Waste Repository." Bishop, California: Inyo County Yucca Mountain Repository Assessment Office. Accessed April 29, 2008. ACC: MOL.20080509.0010. URL: http://www.inyoyucca.org/lsn.html

181276	Johnson and Michelhaugh 2003	Johnson, P.E. and Michelhaugh, R.D. 2003. *Transportation Routing Analysis Geographic Information System (TRAGIS) User's Manual.* ORNL/NTRC-006, Rev, 0. Oak Ridge, Tennessee: Oak Ridge National Laboratory. ACC: MOL.20070712.0024.
181957	Kaltenecker and Wicklow-Howard 1994	Kaltenecker, J. and Wicklow-Howard, M. 1994. "Microbiotic Soil Crusts in Sagebrush Habitats of Southern Idaho." *Interior Columbia Basin Ecosystem, Index of Science.* Washington, D.C.: USDA Forest Service, Interior Columbia Basin Ecosystem. Accessed July 13, 2007. ACC: MOL.20070731.0067. URL: http://www.icbemp.gov/science
174205	Kane et al. 2005	Kane, G.; Cornelius, B.; Charles, J.; Moose, G.; Frank-Churchill, M.; and Arnold, R. 2005. *American Indian Perspectives on the Proposed Rail Alignment Environmental Impact Statement for the U.S. Department of Energy's Yucca Mountain Project.* Las Vegas, Nevada: American Indian Writers Subgroup, Consolidated Group of Tribes and Organizations. ACC: ESU.20050707.0001.
181435	Koonce et al. 2006	Koonce J.E.; Yu, Z.; Farnham, I.M.; and Stetzenbach, K.J. 2006. "Geochemical Interpretation of Groundwater Flow in the Southern Great Basin." *Geosphere, 2,* (2), 88-101. Boulder, Colorado: Geological Society of America. TIC: 259515.
103283	La Camera et al. 1999	La Camera, R.J.; Locke, G.L.; and Munson, R.H. 1999. *Selected Ground-Water Data for Yucca Mountain Region, Southern Nevada and Eastern California, Through December 1997.* Open-File Report 98-628. Carson City, Nevada: U.S. Geological Survey. ACC: MOL.19990921.0120.
178692	La Camera et al. 2005	La Camera, R.J.; Locke, G.L.; and Habte, A.M. 2005. *Selected Ground-Water Data for Yucca Mountain Region, Southern Nevada and Eastern California, January-December 2003.* Open-File Report 2005-1286. Carson City, Nevada: U.S. Geological Survey. ACC: MOL.20070517.0100.
178691	La Camera et al. 2006	La Camera, R.J.; Locke, G.L.; Habte, A.M.; and Darnell, J.G. 2006. *Selected Ground-Water Data for Yucca Mountain Region, Southern Nevada and Eastern California, January-December 2004.* Open-File Report 2006-1285. Carson City, Nevada: U.S. Geological Survey. ACC: MOL.20070212.0119.

181171	Las Vegas Sun 2006	Las Vegas Sun 2006. "Editorial: Fighting fire with money." Las Vegas, Nevada: *Las Vegas Sun*. Accessed May 11, 2007. TIC: 259645. URL: http://www.lasvegassun.com/sunbin/stories/sun/2006/jan/21/520000940.html?fighting%20fire%20with%20money
174559	Lawrence 2002	Lawrence, A. 2002. "Radiation Risk Estimation from Total Effective Dose Equivalents (TEDEs)." Memorandum from A. Lawrence (DOE) to distribution, August 9, 2002, with attachments. ACC: MOL.20050815.0190.
176369	Lowry et al. 2005	Lowry, J.H., Jr.; Ramsey, R.D.; Boykin, K.; Bradford, D.; Comer, P.; Falzarano, S.; Kepner, W.; Kirby, J.; Langs, L.; Prior-Magee, J.; Manis, G.; O'Brien, L.; Pohs, L.; Rieth, W.; Sajwaj, T.; Schrader, S.; Thomas, K.A.; Schrupp, D.; Schulz, K.; Thompson, B.; Wallace, C; Velasquez, C.; Waller, E.; and Wolk, B. 2005. *Southwest Regional Gap Analysis Project, Final Report on Land Cover Mapping Methods.* Logan, Utah: Utah State University, Remote Sensing/GIS Laboratory. ACC: MOL.20060216.0166.
181001	Lupton 2007	Lupton, R. 2007. "DOE Payments-Equal-to-Taxes (PETT)." Record of conversation from R. Lupton (DOE/YMSCO) to Pixie Baxter, May 21, 2007. ACC: MOL.20070809.0002.
180713	LVCVA 2006	LVCVA (Las Vegas Convention and Visitors Authority) 2006. *2006 Las Vegas Year-to-Date Executive Summary.* Las Vegas, Nevada: Las Vegas Convention and Visitors Authority. TIC: 259637
181163	LVMPD n.d.	LVMPD (Las Vegas Metropolitan Police Department) n.d. *The Changing Face of Law Enforcement: Las Vegas Metropolitan Police Department 2004/2005 Annual Report.* Las Vegas, Nevada: Las Vegas Metropolitan Police Department. MOL.20070814.0143.
181156	MGT 2006	MGT (MGT of America) 2006. *Clark County School District Financial Management Review, Final Report.* Tallahassee, Florida: MGT of America. ACC: MOL.20070802.0267.
180999	Money 2007	Money 2007. "Forecast: 100 Biggest Markets." New York, New York: Time Warner Company. Accessed June 7, 2007. TIC: 259677. URL: http://money.cnn.com/2007/04/09/real_estate/forecast.moneymag/index.htm

181663	Morton 2007	Morton, L. 2007. "Fw: Baseline Radiological Monitoring Grid Population Projections." E-mail from L. Morton to J. Summerson, J. Rivers, E. Harr and S. Walker, February 22, 2007, with attachment. ACC: MOL.20070712.0058; MOL.20070809.0079.
181672	Morton 2007	Morton, L. 2007. "SEIS Data Transfer - Biological Resource Information." E-mail from L. Morton to J. Summerson, March 26, 2007, with attachment. ACC: MOL.20070712.0059.
153066	Murphy 2000	Murphy, S.L. 2000. *Deaths: Final Data for 1998. National Vital Statistics Reports.* Vol. 48, No. 11. Hyattsville, Maryland: National Center for Health Statistics. TIC: 249111.
181014	NAHB 2007	NAHB (National Association of Home Builders) 2007. "New and Existing Single Family Home Prices by Region - United States." Washington, D.C.: National Association of Home Builders. Accessed May 11, 2007. TIC: 259573. URL: http://www.nahb.org/fileUpload_details.aspx?contentID=55761
174324	NatureServe 2004	NatureServe 2004. *Landcover Descriptions for The Southwest Regional Gap Analysis Project.* Arlington, Virginia: NatureServe. TIC: 257833.
181638	NDCNR n.d.	NDCNR (Nevada Department of Conservation and Natural Resources) n.d. "Land and Management Status." *Nevada Natural Resources Status Report.* Carson City, Nevada: State of Nevada, Nevada Department of Conservation and Natural Resources. Accessed June 29, 2007. ACC: MOL.20070712.0051. URL: http://www.dcnr.nv.gov/nrp01/land01.htm
155820	NDE 2001	NDE (Nevada Department of Education). 2001. "Nevada School Enrollments, 2000-2001." Carson City, Nevada: Nevada Department of Education. Accessed August 14, 2001. ACC: MOL.20011009.0018. URL: http://www.nde.state.nv.us/admin/deptsuper/fiscal/2000_2001DistrictTotal.html
157146	NDE 2001	NDE (Nevada Department of Education) 2001. "Nevada Public Schools, Four Year Comparison of Enrollments, End of First School Month." *2001 Research Bulletin.* Carson City, Nevada: Nevada Department of Education. Accessed December 11, 2001. TIC: 251444. URL: http://www.nde.state.nv.us/admin/deptsuper/fiscal/research.html

181169 NDE 2007 Nevada Department of Education 2007. "Nevada Count Day School Enrollments, 2005-2006 School Year." *Enrollment-Public Schools.* Carson City, Nevada: Nevada Department of Education. Accessed May 10, 2007. ACC: MOL.20070718.0059. URL: http://www.nde.state.nv.us/resources/enrollment-publicschools.html

181158 NDE n.d. Nevada Department of Education n.d. "District Demographic Profile, Clark County School District." *Nevada Annual Reports of Accountability*. Carson City, Nevada: Nevada Department of Education. Accessed May 9, 2007. ACC: MOL.20070712.0042. URL: http://www.nevadareportcard.com/profile/overview.aspx?levelid=D&entityid=02

181159 NDE n.d. Nevada Department of Education n.d. "District Demographic Profile, Nye County School District." *Nevada Annual Reports of Accountability*. Carson City, Nevada: Nevada Department of Education. Accessed May 9, 2007. ACC: MOL.20070712.0043. URL: http://www.nevadareportcard.com/profile/overview.aspx?levelid=D&entityid=12

181160 NDE n.d. Nevada Department of Education n.d. "District Demographic Profile, Clark County School District - Students, Student / Teacher Ratio." *Nevada Annual Reports of Accountability*. Carson City, Nevada: Nevada Department of Education. Accessed May 9, 2007. ACC: MOL.20070712.0044. URL: http://www.nevadareportcard.com/profile/studteacherratio.aspx?levelid-D&entityid=02&yearid=05-06

181161 NDE n.d. Nevada Department of Education n.d. "District Demographic Profile, Nye County School District - Students, Student / Teacher Ratio." *Nevada Annual Reports of Accountability*. Carson City, Nevada: Nevada Department of Education. Accessed May 29, 2007. ACC: MOL.20070712.0045. URL: http://www.nevadareportcard.com/profile/studteacherratio.aspx?levelid=D&entityid=12&yearid=05-06

184969 NDEP 2007 NDEP (Nevada Division of Environmental Protection) 2007. *State of Nevada Solid Waste Management Plan 2007*. Carson City, Nevada: State of Nevada, Nevada Division of Environmental Protection. ACC: MOL.20080215.0031.

180712	NDTER 2006	NDETR (Nevada Department of Employment, Training & Rehabilitation) 2006. *2006 Nevada Covered Employment.* Carson City, Nevada: State of Nevada, Nevada Department of Employment, Training & Rehabilitation. ACC: MOL.20070303.0014.
181180	NDETR 2006	NDETR (Nevada Department of Employment, Training & Rehabilitation) 2006. "Nevada Employer Directory." *Nevada's Largest Employers, 4th Quarter 2006, Nye County.* Carson City, Nevada: Nevada Department of Employment, Training & Rehabilitation. Accessed July 10, 2007. ACC: MOL.20070712.0047. URL: http://www.nevadaworkforce.com/?PAGEID=67&SUBID=169
180734	NDETR 2007	NDETR (Nevada Department of Employment, Training & Rehabilitation) 2007. *Nevada Employment & Unemployment Estimates for March 2007.* Carson City, Nevada: State of Nevada, Nevada Department of Employment, Training & Rehabilitation. ACC: MOL.20070712.0046.
174543	NDOA 2005	NDOA (Nevada Department of Agriculture) 2005. "Noxious Weed List." Reno, Nevada: Nevada Department of Agriculture, Plant Industry Division. Accessed August 30, 2005. TIC: 257697. URL: http://agri.nv.gov/nwac/PLANT_NoxWeedList.htm
178749	NDOT n.d.	NDOT (Nevada Department of Transportation) n.d. "2005 Annual Traffic Report." Carson City, Nevada: Nevada Department of Transportation, Traffic Information Division. Accessed January 24, 2007. ACC: MOL.20070201.0273. URL: http://www.nevadadot.com/reports_pubs/traffic_report/2005/images/TrafficCover.jpg
172302	Nevada Power Company 2004	Nevada Power Company 2004. "Nevada Power Facts." Las Vegas, Nevada: Nevada Power Company. Accessed November 11, 2004. TIC: 257153. URL: http://www.nevadapower.com/company/facts/
181270	Nevada Power Company 2006	Nevada Power Company 2006. "Nevada Power Completes New 75-Megawatt Generating Unit." *Nevada Power - News Release - April 27, 2006.* Las Vegas, Nevada: Nevada Power Company. Accessed June 5, 2007. ACC: MOL.20070712.0028. URL: http://www.nevadapower.com/news/releases/ShowPR.cfm?pr_id=4727
174418	Nevada State Demographer n.d.	Nevada State Demographer n.d. *Nevada County Population Estimates July 1, 1990 to July 1, 2004, includes Cities and Towns.* Reno, Nevada: Nevada State Demographer, Nevada Department of Taxation. ACC: MOL.20050725.0392.

181749	Nevada State Demographer n.d.	Nevada State Demographer n.d. *Nevada County Population Estimates July 1, 1990 to July 1, 2005, Includes Cities and Towns.* Reno, Nevada: Nevada State Demographer's Office. ACC: MOL.20070303.0004.
180794	Nevada State Demographer's Office 2006	Nevada State Demographer's Office. 2006. *Nevada County Population Estimates July 1, 1990 to July 1, 2006, Includes Cities and Towns.* Reno, Nevada: Nevada State Demographer's Office. ACC: MOL.20071003.0184.
181186	Nevada State Fire Marshal 2006	Nevada State Fire Marshal 2007. *2006 Annual Fire Statistics Report, National Fire Incident Reporting System (NFIRS).* Carson City, Nevada: Nevada Department of Public Safety. ACC: MOL.20070718.0052.
173383	Nevada State Office of Energy 2005	Nevada State Office of Energy 2005. *2005 Status of Energy in Nevada.* Carson City, Nevada: Nevada State Office of Energy, Office of the Governor. ACC: MOL.20050420.0227.
181176	NFPA 2005	NFPA (National Fire Protection Association) 2007. "The U.S. Fire Service (2005)." *NFPA, Research & Reports, Fire Statistics.* Quincy, Massachusetts: National Fire Protection Association. Accessed May 30, 2007. TIC: 259632. URL: http://www.nfpa.org/categoryList.asp?categoryID=955&URL=Research%20&%20Reports/Fire%20statistics/The%20U.S.%20fire%20service
138431	NRC 1987	NRC (U.S. Nuclear Regulatory Commission) 1987. "Design of Structures, Components, Equipment, and Systems." Chapter 3 of *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants.* NUREG-0800. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 203894.
182132	NRC 2007	NRC (U.S. Nuclear Regulatory Commission) 2007. *Igneous Activity at Yucca Mountain: Technical Basis for Decisionmaking.* Washington, D.C.: U.S. Nuclear Regulatory Commission, Advisory Committee on Nuclear Waste and Materials. ACC: LLR.20070725.0023.
182194	NWRPO 2005	NWRPO (Nye County Nuclear Waste Repository Project Office) 2005. *Nye County Early Warning Drilling Program Phase IV Drilling Report.* NWRPO-2004-04. Pahrump, Nevada: Nye County Nuclear Waste Repository Project Office. ACC: MOL.20060116.0065.

156115	Nye County Nuclear Waste Repository Project Office 2001	Nye County Nuclear Waste Repository Project Office 2001. *Nye County Nuclear Waste Repository Project Office Independent Scientific Investigations Program Final Report, Fiscal Years 1996-2001.* NWRPO-2001-04. Pahrump, Nevada: U.S. Department of Energy, Nye County Nuclear Waste Repository Project Office. ACC: MOL.20010906.0199.
181182	Nye County School District 2007	Nye County School District 2007. "Every Child a Success!" *Fast Facts 2006-2007.* Pahrump, Nevada: Nye County School District. Accessed September 13, 2007. ACC: MOL.20070918.0102. URL: http://www.nye.k12.nv.us/
181251	OCRWM 2007	OCRWM (Office of Civilian Radioactive Waste Management) 2007. "Yucca Mountain Silicosis Screening Program." Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. Accessed June 4, 2007. ACC: MOL.20070712.0029. URL: http://www.ocrwm.doe.gov/ym_repository/silicosis.shtml
181184	Pahrump Valley Fire Rescue Service 2004	Pahrump Valley Fire Rescue Service 2004. *Pahrump Valley Fire Rescue Service Task Force, Final Report.* Pahrump, Nevada: Pahrump Valley Fire Rescue Service. TIC: 259660.
181239	Parizek 2004	Parizek, R.R. 2004. "Nuclear Waste Technical Review Board has Carefully Considered Your Letter of October 27, 2003, Based Upon its Examination of the Information, the Board Sees Nothing that Would Alter the Board's Previous Conclusion, that the Evidence Presented Does not Make a Credible Case for the Hypothesis of Ongoing Intermittent Hydrothermal Activity at Yucca Mountain." Letter from R.R. Parizek (NWTRB) to H.W. Swainston (Attorney at Law), February 25, 2004. ACC: MOL.20070613.0005.
185127	Quittmeyer 2008	Quittmeyer, R. 2008. "Re: Questions on Strain Rates at Yucca Mountain - for Final SEIS." E-mail from R. Quittmeyer to K. Davis, February 20, 2008. ACC: MOL.20080317.0051.
172306	Rhode 2004	Rhode, D. 2004. "Re: Yucca Mtn Cultural Resources." E-mail from D. Rhode to M. Russ, April 27, 2004. ACC: MOL.20041122.0214.
103451	Rodefer et al. n.d.	Rodefer, T.; Selmi, S.; Butler, J.; and Naroll, M. n.d. *Nevada Statistical Abstract 1996.* Carson City, Nevada: State of Nevada, Department of Administration. TIC: 243961.
161591	Sharpe 2003	Sharpe, S. 2003. *Future Climate Analysis—10,000 Years to 1,000,000 Years After Present.* MOD-01-001 Rev 01. Reno, Nevada: Desert Research Institute. ACC: MOL.20030407.0055.

185335	Smistad 2008	Smistad, E. 2008. "Use of New Strain Data." Email from E. Smistad to J. Rivers, April 8, 2008. ACC: MOL.20080509.0017.
180955	Smith 2007	Smith, H. 2007. "Home Sales End 2006 on Decline." *Las Vegas Review-Journal.* Las Vegas, Nevada: Las Vegas Review-Journal. TIC: 259488.
184946	Smith 2007	Smith, K. 2007. *Seismicity in the Vicinity of Yucca Mountain, Nevada, for the Period October 1, 2004, to September 30, 2006.* Document ID: TR-07-002. Reno, Nevada: University of Nevada, Reno, Nevada Seismological Laboratory. ACC: MOL.20071129.0141.
184947	Smith and von Seggern 2007	Smith, K. and von Seggern, D. 2007. *Seismicity in the Vicinity of Yucca Mountain, Nevada, for the Period October 1, 2002, to September 30, 2003.* Document ID: TR-04-002. Reno, Nevada: University of Nevada, Reno, Nevada Seismological Laboratory. ACC: MOL.20071210.0356.
181013	SNHBA 2007	SNHBA (Southern Nevada Home Builders Association) 2007. *Area Information, January-March 2007 - Change from January-March 2006.* Las Vegas, Nevada: Southern Nevada Home Builders Association. TIC: 259639.
174109	SNL 2007	SNL (Sandia National Laboratories) 2007. *Hydrogeologic Framework Model for the Saturated Zone Site-Scale Flow and Transport Model.* MDL-NBS-HS-000024 Rev 01. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20070411.0003.
174294	SNL 2007	SNL (Sandia National Laboratories) 2007. *Simulation of Net Infiltration for Present-Day and Potential Future Climates.* MDL-NBS-HS-000023 Rev 01. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20070530.0014.
176828	SNL 2007	SNL (Sandia National Laboratories) 2007. *Seismic Consequence Abstraction.* MDL-WIS-PA-000003 Rev 03. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20070928.0011.
177391	SNL 2007	SNL (Sandia National Laboratories) 2007. *Saturated Zone Site-Scale Flow Model.* MDL-NBS-HS-000011 Rev 03. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20070626.0004; DOC.20071001.0013.
177392	SNL 2007	SNL (Sandia National Laboratories) 2007. *Site-Scale Saturated Zone Transport.* MDL-NBS-HS-000010 Rev 03. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20070822.0003.

184614	SNL 2007	SNL (Sandia National Laboratories) 2007. *UZ Flow Models and Submodels.* MDL-NBS-HS-000006 Rev 03 AD 01. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20080108.0003; DOC.20080114.0001.
183750	SNL 2008	SNL (Sandia National Laboratories) 2008. *Saturated Zone Flow and Transport Model Abstraction.* MDL-NBS-HS-000021 Rev 03 AD 02. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20080107.0006.
181261	SNWA n.d.	SNWA (Southern Nevada Water Authority) n.d. *Southern Nevada Water Authority*, *2006 Water Resource Plan.* Las Vegas, Nevada: Southern Nevada Water Authority. ACC: MOL.20070718.0055.
181526	Spence 2007	Spence, R.E. 2007. "2007 State Fire Marshal Nevada Combined Agency Hazardous Material Facility Reports for Company Number 1403, Facility Numbers 2796, 54188, 54189, 54659, 55555, 55683, 55927, and 55942." Letter from R.E. Spence (DOE/OCRWM) to V.A. Capucci (State of Nevada), February 23, 2007, 0607071093, MFR: YMSOO:MJC-0649, ATS: YD-200700481, with enclosures. ACC: CCU.20070606.0007.
178726	State of Nevada 2006	State of Nevada 2006. "Special Hydrographic Abstract." *Nevada Division of Water Resources Water Rights Database.* Carson City, Nevada: State of Nevada, Department of Conservation & Natural Resources. Accessed January 17, 2007. ACC: MOL.20070201.0268. URL: http://water.nv.gov/water%20Rights/permitdb/hyd_abs2.cfm?
181056	Swainston 2003	Swainston, H.W. 2003. "Letter Submitting a Copy of Document Published under Auspices of Siberian Branch of Russian Academy of Sciences United Institute of Geology, Geophysics & Mineralogy." Letter to M.L. Corrandini, October 27, 2003. ACC: MOL.20070613.0006.
179926	SWReGAP n.d.	SWReGAP (Southwest Regional Gap Analysis Project) n.d. "Landcover Data for Nevada," *SWReGAP Landcover Data - Nevada.* Denver, Colorado: U.S. Geological Survey. Accessed March 26, 2007. ACC: MOL.20070613.0011. URL: http://earth.gis.usu.edu/swgap/landcover_nv.php

185182	Taylor 2007	Taylor, T. 2007. "Ruling #5750, In the Matter of Applications 59352, 62529, 66072, 66077, 66078, 66079 and 66081 Filed to Appropriate the Public Waters of an Underground Source Within the Amargosa Desert Hydrographic Basin (230), Nye County, Nevada." *Nevada Division of Water Resources Rulings Query Results.* Carson City, Nevada: State of Nevada, Division of Water Resources. Accessed March 4, 2008. ACC: MOL.20080306.0053. URL: http://water.nv.gov/Orders&Rulings/Rulings/rulings_results.cfm
147766	Thiel 1999	Thiel Engineering Consultants 1999. *Data Assessment & Water Rights/Resource Analysis of: Hydrographic Region #14 Death Valley Basin.* Reno, Nevada: Thiel Engineering Consultants. ACC: MOL.19990218.0214.
181181	TischlerBise 2005	TischlerBise 2005. *Cost of Land Use Fiscal Impact Analysis: Pahrump Regional Planning District, Nevada.* Bethesda, Maryland: TischlerBise. ACC: MOL.20070718.0061.
176524	Transportation Research Board 2001	Transportation Research Board 2001. *Highway Capacity Manual 2000.* HCM2000. Washington, D.C.: National Research Council, Transportation Research Board. TIC: 258170.
181265	Tri-Core Engineering 2005	Tri-Core Engineering and Pooled Resources 2005. *Final Report of Investigation for a Pahrump Sanitary Sewer District.* Project Number: 5112.0006. Scottsdale, Arizona: Tri-Core Engineering and Pooled Resources. TIC: 259644.
148197	United States v. Dann et al. 1985	*United States v. Dann et al.*, 470 U.S. 39; 105 S. Ct. 1058. Decided February 20, 1985. ACC: MOL.20010724.0314.
185193	USFA 2008	USFA (U.S. Fire Administration) 2008. "National Fire Department Census Database." State of Nevada. Emmitsburg, MD: U.S. Fire Administration. Accessed March 5, 2008. ACC: MOL.20080320.0044. URL: https://www.usfa.dhs.gov/applications/census/states.cfm
181273	VEA n.d.	VEA (Valley Electric Association) n.d. *2005 Annual Report.* Pahrump, Nevada: Valley Electric Association. TIC: 259752.
172053	von Seggern and Smith 2003	von Seggern, D.H. and Smith, K.W. 2003. *Seismicity in the Vicinity of Yucca Mountain, Nevada, for the Period October 1, 2001, to September 30, 2002.* Document ID: TR-03-002, Rev. 0. Reno, Nevada: University of Nevada, Reno, Nevada Seismological Laboratory. ACC: MOL.20030910.0265.

184948	von Seggern and Smith 2007	von Seggern, D. and Smith, K. 2007. *Seismicity in the Vicinity of Yucca Mountain, Nevada, for the Period October 1, 2003, to September 30, 2004.* TR-05-001, Rev. 0. Reno, Nevada: University of Nevada, Reno, Nevada Seismological Laboratory. ACC: MOL.20071024.0044.
181575	Wade 2000	Wade, S.A. 2000. "U.S. Department of Energy Quarterly Pumpage Report for Water Wells J-13, J-12, VH-1, and C-Well for the Period January through March 2000 (Water Appropriation Permits 57373, 57374, 57375, 57376, 58827, 58828, and 58829)." Letter from S.A. Wade (DOE/YMSCO) to R.M. Turnipseed (State of Nevada), April 11, 2000, OPE:MJC-1152. ACC: MOL.20000530.0232.
181576	Wade 2000	Wade, S.A. 2000. "U.S. Department of Energy Quarterly Pumpage Report for Water Wells J-13, J-12, VH-1, and C-Well for the Period April through June 2000 (Water Appropriation Permits 57373, 57374, 57375, 57376, 58827, 58828, and 58829)." Letter from S.A. Wade (DOE/YMSCO) to R.M. Turnipseed (State of Nevada), July 12, 2000, OPE:MJC-1666. ACC: MOL.20000814.0344.
181577	Wade 2000	Wade, S.A. 2000. "U.S. Department of Energy Quarterly Pumpage Report for Water Wells J-13, J-12, VH-1, and C-Well for the Period July through September 2000 (Water Appropriation Permits 57373, 57374, 57375, 57376, 58827, 58828, and 58829)." Letter from S.A. Wade (DOE/YMSCO) to H. Ricci (State of Nevada), October 11, 2000, OPE:MJC-0034. ACC: MOL.20001101.0210.
181578	Wade 2001	Wade, S.A. 2001. "U.S. Department of Energy Quarterly Pumpage Report for Water Wells J-13, J-12, VH-1, and C-Well for the Period October through December 2000 (Water Appropriation Permits 57373, 57374, 57375, 57376, 58827, 58828, and 58829)." Letter from S.A. Wade (DOE/YMSCO) to H. Ricci (State of Nevada), January 10, 2001, OPE:SAW-0515. ACC: MOL.20010306.0338.
181580	Wade 2002	Wade, S.A. 2002. "Yucca Mountain Site Characterization Project (YMP) Public Water System Permit NY-0867-12NCNT Annual Update." Letter from S.A. Wade (DOE/YMSCO) to J.H. Larson (State of Nevada), January 30, 2002, OPE:MJC-0539, with enclosure. ACC: MOL.20020213.0104.
181581	Wade 2003	Wade, S.A 2003. "Yucca Mountain Project (YMP) Public Water System Permit #NY-0867-12NCNT Annual Update." Letter from S.A. Wade (DOE/ORD) to J.H. Larson (State of Nevada), January 30, 2003, 0131035879, OFO:MJC-0602, with enclosure. ACC: MOL.20030401.0041.

181582	Wade 2004	Wade, S.A. 2004. "Yucca Mountain Project (YMP) Public Water System Permit NY-0867-12NCNT Annual Update." Letter from S.A. Wade (DOE/ORD) to H.A. Asgarian (State of Nevada), January 30, 2004, 0202040305, OFO:MJC-0551, with enclosure. ACC: MOL.20040402.0265.
181583	Wade 2005	Wade, S.A. 2005. "Yucca Mountain Project (YMP) Public Water System Permit NY-0867-12NCNT Annual Update." Letter from S.A. Wade (DOE/ORD) to J.H. Larson (State of Nevada), February 1, 2005, 0203054638, MFR:OFO:MJC-0602, with enclosure. ACC: MOL.20050308.0327.
103485	Wernicke et al. 1998	Wernicke, B.; Davis, J.L.; Bennett, R.A.; Elosegui, P.; Abolins, M.J.; Brady, R.J.; House, M.A.; Niemi, N.A.; and Snow, J.K. 1998. "Anomalous Strain Accumulation in the Yucca Mountain Area, Nevada." *Science, 279,* 2096-2100. New York, New York: American Association for the Advancement of Science. TIC: 235956.
175199	Wernicke et al. 2004	Wernicke, B.; Davis, J.L.; Bennett, R.A.; Normandeau, J.E.; Friedrich, A.M.; and Niemi, N.A. 2004. "Tectonic Implications of a Dense Continuous GPS Velocity Field at Yucca Mountain, Nevada." *Journal of Geophysical Research, 109,* (B12404), 1-13. Washington, D.C.: American Geophysical Union. TIC: 257651.
180739	Williams 2003	Williams, N.H. 2003. "Contract No. DE-AC28-01RW12101-Transmittal of Report Technical Basis Report No 11: Saturated Zone Flow and Transport Addressing Twenty-Five Key Technical Issue (KTI) Agreements Related to Saturated Zone Flow and Transport." Letter from N.H. Williams (BSC) to J.D. Ziegler (DOE/ORD), August 29, 2003, TB:cg-0828038612, with enclosures. ACC: MOL.20040105.0269.
182120	Wilson and Cline 2002	Wilson, N.S.F. and Cline, J.S. 2002. *Thermochronological Evolution of Calcite Formation at the Proposed Yucca Mountain Repository Site, Nevada: Part 1, Secondary Mineral Paragenesis and Geochemistry*, Revision 0. TR-02-005.1. Las Vegas, Nevada: University of Nevada Las Vegas. ACC: MOL.20041217.0254.
182121	Wilson et al. 2002	Wilson, N.S.F., Cline, J.S., and Amelin, Y. 2002. *Thermochronological Evolution of Calcite Formation at the Proposed Yucca Mountain Repository Site, Nevada: Part 2, Fluid Inclusion Analyses and U-Pb Dating*, Revision 0. TR-02-005.2. Las Vegas, Nevada: University of Nevada Las Vegas. ACC: MOL.20041217.0255.

163589	Wilson et al. 2003	Wilson, N.S.F.; Cline, J.S.; and Amelin, Y.V. 2003. "Origin, Timing, and Temperature of Secondary Calcite–Silica Mineral Formation at Yucca Mountain, Nevada." *Geochimica et Cosmochimica Acta, 67,* (6), 1145-1176. New York, New York: Pergamon. TIC: 254369.
104842	YMP 1996	YMP (Yucca Mountain Site Characterization Project) 1996. *Regulated Materials Management Plan.* YMP/91-35, Rev. 1. Las Vegas, Nevada: Yucca Mountain Site Characterization Office. ACC: MOL.19960722.0079.
156763	YMP 2001	YMP (Yucca Mountain Site Characterization Project) 2001. "PETT and Tax Numbers." E-mail from Yucca Mountain Project to P. Baxter, June 26, 2001, with attachments. ACC: MOL.20010816.0151.
173954	Ziegler 2005	Ziegler, J.D. 2005. "Report of Unexpected Geologic Condition, South Ramp of the Exploratory Studies Facility between Stations 75+00 and 76+00." Correspondence from J.D. Ziegler (DOE/ORD) to J.D. Parrott (NRC), March 23, 2005, 0324055103, MFR:OLA&S:DHC-0848, Project No. WM-00011, with enclosure. ACC: MOL.20050406.0362.

4

Environmental Impacts of Repository Construction, Operation and Monitoring, and Closure

TABLE OF CONTENTS

Section | Page

LIST OF TABLES

LIST OF FIGURES

4. ENVIRONMENTAL IMPACTS OF REPOSITORY CONSTRUCTION, OPERATIONS, MONITORING, AND CLOSURE

This chapter describes *preclosure* environmental *impacts* that could result from the *Proposed Action*, which is to construct, operate, monitor, and eventually close a *geologic repository* for the *disposal* of *spent nuclear fuel* and *high-level radioactive waste* at Yucca Mountain.

Preclosure refers to the time from the beginning of *construction* to final *repository-closure* and includes the *construction analytical period, operations analytical period*, *monitoring analytical period,* and *closure analytical period* that the U.S. Department of Energy (DOE or the Department) analyzed. Chapter 5 of this *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F-S1) (Repository SEIS) discusses the environmental consequences of *postclosure* repository performance—that period out to 10,000 years and beyond after *repository-closure*. Chapter 6 discusses the environmental consequences of transportation, and Chapter 7 discusses the environmental consequences of the *No-Action Alternative*.

Section 4.1 describes potential environmental impacts from activities at the repository site and from offsite manufacturing of repository components [for example, *transportation, aging, and disposal (TAD) canisters*, *waste packages*, and *drip shields*]. It also describes the impacts from proposed special-use airspace above the repository. The methods DOE used in the analyses to predict the potential impacts in this section were conservative. This means that the predicted results are likely to be higher than the actual values that would be measured or observed. Examples of conservative methods included not considering *best management practices* for dust suppression in the predictive release and concentration analyses for *particulate matter*, not taking credit for demonstrated successful remediation and reclamation efforts in the disturbed land analyses, and not applying DOE *radiation* protection program objectives such as As Low As Reasonably Achievable into worker radiation *exposure* analyses. The occupational and human health and safety and *accident* analyses used multiple methods that were conservative, which increases the likelihood that the predicted results would be higher than the actual measured or observed values. Each of the resource sections in this chapter and any associated appendices provide the specifics of the analyses.

Since DOE completed the *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F; DIRS 155970-DOE 2002, all) (Yucca Mountain FEIS), it has modified its repository design and operational plans. These modifications have resulted in changes to information for the analyses of potential environmental impacts and, therefore, resulted in new impact analyses for each of the 15 resource and subject areas evaluated in this Repository SEIS. Land disturbance, water and fuel use, number of repository workers, and credible accidents from repository-related activities are examples of information DOE used for analysis of impacts that have changed since the completion of the FEIS. This new information, in turn, resulted in changes to the impact analyses for multiple resource areas. For example, new information for land disturbance required a reevaluation of impacts to land use and ownership, *air quality, hydrology,* biological resources and soils, cultural resources, aesthetics, and noise.

DEFINITIONS OF DURATION TERMS

Repository SEIS analytical periods:

Four timeframes are defined for use in this Repository SEIS to best evaluate potential preclosure environmental impacts:

- **Construction analytical period: 5 years**—Begins upon receipt of the construction authorization from the NRC and ends prior to receipt of a license to receive and possess radiological materials. Activities would include site preparation, surface construction, and subsurface development.
- **Operations analytical period: 50 years**—Begins upon receipt of a license to receive and possess radiological materials and ends upon emplacement of the final waste package. Activities would include receipt, handling, aging, emplacement, and monitoring of waste, as well as continued construction of surface and subsurface facilities.
- **Monitoring analytical period: 50 years**—Begins upon emplacement of the final waste package. Activities would include maintaining active ventilation of the repository for as long as 50 years, remotely inspecting waste packages, and continuing investigations in support of predictions related to postclosure performance.
- **Closure analytical period: 10 years**—Overlaps the last 10 years of the monitoring period and includes activities that would begin upon receipt of a license amendment to close. Activities would include decommissioning and demolishing surface facilities, emplacing drip shields, backfilling subsurface-to-surface openings, restoring the surface to its approximate condition before repository construction, and constructing monuments to mark the site.

Operational phases:

Four phases used in DOE's application for construction authorization to indicate when specific facilities are expected to be operational under the planned phased construction. Operational phases are Phase 1, Phase 2, Phase 3, and Phase 4.

Preclosure:

The timeframe from construction authorization to repository closure.

Postclosure:

The timeframe after permanent closure of the repository through the 1 million years analyzed in this Repository SEIS.

Repository-closure:

The point in time when activities associated with the closure analytical period, such as decommissioning and demolishing surface facilities and backfilling subsurface-to-surface openings, have been completed. Permanent closure of the repository would be complete; postclosure timeframe would begin.

Where noted in this chapter of the Repository SEIS, DOE summarizes, incorporates by reference, and updates Chapter 4 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 4-1 to 4-128) and presents new information, as applicable, from studies and investigations that continued after the completion of the FEIS. If the Department did not use information from the FEIS, but rather based the impact analysis in a subsection on new information, the introduction to that subsection so states and does not reference the FEIS. To ensure that the source of the information is clear, DOE states it is summarizing, incorporating by reference, and updating the FEIS in the introduction to each applicable section or subsection of Section 4.1.

Section 4.2 describes potential environmental impacts of waste *retrieval* if this option became necessary. The current concept for retrieval has not changed from that which DOE analyzed in the Yucca Mountain FEIS, which is summarized and incorporated by reference.

Section 4.3 presents a new section that evaluates actions that include repair, replacement, or improvement of existing Yucca Mountain Project facilities that would enable DOE to continue ongoing operations, scientific testing, and routine maintenance until the U.S. Nuclear Regulatory Commission (NRC) decides whether to authorize construction of a repository. DOE needs to improve the *Yucca Mountain site infrastructure* not only to ensure safety for workers, regulators, and visitors, but also to comply with applicable environmental, health, and safety standards and DOE Directives. The Department could implement these specific elements before it received construction authorization from the NRC. Before implementation, a Record of Decision on this Repository SEIS will present any decisions DOE might make in relation to the improvements. These actions would be independent of repository construction.

4.1 Preclosure Environmental Impacts of Construction, Operations, Monitoring, and Closure of a Repository

This section describes the preclosure environmental impacts from the Proposed Action. DOE has described these impacts by the *analytical periods* of the Proposed Action—construction, operations, monitoring, and closure—and the activities (some of which overlap) associated with them.

The following paragraphs summarize the periods and associated activities DOE has evaluated in this Repository SEIS. Chapter 2 (Table 2-1) of this Repository SEIS describes these periods and activities in detail.

Construction Analytical Period (5 Years)

The *construction analytical period* would begin when the NRC authorized DOE to build the repository. For analysis purposes, this Repository SEIS assumes construction would begin in about 2012 and would be complete upon receipt of the NRC license to receive and possess radiological materials. Site preparation would include such activities as the demolition or relocation of existing facilities, excavation of fill material down to the original ground contours, and placement and compaction of engineered *backfill* in the areas of facility construction. The Department would construct new surface facilities and balance of plant facilities (which would include infrastructure) necessary for initial receipt and *emplacement* of spent nuclear fuel and high-level *radioactive* waste. In addition, DOE would begin development (excavation and preparation for use) of the *subsurface facility*.

Operations Analytical Period (up to 50 Years)

For this analysis, DOE assumed that repository operations would begin in 2017, after it received a license from the NRC to receive and possess spent nuclear fuel and high-level radioactive waste. The *operations analytical period* would include continued construction of surface facilities and development (excavation and preparation for use) of the *subsurface* repository, receipt and handling of spent nuclear fuel and high-level radioactive waste in surface facilities, and emplacement of these materials in the completed portions of the repository. Surface facility construction activities would continue for approximately 5 years into the operations period. Development activities would last 22 years and would be concurrent with handling and emplacement. Handling and emplacement activities would last up to 50 years.

Monitoring Analytical Period (50 Years)

Monitoring of the emplaced material and maintenance of the repository would start with the first emplacement of a waste package and would continue through the *closure analytical period*. After the completion of the operations analytical period (emplacement), the *monitoring analytical period* that DOE used for analysis in this Repository SEIS would begin. Monitoring would be the primary activity. DOE would maintain the repository in a configuration that enabled continued monitoring and inspection of the waste packages, continued investigations in support of long-term repository performance (the ability to isolate waste from the *accessible environment*), and the retrieval of waste packages, if necessary. This period would last 50 years. DOE has also analyzed the potential for a monitoring period of up to 250 years. This analysis is included in Appendix A, Section A.6.

Closure Analytical Period (10 Years)

Repository closure would occur after DOE applied for and received a license amendment from the NRC. Closure would take 10 years and would occur during the last 10 years of the monitoring analytical period. The closure of the repository facilities would include the following activities:

- Emplacing the drip shields,
- Removing and salvaging reusable equipment and materials,
- Backfilling and sealing subsurface-to-surface openings,
- Constructing monuments to mark the area,
- *Decommissioning* and demolishing surface facilities, and
- Restoring the surface to its approximate condition before repository construction.

4.1.1 IMPACTS TO LAND USE AND OWNERSHIP

This section describes potential land use and ownership impacts from activities under the Proposed Action. The *region of influence* for land use and ownership impacts is the *analyzed land withdrawal area* and an area to the south that DOE proposes to use for offsite facilities and an access road from U.S. Highway 95. Congress would define the actual land withdrawal area. The analysis considered impacts from direct disturbances in relation to proposed repository construction, operations, monitoring, and closure as well as construction and operation of the access road and offsite facilities. It also considered impacts from the transfer of lands to DOE control. Section 4.1.1.1 summarizes, incorporates by reference, and updates Section 4.1.1.1 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 4-5 and 4-6). Section 4.1.1.2 provides a new analysis based on the modified design and operational plan. Section 4.1.15 describes the requirement for airspace restrictions and the impacts to airspace use from these restrictions.

4.1.1.1 Impacts to Land Use and Ownership from Land Withdrawal

To develop a repository at Yucca Mountain, DOE would have to obtain permanent control of the geologic repository operations area, currently under the control of DOE (National Nuclear Security Adminsitration), the U.S. Department of Defense (U.S. Air Force), and the U.S. Department of the Interior (Bureau of Land Management). This would require Congressional action. The geologic repository operations area would occupy a small portion of a larger area [600 square kilometers (230 square miles or approximately 150,000 acres)], which would include a buffer zone. Because Congress has not withdrawn this land, this Repository SEIS refers to the 230 square miles as the analyzed land withdrawal area.

At present, the Bureau of Land Management administers approximately 180 square kilometers (44,000 acres) of the analyzed land withdrawal area. Most of this area is associated with the current right-of-way (N-47748) for previous *site characterization* activities. As such, with the exception of about 17.22 square kilometers (4,255.50 acres) near the site of the proposed repository (67 FR 53359) and an existing patented mining claim, these lands are available for public uses such as mineral exploration, recreation, and grazing. Congress granted these rights under various federal laws, such as the *Federal Land Policy and Management Act of 1976*, as amended (43 U.S.C. 1701 et seq.).

The Bureau of Land Management would conduct mineral examinations to assess valid existing rights in all mining claims within the lands subject to the permanent legislative withdrawal. DOE would provide just compensation for the acquisition of such valid property rights. DOE, in consultation with the U.S. Air Force and the Bureau of Land Management, as appropriate, would manage the withdrawn land in accordance with the *Federal Land Policy and Management Act of 1976*, the conditions of the permanent legislative withdrawal set forth by Congress, and other applicable laws.

4.1.1.2 Impacts to Land Use and Ownership from Construction, Operations, Monitoring, and Closure

During the construction, operations, and monitoring analytical periods, DOE would disturb or clear land for subsurface and surface facility construction. The total land disturbance for the proposed repository, access road, and offsite facilities would be approximately 9 square kilometers (2,200 acres).

Land disturbances would include approximately 8.5 square kilometers (2,100 acres) of small noncontiguous areas inside the analyzed land withdrawal area. Most of the surface facilities and disturbed land would be in the *geologic repository operations area* (Chapter 2, Section 2.1.2). Repository activities would not conflict with current land uses on adjacent lands under control of the Bureau of Land Management, U.S. Air Force, and DOE.

The Proposed Action would disturb approximately 0.57 square kilometer (140 acres) of Bureau of Land Management land outside the analyzed land withdrawal area for construction of offsite facilities and an access road from U.S. Highway 95. DOE would relocate the current access road intersection with U.S. Highway 95 approximately 0.39 kilometer (0.24 mile) to the southeast to line up with the intersection of Nevada State Route 373 and U.S. Highway 95. The projected volume of traffic could be handled by acceleration and deceleration lanes and a controlled access at the Gate 510/State Route 373/U.S. Highway 95 intersection. The estimated area for such an intersection would be approximately 0.11 square kilometer (28 acres). Because the existing highway through this area uses approximately 0.065 square kilometer (16 acres), only about 0.049 square kilometer (12 acres) of new land would be necessary. Approximately 0.097 square kilometer (24 acres) would be necessary for 1.6 kilometers (1 mile) of new road about 61 meters (200 feet) wide. Relocation of the road would require cooperation with Nye County plans for the Amargosa Valley area, a right-of-way from the Bureau of Land Management, and coordination with the Nevada Department of Transportation.

The analysis assumed a training facility, the Sample Management Facility, a marshalling yard and warehouse, and temporary housing for construction workers would be near Gate 510 on Bureau of Land Management land outside the analyzed land withdrawal area. As noted in Section 3.1.1.1 of this Repository SEIS, the Bureau of Land Management has designated for disposal a portion of the land south of the analyzed land withdrawal area and Nye County has formally notified the Bureau of its intent to purchase up to 1.2 square kilometers (296 acres) for development that could host these facilities (DIRS 182804-Maher 2006, all). The training facility would require a 0.02-square-kilometer (5-acre) parcel for the facility, associated parking, landscaping, and access. The Sample Management Facility would require 0.012 square kilometer (3 acres). DOE could build the Sample Management Facility inside the analyzed land withdrawal area; however, to be conservative, the analysis assumed it would be outside the land withdrawal area. The marshalling yard and warehouse would require fencing, offices, warehousing, open laydown, and shops on 0.2 square kilometer (50 acres). Temporary housing accommodations for construction workers would require approximately 0.10 square kilometer (25 acres), but DOE would reclaim the lands when it no longer needed to use them. DOE could use the temporary accommodations for *railroad* construction workers in the Crater Flat area, which is part of the proposal in the Rail Alignment EIS. Depending on the need for housing, the Department could use the rail construction camp either in lieu of temporary accommodations at the southern boundary or in addition to those accommodations.

The Bureau of Land Management controls lands to the south of the analyzed land withdrawal area and manages them in accordance to the *Record of Decision for the Approved Las Vegas Resource Management Plan and Final Environmental Impact Statement* (DIRS 176043-BLM 1998, all). This plan designates corridors in its planning area to avoid Areas of Critical Environmental Concern. The proposed activities outside the analyzed land withdrawal area would not overlap such areas (DIRS 103079-BLM 1998, Map 2-7) and, therefore, they do not conflict with the Bureau's management plan.

Chapter 6 discusses land use and impacts from construction and operation of a *railroad* in Nevada and associated rail facilities.

Before any ground disturbing activities, DOE would identify geodetic control monuments in areas that could be disturbed. If there was a need to relocate a monument, DOE would notify the Office of the Director of the National Oceanic and Atmospheric Administration, National Geodetic Survey no less than 90 days before any planned activities that could disturb or destroy the monument. During closure, DOE would restore disturbed areas it no longer needed to their approximate condition before repository construction.

Surface disturbance inside the analyzed land withdrawal area of approximately 8.5 square kilometers (2,100 acres) would represent a small amount of the 600 square kilometers (150,000 acres) of the withdrawal. Further, 2.43 square kilometers (600 acres) were previously disturbed (Chapter 3, Section 3.1.1.2). DOE also would disturb approximately 0.48 square kilometer (120 acres) of previously undisturbed land outside the analyzed land withdrawal area but would avoid conflicts with surrounding land uses to the extent possible. Therefore, land use impacts from activities under the Proposed Action would be small.

4.1.2 IMPACTS TO AIR QUALITY

This section updates potential impacts to air quality in the Yucca Mountain region from release of nonradiological air pollutants during construction, operations, monitoring, and closure of the proposed repository since completion of the Yucca Mountain FEIS. DOE based its reanalysis of impacts to air quality for this Repository SEIS on the modified design that Chapter 2 describes. The region of influence is an area with a radius of approximately 84 kilometers (52 miles) around the Yucca Mountain site. Appendix B discusses the methods DOE used for air quality analysis for this Repository SEIS, including the new model for estimation of the annual and short-term (24-hour or less) air quality impacts at the proposed repository, and provides additional data and intermediate results the Department used to estimate air quality impacts. Section 4.1.7.2 discusses health impacts associated with radiological air quality.

PARTICULATE MATTER

$PM_{2.5}$:
Particulate matter with an aerodynamic diameter of 2.5 micrometers or less (about 0.0001 inch).

PM_{10}:
Particulate matter with an aerodynamic diameter of 10 micrometers or less (about 0.0004 inch).

As a frame of reference, the diameter of the average human hair is approximately 70 micrometers.

Sources of nonradiological air pollutants at the repository site would include *fugitive dust* emissions from land disturbances and excavated rock handling; fugitive dust emissions from concrete batch plant operations; and *nitrogen dioxide*, *sulfur dioxide*, *carbon monoxide*, and particulate matter emissions from fossil-fuel use. DOE used the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) computer program to estimate the annual and short-term (24-hour or less) air quality impacts. The Department evaluated impacts for five *criteria pollutants*: carbon monoxide, nitrogen dioxide, sulfur dioxide, *ozone*, and particulate matter. The analysis did not *quantitatively* address the criteria pollutant lead because there would be no significant sources of airborne lead at the repository (Appendix B, Section B.1). DOE used the *National Ambient Air Quality Standards*, described in Chapter 3, Section 3.1.2.1, to analyze air quality impacts. These standards set limits to protect public health, including the health of sensitive populations such as asthmatics, children, and the elderly. In addition to the criteria pollutants, DOE evaluated potential impacts from cristobalite, a form of silica dust that is the causative agent for silicosis and might be a *carcinogen*. *Erionite* is an uncommon zeolite mineral that underground construction could encounter, but it appears to be absent or rare at the proposed repository depth and location. Erionite would not affect air quality in the area around the repository, and DOE did not consider it in the analysis. Ozone is not emitted directly into the atmosphere, but is created by complex chemical reactions of precursor pollutants in the presence of sunlight. The precursor pollutants are *nitrogen oxides* (including nitrogen dioxide) and volatile organic compounds. The major source for volatile organic compounds and nitrogen dioxide is the burning of fossil fuels. DOE's analysis of ozone evaluated the emissions of these precursors. Section 4.1.2.6 of this Repository SEIS discusses greenhouse gases, primarily carbon dioxide.

The air quality analysis evaluated impacts at the potential locations of *maximally exposed individual* members of the public. (Section 4.1.7.1 presents impacts to workers.) The analysis defined the locations as the nearest points of unrestricted public access outside the analyzed land withdrawal area. For periods of 1 year or longer, the analysis assumed maximally exposed individuals were at the southern boundary of the land withdrawal area, the closest location they could be for long periods during repository activities. The maximum air quality impact (that is, air concentration) that would result from repository activities could occur at different locations along the boundary of the land withdrawal area depending on the release period and the averaging time. The maximally exposed individual would be the person at the location with the highest concentration per release period and averaging time. Appendix B, Section B.3 describes the locations of maximally exposed individuals in greater detail.

CONFORMITY

Section 176(c)(1) of the *Clean Air Act* (42 U.S.C. 7401 et seq.) requires federal agencies to ensure that their actions conform to applicable implementation plans for the achievement and maintenance of National Ambient Air Quality Standards for criteria pollutants. To achieve conformity, a federal action must not contribute to new violations of standards for ambient air quality, increase the frequency or severity of existing violations, or delay timely attainment of standards in the area of concern (for example, a state or smaller air quality region). The U.S. Environmental Protections Agency (EPA) general conformity regulations (40 CFR Part 93, Subpart B) contain guidance for determination of whether a proposed federal action would cause emissions to be above certain levels in locations that EPA designated as nonattainment or maintenance areas. If there are not enough air quality data to determine the status of attainment of a remote or sparsely populated area, the area is listed as unclassifiable. The quality of the air in the region of influence is unclassifiable because of limited air quality data (40 CFR 81.329). For regulatory purposes, EPA considers unclassifiable areas to be in attainment.

A portion of Clark County is in nonattainment for carbon monoxide, PM_{10}, and the 8-hour ozone standard (40 CFR Part 81). These nonattainment areas are outside the 84-kilometer (52-mile) region of influence for air quality. A portion of Inyo County, California, is in nonattainment for the PM_{10} standard (40 CFR Part 81). This nonattainment area is also outside the 84-kilometer region of influence for air quality. A portion of Nye County near the town of Pahrump has a maintenance status for PM_{10}. This maintenance area is at the edge of the 84-kilometer region of influence for air quality.

The provisions of the conformity rule apply only where the action is in a federally classified nonattainment or maintenance area. As already specified, there are no nonattainment areas in the region of influence for air quality. The repository would be less than 84 kilometers (52 miles) from a PM_{10} maintenance area, and PM_{10} impacts from repository activities would be very small. Although the conformity regulations would not apply to the Proposed Action, DOE would work with Nye County to ensure that the Proposed Action would not contribute to additional violations of PM_{10} air quality standards in the maintenance area.

This conformity review applies only to those portions of the Proposed Action that are in the 84-kilometer (52-mile) region of influence for air quality. The conformity review for the balance of the rail alignment is in the Rail Alignment EIS.

4.1.2.1 Impacts to Air Quality from Construction

This section describes nonradiological air quality impacts that could occur during the construction analytical period of the proposed repository. For analytical purposes, DOE assumed that the construction period would last 5 years and that construction activities would be evenly distributed over the period. Activities during this period would include infrastructure upgrades, excavation of fill material, subsurface excavation to prepare the repository for initial emplacement operations, construction of surface facilities in the geologic repository operations area and *South Portal development area*, and construction of ventilation *shafts* and associated access roads. Table 2-1 of this Repository SEIS lists activities during the construction period.

Construction activities would result in emissions of air pollutants from subsurface and surface activities. These emissions would include the following:

- Fugitive dust in the form of PM_{10} (particulate matter with an aerodynamic diameter of 10 micrometers or less) during site preparation from the excavation of undocumented fill in the geologic repository operations area;

- Fugitive dust (PM_{10}) from land-disturbing activities during surface construction, which would include the access road, utility corridor, surface facilities, *Aging Facility*, and Rail Equipment Maintenance Yard and other rail facilities;

- Fugitive dust (PM_{10}) from the placement and maintenance of excavated rock at a surface storage pile;

- Particulate matter (PM_{10}) from ventilation exhausts during subsurface excavation;

- Particulate matter (PM_{10}) from three concrete batch plants; and

- Gaseous criteria pollutants (carbon monoxide, nitrogen dioxide, sulfur dioxide) and particulate matter with an aerodynamic diameter of 2.5 micrometers or less ($PM_{2.5}$) from fossil fuel consumption by construction vehicles.

Table 4-1 lists the maximum estimated impacts to air quality at the boundary of the analyzed land withdrawal area for repository activities that would occur in that area. Maximum concentrations of carbon monoxide, nitrogen dioxide, sulfur dioxide, and $PM_{2.5}$ at the analyzed land withdrawal area boundary would be small. The maximum concentration of PM_{10} would be within the regulatory limit. Although normal dust suppression measures such as watering the ground surface would reduce the PM_{10} concentration, the analysis did not consider such measures.

The maximum annual concentration of the ozone precursor nitrogen dioxide would be less than 0.05 percent of the regulatory limit, and the annual emissions would be less than 4 percent of the total estimated nitrogen oxide emissions of approximately 1.3 million kilograms (1,400 tons) in Nye County during 2002 (DIRS 177709-EPA 2006, all). The other ozone precursor, volatile organic compounds, would have estimated annual emissions of about 5,300 kilograms (about 12,000 pounds) from repository construction activities. Because Yucca Mountain is in an attainment area for ozone, the analysis compared the estimated annual release of volatile organic compounds to the Prevention of Significant Deterioration of Air Quality emission threshold for volatile organic compounds for stationary sources (40 CFR 52.21). The volatile organic compound emission threshold is 36,000 kilograms (80,000 pounds) per year, so the peak annual release from the repository would be well below the level. The impact of these pollutants on ozone formation should not cause violations of the ozone standard.

Cristobalite is one of several naturally occurring crystalline forms of silica (silicon dioxide) that occur in Yucca Mountain *tuffs*. Cristobalite is principally a concern for workers who could inhale the particles during subsurface excavation operations (Section 4.1.7.1). Prolonged high exposure to crystalline silica might cause silicosis, a disease characterized by scarring of the lung tissue. Research has shown an increased cancer *risk* to humans who already have developed adverse noncancer effects from silicosis, but the cancer risk to otherwise healthy individuals is not clear.

Cristobalite would be emitted from the subsurface by the ventilation system during excavation operations, and there would be releases in the form of fugitive dust from the excavated rock pile. Fugitive dust from the rock pile would be the largest potential source of cristobalite exposure to surface workers and to the

Table 4-1. Maximum construction analytical period concentrations of criteria pollutants and cristobalite at the land withdrawal area boundary (micrograms per cubic meter).[a,b]

Pollutant	Averaging time	Regulatory limit[c]	Maximum concentration[d]	Percent of regulatory limit
Carbon monoxide[e]	8-hour	10,000	16	0.16
	1-hour	40,000	130	0.32
Nitrogen dioxide[e]	Annual	100	0.043	0.043
Sulfur dioxide[e]	Annual	80	0.00016	0.00020
	24-hour	365	0.023	0.0062
	3-hour	1,300	0.18	0.014
PM_{10}[e]	24-hour	150	59	40
$PM_{2.5}$[e]	Annual	15	0.0024	0.016
	24-hour	35	0.34	1.0
Cristobalite	Annual	10[f]	0.048	0.48[f]

a. Appendix B describes the analysis of maximum concentrations and percent of regulatory limits.
b. All numbers except regulatory limits are rounded to two significant figures.
c. Regulatory limits for criteria pollutants are from 40 CFR 50.4 through 50.11 and Nevada Administrative Code 445B.22097 (Table 3-5).
d. Sum of highest estimated concentrations at the accessible land withdrawal boundary regardless of direction (Appendix B contains more information). Does not include background concentrations. Table 3-2 in Chapter 3 lists the highest measured background concentrations at Yucca Mountain. The maximum concentrations would not exceed the regulatory limits after adding the highest background concentrations.
e. DOE assumed that construction vehicles would be between model years 2006 and 2010 and would meet Tier 3 emission standards.
f. There are no regulatory limits for public exposure to cristobalite. DOE used a comparative benchmark of 10 micrograms per cubic meter (Section 4.1.2.1 and Appendix B, Section B.1).

public. DOE would perform evaluations of airborne crystalline silica at Yucca Mountain during routine operations and tunneling. For this analysis, DOE assumed that 28 percent of the fugitive dust from the rock pile and subsurface excavation would be cristobalite. This reflects the maximum cristobalite content of the parent rock, which ranges from 18 to 28 percent (DIRS 104523-CRWMS M&O 1999, p. 4-81). Using the parent rock percentage overestimates the airborne cristobalite concentration because studies of *ambient* and occupational airborne crystalline silica have shown that most of the silica is coarse (not respirable) and that larger particles do not stay airborne but rapidly deposit on the surface. Table 4-1 lists estimated cristobalite concentrations at the analyzed land withdrawal boundary during the construction analytical period.

There are no regulatory limits for public exposure to cristobalite, even though there are regulatory limits for worker exposure (29 CFR 1910.1000). Due to the lack of regulatory limits for public exposure to cristobalite, this analysis used a comparative benchmark of 10 micrograms per cubic meter. A U.S. Environmental Protection Agency (EPA) health assessment stated that the risk of silicosis is less than 1 percent for a cumulative exposure of 1,000 micrograms per cubic meter multiplied by years (DIRS 103243-EPA 1996, p. 1-5). Over a 70-year lifetime, this benchmark would correspond to an annual average exposure concentration of approximately 14 micrograms per cubic meter. For added conservatism, the analysis used an annual concentration of 10 micrograms per cubic meter as the benchmark. Table 4-1 compares the estimated cristobalite concentrations and this assumed benchmark. The postulated annual average exposure would be less than 0.5 percent of the benchmark. DOE would use common dust suppression techniques (such as water spraying) to reduce releases of fugitive dust, and thus cristobalite, from the excavated rock pile.

Surface construction outside the analyzed land withdrawal area (that is, off the Yucca Mountain site) would occur during the construction analytical period. Offsite construction would include an intersection at U.S. Highway 95, the Sample Management Facility, and other areas such as a training facility and an offsite marshalling yard for construction materials. Because these activities would be outside the analyzed land withdrawal area, the potential location of the maximally exposed individual member of the public would not be at the boundary of that area, as with activities within the area. The maximally exposed member of the public would be adjacent to the offsite construction. Table 4-2 lists the maximum estimated impacts to air quality as a result of offsite construction. The maximum concentrations are for individuals 100 meters (330 feet) from the construction activities (Appendix B, Section B.3). Although DOE would use dust suppression measures to reduce the PM_{10} concentration, the impact analysis did not consider such measures.

Table 4-2. Maximum construction analytical period concentration of criteria pollutants 100 meters (330 feet) from offsite construction activities (micrograms per cubic meter).

Pollutant	Averaging time	Regulatory limit[a]	Maximum concentration	Percent of regulatory limit
Carbon monoxide[b]	8-hour	10,000	21	0.21
	1-hour	40,000	170	0.42
Nitrogen dioxide[b]	Annual	100	1.0	1.0
Sulfur dioxide[b]	Annual	80	0.0040	0.0051
	24-hour	365	0.032	0.0088
	3-hour	1,300	0.24	0.019
PM_{10}	24-hour	150	64	43
$PM_{2.5}$	Annual	15	0.057	0.38
	24-hour	35	0.49	1.4

Note: All numbers except regulatory limits are rounded to two significant figures.

a. Regulatory limits for criteria pollutants are from 40 CFR 50.4 through 50.11 and Nevada Administrative Code 445B.22097 (Table 3-5).

b. DOE assumed construction vehicles would be between model years 2006 and 2010 and would meet Tier 3 emission standards.

The maximally exposed individual member of the public who was near offsite construction would also be exposed to concentrations of criteria pollutants from activities in the land withdrawal area. Therefore, the maximum air quality impact for a person near offsite construction must include a contribution from activities in the land withdrawal area. Because PM_{10} is the criteria pollutant that would be closest to reaching its regulatory limit, DOE selected it for air quality impact analysis. Individuals near offsite construction could be affected by a maximum PM_{10} concentration of 53 micrograms per cubic meter from repository construction activities in the land withdrawal area. This is less than 36 percent of the PM_{10} regulatory limit. Therefore, the total maximum PM_{10} air quality impact near the offsite construction could be about 78 percent of the regulatory limit. DOE calculated this value by adding the less than 36 percent of the regulatory limit from activities in the land withdrawal area to the 43 percent of the regulatory limit from offsite construction activities. (The scenario does not consider background concentrations of PM_{10}. Table 3-2 in Chapter 3 lists the highest measured background concentration of PM_{10} at Yucca Mountain.) This most conservative case assumes that peak offsite construction would occur simultaneously with peak construction in the land withdrawal area. It does not consider normal dust suppression methods. The actual air quality impact for PM_{10} should be less than the most conservative case.

4.1.2.2 Impacts to Air Quality from Operations

This section describes potential nonradiological air quality impacts during the operations analytical period of the Yucca Mountain Repository. For analytical purposes, this period would begin on receipt of an NRC license amendment to receive and possess spent nuclear fuel and high-level radioactive waste, and would include receipt, handling, *aging*, emplacement, and monitoring of these materials. DOE plans to continue surface construction during the first 5 years and to continue subsurface development during the first 25 years of this period. The maximum air quality impacts would occur during the first 5 years of the period, when surface construction and operation activities would occur at the same time. The operations analytical period would last up to 50 years and would end on emplacement of the last waste package.

Continued subsurface development would result in the release of fugitive dust (PM_{10}) from the ventilation exhausts. Activities at the surface would result in the following air emissions during this period:

- Fugitive dust (PM_{10}) from continued land-disturbing construction activities on the surface, which would include the *North Construction Portal*, remaining facilities at the *North Portal*, and a remaining aging pad;
- Fugitive dust (PM_{10}) from the excavation, placement, and maintenance of rock at the excavated rock storage pile;
- Cristobalite emissions from subsurface excavations and the excavated rock storage pile;
- Particulate matter (PM_{10}) from the concrete batch plants;
- Gaseous criteria pollutants (carbon monoxide, nitrogen dioxide, and sulfur dioxide) and particulate matter ($PM_{2.5}$) from vehicles during surface construction and the emplacement of waste packages; and
- Gaseous criteria pollutants and particulate matter ($PM_{2.5}$) from diesel boilers and standby and emergency diesel generators.

Table 4-3 lists the maximum estimated impacts to air quality at the boundary of the analyzed land withdrawal area during the operations analytical period.

As listed in Table 4-3, the maximum offsite concentrations of carbon monoxide, nitrogen dioxide, sulfur dioxide, and $PM_{2.5}$ would be small. The public maximally exposed individual would be exposed to less than 3 percent of the applicable regulatory limits. The maximum offsite concentration of PM_{10} could be about 7.6 percent of the applicable regulatory limits. The analysis did not take credit for standard construction dust suppression measures, which DOE would implement to further lower projected PM_{10} concentrations by reducing fugitive dust from surface-disturbing activities. These suppression methods would have little effect on $PM_{2.5}$ concentrations because fugitive dust is not a major source of this pollutant.

The maximum annual concentration of the ozone precursor nitrogen dioxide during the operations analytical period would be about 0.12 percent of the regulatory limit and the annual emissions would be about 10 percent of the total estimated nitrogen dioxide emissions of 1.3 million kilograms (1,400 tons) in Nye County during 2002 (DIRS 177709-EPA 2006, all). Nitrogen dioxide forms primarily from

Table 4-3. Maximum operations analytical period concentrations of criteria pollutants and cristobalite at the land withdrawal area boundary (micrograms per cubic meter).[a,b]

Pollutant	Averaging time	Regulatory limit[c]	Maximum concentration[d]	Percent of regulatory limit
Carbon monoxide[e]	8-hour	10,000	68	0.68
	1-hour	40,000	550	1.4
Nitrogen dioxide[e]	Annual	100	0.12	0.12
Sulfur dioxide[e]	Annual	80	0.00078	0.00098
	24-hour	365	0.11	0.030
	3-hour	1,300	0.89	0.068
PM_{10}[e]	24-hour	150	11	7.6
$PM_{2.5}$[e]	Annual	15	0.0064	0.043
	24-hour	35	0.91	2.6
Cristobalite	Annual	10[f]	0.0021	0.021[f]

a. Appendix B describes the analysis of maximum concentrations and percent of regulatory limits.
b. All numbers except regulatory limits are rounded to two significant figures.
c. Regulatory limits for criteria pollutants are from 40 CFR 50.4 through 50.11 and Nevada Administrative Code 445B.22097 (Table 3-5).
d. Sum of highest estimated concentrations at the accessible land withdrawal boundary regardless of direction (Appendix B contains more information). Does not include background concentrations. Table 3-2 in Chapter 3 lists the highest measured background concentrations at Yucca Mountain. The maximum concentrations would not exceed the regulatory limits after adding the highest background concentrations.
e. DOE assumed that all construction vehicles during the first 5 years of the operations analytical period would be between model years 2006 and 2010 and would meet Tier 3 emission standards.
f. There are no regulatory limits for public exposure to cristobalite. DOE used a comparative benchmark of 10 micrograms per cubic meter (Section 4.1.2.1 and Appendix B, Section B.1).

combustion of fossil fuels from sources such as standby diesel generators, emergency diesel generators, and fossil-fuel vehicles. The Proposed Action would consume only about 2.2 percent of diesel fuel use in Clark, Nye, and Lincoln counties in 2004 and only about 0.04 percent of the gasoline (Section 4.1.11.4). The other ozone precursor, volatile organic compounds, would have an estimated maximum annual emission of about 14,000 kilograms (about 30,000 pounds) during the first 5 years of the operations period. As discussed in Section 4.1.2.1, this would be significantly below the Prevention of Significant Deterioration of Air Quality emission threshold for volatile organic compounds. DOE anticipates that the impact of these pollutants on ozone formation would not cause violations of the ozone standard.

Table 4-3 also lists cristobalite concentrations at the land withdrawal area boundary. As Section 4.1.2.1 discusses for the construction analytical period, the analysis of the operations analytical period assumed that 28 percent of the fugitive dust releases from the excavated rock pile would be cristobalite. There are no public limits for exposure to cristobalite, so the analysis used an approximate annual average concentration of 10 micrograms per cubic meter as a benchmark. The estimated exposures to cristobalite from repository operations would be approximately 0.002 microgram per cubic meter, or less than 0.03 percent of the benchmark.

Concentrations of PM_{10} would be less during the operations analytical period than during the construction analytical period due to a decrease in surface disturbance and a reduction in concrete batch plant operations. Concentrations of cristobalite also would decrease during the operations analytical period even though the amount of subsurface excavation and the size of the excavated rock pile would increase. Concentrations of gaseous criteria pollutants would increase during the first 5 years of the operations period over those of the construction period due to vehicle emissions from construction activities and repository operations and to emissions from diesel generators and boilers.

No air quality impacts would result from facilities outside the land withdrawal area during the operations analytical period. The training facility and marshalling yard would not be significant sources of criteria pollutants. The amount of fuel that vehicles would use at the facilities would not be large. Standard dust suppression methods would mitigate potential fugitive dust (PM_{10}) emissions at the marshalling yard.

4.1.2.3 Impacts to Air Quality from Monitoring

This section describes potential nonradiological air quality impacts during the monitoring analytical period of the proposed repository. For analytical purposes, this period would begin with the emplacement of the final waste package and continue for 50 years after the end of the operations analytical period. Activities during this period would include maintenance of active ventilation of the repository for as long as 50 years, remote inspection of waste packages, retrieval of waste packages to correct detected problems (if necessary), and continuing investigations to support predictions of postclosure repository performance. Section 4.2 discusses air quality impacts of the retrieval contingency.

After the completion of emplacement activities, DOE would continue monitoring and maintenance activities. During this period, air pollutant emissions would decrease. Surface construction, subsurface excavation, and subsurface emplacement activities would be complete, resulting in a lower level of emissions in comparison to previous periods. Pollutant concentrations at the analyzed land withdrawal area boundary would be substantially lower than those in Table 4-3.

No air quality impacts would result from facilities outside the land withdrawal area during the monitoring analytical period. There would be significantly less activity at offsite facilities such as the training facility and marshalling yard, so they would not be significant sources of criteria pollutants.

4.1.2.4 Impacts to Air Quality from Closure

This section describes potential nonradiological air quality impacts during the closure analytical period of the proposed repository. This period, which would last 10 years and would overlap the last 10 years of the monitoring analytical period, would begin on receipt of a license amendment to close the repository. Activities would include closure of subsurface repository facilities, backfilling, sealing of subsurface-to-surface openings, decommissioning and demolition of surface facilities, construction of monuments to mark the site, and reclamation of remaining disturbed lands. These activities would result in the following air emissions during this period:

- Fugitive dust (PM_{10}) emissions from the handling, processing, and transfer of backfill material to the subsurface;
- Fugitive dust (PM_{10}) releases from demolition of buildings, removal of debris, and land reclamation;
- Cristobalite releases from the handling and storage of excavated rock; and
- Gaseous criteria pollutants (carbon monoxide, nitrogen dioxide, and sulfur dioxide) and particulate matter ($PM_{2.5}$) from fuel consumption.

Table 4-4 lists the maximum estimated impacts to air quality at the boundary of the analyzed land withdrawal area during the closure analytical period.

Table 4-4. Maximum closure analytical period concentrations of criteria pollutants and cristobalite at the land withdrawal area boundary (micrograms per cubic meter).[a,b]

Pollutant	Averaging time	Regulatory limit[c]	Maximum concentration[d]	Percent of regulatory limit
Carbon monoxide[e]	8-hour	10,000	2.9	0.029
	1-hour	40,000	24	0.059
Nitrogen dioxide[e]	Annual	100	0.023	0.023
Sulfur dioxide[e]	Annual	80	0.000045	0.000056
	24-hour	365	0.0065	0.0018
	3-hour	1,300	0.052	0.0040
PM_{10}[e]	24-hour	150	29	16
$PM_{2.5}$[e]	Annual	15	0.0013	0.0090
	24-hour	35	0.19	0.55
Cristobalite	Annual	10[f]	0.0026	0.026[f]

a. Appendix B describes the analysis of maximum concentrations and percent of regulatory limits.
b. All numbers except regulatory limits are rounded to two significant figures.
c. Regulatory limits for criteria pollutants are from 40 CFR 50.4 through 50.11 and Nevada Administrative Code 445B.22097 (Table 3-5).
d. Sum of highest estimated concentrations at the accessible land withdrawal boundary regardless of direction (Appendix B contains more information). Does not include background concentrations. Table 3-2 in Chapter 3 lists the highest measured background concentrations at Yucca Mountain. The maximum concentrations would not exceed the regulatory limits after adding the highest background concentrations.
e. DOE assumed that all construction vehicles would be between model years 2006 and 2010 and would meet Tier 3 emission standards.
f. There are no regulatory limits for public exposure to cristobalite. DOE used a comparative benchmark of 10 micrograms per cubic meter (Section 4.1.2.1 and Appendix B, Section B.1).

Gaseous criteria pollutants would result primarily from vehicle exhaust. During the closure analytical period, the maximum concentrations of carbon monoxide, nitrogen dioxide, sulfur dioxide, and $PM_{2.5}$ would be small. Concentrations of carbon monoxide, nitrogen dioxide, and sulfur dioxide would be less than 0.1 percent of the regulatory limits, and concentrations of $PM_{2.5}$ would be less then 1 percent of the regulatory limits. The maximum offsite concentration of PM_{10} would be less than 17 percent of the regulatory limit. The analysis did not take credit for standard construction dust suppression measures, which DOE would implement and would further lower projected PM_{10} concentrations by reduction of fugitive dust from surface-disturbing activities. These suppression methods would not affect the concentrations of $PM_{2.5}$ because fugitive dust is not a major source of that pollutant.

As with the construction analytical period (Section 4.1.2.1), the analysis of the closure analytical period assumed that 28 percent of the fugitive dust releases from the excavated rock pile would be cristobalite. Table 4-4 lists estimated cristobalite concentrations for the maximally exposed offsite individual during closure. As noted in Section 4.1.2.1, there are no public limits for exposure to cristobalite, so the analysis used an approximate annual average concentration of 10 micrograms per cubic meter as a benchmark. The estimated exposures to cristobalite from repository closure would be approximately 0.0026 microgram per cubic meter, or less than 0.03 percent of the benchmark.

4.1.2.5 Total Impacts to Air Quality from All Periods

The nonradiological air quality analysis examined concentrations of criteria pollutants at the boundary of the land withdrawal area in comparison with the *National Ambient Air Quality Standards* for periods ranging from 1 hour to an annual average concentration of pollutant. The analysis calculated the maximum project impact from the highest unit release concentrations of the AERMOD computer model from the years modeled (Appendix B describes the analysis). The highest concentrations of all criteria pollutants except PM_{10} would be less than 3 percent of applicable standards in all cases. The highest concentrations of PM_{10} from activities in the land withdrawal area could be 40 percent of the 24-hour limit during the construction analytical period.

4.1.2.6 Impacts from Greenhouse Gases

The burning of fossil fuels such as diesel and gasoline emits carbon dioxide, which is a greenhouse gas. DOE's use of fossil fuel at the repository would be greatest during the construction and operations analytical periods for construction equipment, surface vehicles, boilers, and generators. Although human activities can produce other greenhouse gases such as methane and nitrous oxide, construction and operations activities would release only carbon dioxide in meaningful quantities (Appendix B, Section B.9). Therefore, DOE has considered only carbon dioxide in this Repository SEIS. Appendix B, Section B.9 describes the methodology and emission factors DOE used to determine carbon dioxide emissions.

Greenhouse gases can trap heat in the atmosphere and have been associated with global climate change . The Intergovernmental Panel on Climate Change, in its Fourth Assessment Report issued in 2007, stated that warming of the Earth's climate system is unequivocal, and that most of the observed increase in globally averaged temperatures since the mid-20th Century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations (DIRS 185132-Parry et al. 2007, Summary). The Panel describes a range of potential environmental impacts associated with climate change at a global and regional level. In North America, for example, the Panel stated that warming in western mountains is projected to cause decreased snowpack, more winter flooding, and reduced summer flows, exacerbating competition for over-allocated water resources. Among other potential impacts for North America cited in the full report were an increased number, intensity and duration of heatwaves, and an extended period of high fire risk.

Greenhouse gases are well mixed throughout the lower atmosphere, such that any anthropogenic emissions would add to cumulative regional carbon dioxide emissions and to global concentrations of carbon dioxide. DOE quantified carbon dioxide emissions from the Proposed Action of this Repository SEIS and presents the results together with estimates of recent State of Nevada and national carbon dioxide emissions. The Energy Information Administration has estimated that 47.9 million metric tons (52.8 million tons) of carbon dioxide emissions would be produced in Nevada in 2004 (DIRS 185316-EIA n.d., all). Overall estimated U.S. emissions of carbon dioxide were 6,089 million metric tons (6,712.5 million tons) in 2005 (DIRS 185248-EPA 2007, all). Neither the State of Nevada nor the Federal Government has carbon dioxide emissions caps, thresholds, or targets. Carbon dioxide emissions from the Proposed Action would add to state and national emissions, making a relatively small incremental contribution to cumulative emissions of carbon dioxide. DOE is not aware of any methodology to correlate the carbon dioxide emissions exclusively from a specific proposed project to any specific impact on global climate change.

4.1.2.6.1 *Greenhouse Gases from Construction Activities*

Carbon dioxide emissions during the construction analytical period would result primarily from the burning of fossil fuels by construction equipment and the manufacture of concrete at concrete batch plants. The maximum annual diesel use during construction would be about 5.5 million liters (1.5 million gallons) and the maximum annual gasoline use would be about 180,000 liters (47,000 gallons). The annual concrete use would be about 65,000 cubic meters (85,000 cubic yards).

Using the methodology and emission factors in Appendix B, Section B.9 of this Repository SEIS, the maximum annual carbon dioxide emissions during the construction period would be about 36,000 metric tons (39,000 tons). This would be 0.075 percent of the carbon dioxide emissions in the State of Nevada in 2004 and 0.00059 percent of the carbon dioxide emissions in the United States in 2005.

4.1.2.6.2 *Greenhouse Gases from Operations Activities*

Carbon dioxide emissions during the operations analytical period would result primarily from the burning of fossil fuels by construction equipment, surface vehicles, boilers, and generators. Concrete batch plants would also be operating early in the operations period while construction continues. The maximum annual diesel use during full operations would be about 20 million liters (5.3 million gallons) and the annual gasoline use would be about 850,000 liters (220,000 gallons). The annual concrete use would be 41,600 cubic meters (54,000 cubic yards) during construction. Using the methodology and emission factors described in Appendix B, Section B.9, the maximum annual carbon dioxide emissions during the operations period would be about 69,000 metric tons (76,000 tons). This would be less than 0.15 percent of the carbon dioxide emissions in the State of Nevada in 2004 and less than 0.0012 percent of the carbon dioxide emissions in the United States in 2005.

4.1.2.6.3 *Greenhouse Gases from All Analytical Periods*

Carbon dioxide emissions during all analytical periods (up to 105 years) would result from the burning of fossil fuels by construction equipment, surface vehicles, boilers, and generators and by the manufacture of concrete. The total diesel use during all analytical periods would be about 740 million liters (195 million gallons) and the total gasoline use would be about 31 million liters (8.2 million gallons). The total concrete use would be about 490,000 cubic meters (640,000 cubic yards). Using the methodology and emission factors described in Appendix B, Section B.9, the total carbon dioxide emissions during all analytical periods would be about 2.2 million metric tons (2.4 million tons).

4.1.3 IMPACTS TO HYDROLOGY

This section summarizes and incorporates by reference applicable portions of Section 4.1.3 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 4-19 to 4-31). In addition, it addresses potential impacts that could change as a result of modifications to repository design and operational plans.

This section describes potential environmental impacts to the hydrology of the Yucca Mountain region from construction, operations, monitoring, and eventual closure of a repository at Yucca Mountain. It identifies and evaluates potential surface-water and *groundwater* impacts separately, as DOE did in the Yucca Mountain FEIS. The region of influence and the assessment attributes, or criteria, are the same as those in the FEIS. Chapter 5 discusses postclosure impacts from the long-term performance of the repository.

The attributes DOE used to assess surface-water impacts were the potential for the introduction and movement of *contaminants*, potential for changes to runoff and infiltration rates, alterations in natural drainage, and potential for flooding to worsen any of these conditions. The region of influence for surface-water impacts includes construction and operation sites that would be susceptible to erosion, areas that permanent changes in surface-water flow could affect near these sites, and downstream areas that eroded soil or potential spills of contaminants would affect. The evaluation of surface-water impacts is very similar to that in the Yucca Mountain FEIS, but DOE modified it to address a slightly larger amount of land disturbance, two additional wastewater *evaporation ponds*, and a tentative facility layout that more specifically incorporates stormwater *detention ponds* into its design.

The attributes DOE used to assess groundwater impacts included the potential to change infiltration rates that could affect groundwater, the potential for the introduction of contaminants, the availability of groundwater for project use, and the potential for such use to affect other groundwater users. The region of influence for the groundwater analysis includes *aquifers* under the areas of construction and operations, aquifers from which DOE could obtain water, and downstream aquifers that repository uses could affect. The evaluation of groundwater impacts is very similar to that in the Yucca Mountain FEIS, but addresses changes to the estimated water demand from the Proposed Action.

4.1.3.1 Impacts to Surface Water from Construction, Operations, Monitoring, and Closure

There are no perennial streams or other permanent, surface-water bodies in the Yucca Mountain region of influence, and instances when precipitation and runoff are sufficient to generate flowing water in drainage channels are infrequent and short lived. Nevertheless, the manner in which the Proposed Action would accommodate or otherwise affect these infrequent conditions determines potential impacts to surface water. The primary impact areas for the Proposed Action are the following:

- Discharges of water to the surface,
- The potential for introduction of contaminants that could spread to surface water,
- The potential for changes to surface-water runoff or infiltration rates, and
- The potential for alteration of natural surface-water drainage, which would include effects to *floodplains* (or flood zones).

4.1.3.1.1 *Discharge of Water to the Surface*

DOE would pump groundwater at the site and store it in tanks to support the following uses: fire protection, deionized water, potable water, cooling tower makeup, and makeup to other water systems. There would be few discharges of water. DOE would pipe sanitary sewage to septic tank and leach field systems, so there would be no production of surface water, and the processes that routinely produced other wastewater would involve discharges to one of four or possibly five lined evaporation ponds as follows:

1. South Portal evaporation pond for dust control water returned from subsurface development,
2. North Construction Portal evaporation pond for dust control water returned from subsurface development,
3. North Portal evaporation pond for process wastewater,
4. *Central operations area* evaporation pond for process wastewater, and

5. Small evaporation pond (possibly) for concrete batch plant wastewater.

DOE would provide water to the subsurface during the development of the underground areas of the proposed repository. The Department would collect excess water from dust suppression applications and water that percolated into the repository *drifts*, if any, and send the water to evaporation ponds at the South Portal development area or the North Construction Portal. The South Portal evaporation pond would have double polyvinyl chloride liners and a leak detection system. The evaporation pond at the North Construction Portal would be of similar construction.

The North Portal evaporation pond, which DOE would locate adjacent to the facilities in the central operations area just outside the geologic repository operations area, would receive wastewater in the form of cooling tower blowdown and water softener regeneration solutions from facility heating and air conditioning systems. DOE would send water from floor and equipment drains of the surface facilities and the emplacement side of the subsurface to the North Portal evaporation pond after verification that it was not contaminated. (The Department would manage contaminated water as *low-level radioactive waste*.) The North Portal evaporation pond, at a minimum, would have a polyvinyl chloride liner. The fourth evaporation pond, also in the central operations area, would receive process water from two oil-water separators and superchlorinated water from maintenance of the drinking water system.

Table 4-5 lists the combined quantities of water discharges to the North Construction Portal and the South Portal ponds, which would be similar to those in the Yucca Mountain FEIS. As listed in the table, the estimates include two phases of underground development (called “heavy” and “light” only in relation to each other) after completion of the primary surface construction analytical period. The estimated quantity of water DOE would discharge to the North Portal evaporation pond would be no different than that in the Yucca Mountain FEIS; that is, about 34,000 cubic meters (9 million gallons) per year for the operations analytical period.

Table 4-5. Combined annual water discharges to the North Construction Portal and the South Portal evaporation ponds.

Analytical period	Duration[a] (years)	Annual discharge[b]	
		(cubic meters)	(million gallons)
Construction	5	4,500	1.2
Operations			
Heavy development	8	6,800	1.8
Light development	up to 17	2,900	0.77

a. Discharge to this pond would occur only during subsurface development activities.
b. Estimated discharge volumes would be 13 percent of the process water sent to the subsurface based on Exploratory Studies Facility construction experience.

With proper maintenance, the lined evaporation ponds should remain intact and produce no adverse impacts at the repository site. DOE would build another, much smaller lined evaporation pond, as appropriate, in the general area of the concrete batch plants to facilitate the collection and management of equipment rinse water. As an option, DOE could divert wastewater from the batch plants to the South Portal evaporation pond.

The water that DOE would use for dust suppression is a type of discharge. DOE studied dust suppression during characterization activities at Yucca Mountain because of the concern that any water added to the surface or subsurface could have effects on the subsurface area of the proposed repository. The amount of water used for dust suppression would result in neither runoff nor infiltration. DOE would establish controls as necessary to ensure that dust suppression would not involve unnecessary quantities of water.

Repository facility operations would involve other uses of water, but they would have little, if any, potential to generate surface water. DOE would collect wastewater from the Wet Handling Facility pool, decontamination stations, surface facility drain system, and various equipment drains and, if sampling of the collection tanks and sumps indicated the presence of *contamination*, would manage that water as low-level radioactive waste.

Discharges to the surface during the monitoring and closure analytical periods would be similar to but less than those for the construction and operations analytical periods. The evaporation ponds would have little or no use, but other manmade sources of surface water would be similar—water storage tanks would be in use, there would be sanitary sewage, and dust suppression would occur as necessary.

4.1.3.1.2 *Potential for Contaminant Spread to Surface Water*

There would be no permanently piped, routine, liquid effluents from surface or subsurface facilities to surface water or drainage channels. The potential for contaminants to reach surface water or surface drainages would be limited to the simultaneous occurrence of a spill or leak and heavy precipitation or snowmelt. Because there are no natural perennial surface waters in the Yucca Mountain region of influence and no readily available sources of contamination, it would take both events to result in a surface spread of contamination.

Potential contaminants during construction would consist mostly of fuels (diesel, propane, and gasoline) and lubricants (oils and grease) for equipment. Fuel storage tanks would be in place early in the construction analytical period, and DOE would construct or install them with appropriate secondary containment (consistent with 40 CFR Part 112). Other potential contaminants, such as paints, solvents, strippers, and concrete additives, also would be in use during construction, but in smaller quantities and much smaller containers. Such materials would probably be in 210-liter (55-gallon) or smaller drums and containers. DOE would minimize the potential for spills and, if they occurred, would minimize contamination by adherence to its *Spill Prevention, Control, and Countermeasures Plan for Site Activities* (DIRS 172055-DOE 2004, all), which it would update for repository construction. The plan would describe actions DOE would take to prevent, control, and remediate spills, and the reporting requirements for a spill or release.

DOE management of the spent nuclear fuel and high-level radioactive waste at the proposed repository would start at the beginning of the operations analytical period. After acceptance at the site and before emplacement in the subsurface facility, DOE would keep these materials in the *restricted area* of the geologic repository operations area. Spent nuclear fuel and high-level radioactive waste, mostly in *canisters*, would also be in transportation *casks, aging overpacks,* transfer casks, or waste packages. These containers would minimize the potential for releases and would shield people, to a large extent, from radiation exposure during the transfer of spent nuclear fuel and high-level radioactive waste between facilities in the geologic repository operations area. In the waste handling buildings, facility system and component design would reduce the likelihood of inadvertent releases to the environment; for example, drain lines would lead to internal tanks or catchments, air emissions would be filtered, and the pool of the Wet Handling Facility would have a stainless-steel liner and leak detection.

DOE would use fuels and lubricants during the operations analytical period for equipment operation and maintenance, and would manage them in the manner described above for the construction analytical period. The Department would use other chemicals and hazardous materials during the operations period, particularly in the Low-Level Waste Facility, which would use sodium hydroxide and sulfuric acid in treatment processes. In addition, activities during the operations period would require relatively small quantities of cleaning solvent. With the exception of fuels, which would be in outdoor tanks with secondary containment, DOE would use and store these hazardous materials inside buildings, and would manage all the materials in accordance with applicable environmental, health, and safety standards and the Spill Prevention, Control, and Countermeasures Plan. Therefore, the potential for spills and leaks of contaminants would be small and, if they occurred, there would be little potential for contaminants to spread far beyond the point of release.

DOE would manage liquid low-level radioactive waste from the waste handling facilities in, or adjacent to, the Low-Level Waste Facility and would maintain the waste in monitored containers. It would maintain and move hazardous and *mixed wastes* in closed containers before shipping them to a permitted treatment facility. These conditions would minimize the potential for spills and releases.

There would be a decrease in general activities at the site after emplacement was complete and the monitoring analytical period began. There would be a corresponding decrease in the potential for spills and releases from routine activities during the operations analytical period. However, decontamination actions that would follow the operations or monitoring period could present other risks due to the use of decontamination solutions and the start of new work. DOE would continue to implement plans and controls to limit the potential for contaminant spread by surface water. In addition, DOE would perform environmental monitoring during the operations and monitoring periods to identify the presence of contaminants that could indicate a release.

In addition to measures to reduce the potential for spills or releases to reach or be spread by surface water, DOE would take measures to prevent runoff and flood waters from reaching areas where they could contact contaminated surfaces or cause releases of hazardous materials. The Department would protect surface facilities that were important to safety (basically those in the restricted area of the geologic repository operations area) against the probable maximum flood by building the structures above the corresponding flood elevation or by using *engineered barriers* such as dikes or drainage channels. It would build other facilities to withstand a *100-year flood*, which is consistent with common industrial practice and DOE policy. Inundation levels for any flood level, even the probable maximum flood, would present no hazard to the subsurface facilities because the *portals* would be at higher elevations than the flood-prone areas. The construction of stormwater retention and detention ponds in appropriate areas would address potential flooding and stormwater pollution issues. DOE would augment the effectiveness of the stormwater ponds, as necessary, by providing diversion channels to move runoff away from surface facilities and aging pads.

The closure analytical period would include further reductions in the potential for contaminant spread, but DOE would continue to implement engineering controls, monitoring, and release-response requirements to ensure that the potential was minimal, which would include during the demolition of surface facilities when water use for dust control would be likely to increase.

4.1.3.1.3 *Potential for Changes to Surface-Water Runoff or Infiltration Rates*

Areas disturbed due to the construction of surface facilities at Yucca Mountain probably would experience changes in the rates of infiltration. Areas where infiltration rates decreased would experience a corresponding increase in surface-water runoff. The Proposed Action could disturb as much as 9 square kilometers (2,200 acres) of land, which would include about 2.43 square kilometers (600 acres) already disturbed as a result of Yucca Mountain characterization activities. In this area of disturbance, areas where soil was loosened or scraped away from *fractured* rock probably would experience increased infiltration rates, and covered or compacted surface areas probably would experience decreased infiltration rates. Most land disturbed during construction would fit into the latter scenario that involved compaction of natural surfaces or the installation of relatively impermeable surfaces like asphalt pads, concrete surfaces, or buildings.

Overall, there would be less infiltration and more runoff from the site. However, DOE expects the change in the amount of runoff that would reach the drainage channels to be small, with small impacts, for two reasons. First, the Department would build the surface geologic repository operations area and the balance of plant facilities (that is, the area where most of the facilities and built-up areas would be) with integral stormwater detention ponds. DOE would control all the runoff from this surface area in this manner and, as a result, runoff increases would not adversely affect existing drainage channels outside this surface area. The second reason applies to the relative scale of the disturbed area and its location. The stormwater detention ponds would minimize the most serious concern from increased runoff from built-up areas, so other increases or decreases in runoff would involve a relatively small amount of the natural drainage. For example, the natural drainage area of Drill Hole Wash, which includes the Midway Valley drainage, represents the area the Proposed Action would affect the most. About 4.8 square kilometers (1,200 acres) of land would be disturbed in and adjacent to the geologic repository operations area. This disturbed area is about 12 percent of the 40 square kilometers (9,900 acres) that make up the drainage area of Drill Hole Wash by the time it reaches *Fortymile Wash*. On a larger scale, most if not all of the total land disturbance of 9 square kilometers (2,200 acres) would be in the natural drainage area for Fortymile Wash. The disturbed area would be approximately 1 percent of the Fortymile Wash drainage, which is about 820 square kilometers (200,000 acres) where the wash leaves the Nevada Test Site near U.S. Highway 95 (DIRS 169734-BSC 2004, Table 7-3). Further, because of the isolated location of these drainage channels, there are no downstream facilities that the minor changes in runoff could reasonably affect.

The Proposed Action would disturb no additional land during the monitoring analytical period and, therefore, there would be no adverse impacts to runoff rates. Reclamation of previously disturbed land would restore preconstruction runoff rates.

Closure of the repository would involve only previously disturbed land. Removal of structures and impermeable surfaces coupled with reclamation efforts would help restore infiltration and runoff rates to nearly predisturbance conditions. DOE would construct monuments to provide long-term markers for the site such that their locations would be impervious to infiltration, but the affected areas would be small.

4.1.3.1.4 *Potential for Altering Natural Surface-Water Drainage*

Construction could involve the placement of structures, facilities, or roadways in or over drainage channels or their associated floodplains (or flood zones). These actions could affect Fortymile, Midway

Valley (Sever), Drill Hole, and Busted Butte (Dune) washes and their associated floodplains. DOE would control surface-water drainage in these washes with diversion channels, culverts, stormwater detention ponds, or similar drainage control measures.

Pursuant to Executive Order 11988, *Floodplain Management*, and its implementing regulations at 10 CFR Part 1022, DOE must, when conducting activities in a floodplain, take action to reduce the risk of flood damage; minimize the impacts of floods on human safety, health, and welfare; and restore and preserve the natural and beneficial values served by floodplains. Appendix C of this Repository SEIS contains a floodplain/wetlands assessment that describes the actions DOE could take. The analysis indicated that consequences of DOE actions in or near the floodplains of the four washes would be minor and unlikely to increase the impacts of floods on human health and safety or harm the natural and beneficial values of the affected floodplains.

The closure analytical period would involve no actions that would alter natural drainage beyond those affected in prior periods. DOE would grade areas where it demolished or removed facilities to match the natural topography to the extent practicable. The Department would not build monuments where they would alter important drainage channels or patterns.

4.1.3.2 Impacts to Groundwater from Construction, Operations, Monitoring, and Closure

The groundwater-related impacts of primary concern are as follows:

- The potential for changes in infiltration rates that could increase the amount of water in the *unsaturated zone* and adversely affect performance of waste containment in the repository, or decrease the amount of recharge to the aquifer;

- The potential for migration of contaminants from the surface to reach the unsaturated zone or aquifers; and

- The potential for project water demands to deplete groundwater resources to an extent that could affect downgradient groundwater use.

4.1.3.2.1 *Potential Infiltration Rate Changes*

Surface-disturbing activities would alter infiltration rates in and around the geologic repository operations area, as described in Section 4.1.3.1. Because impermeable surfaces and compacted ground would cover much of the disturbed land, DOE anticipates a net decrease in infiltration and a corresponding increase in runoff over the disturbed area. In the semiarid environment of Yucca Mountain, much of the total infiltration occurs in areas of higher elevation, areas with thin or no soil cover, or in the upper reaches of washes. The amount of projected recharge along Fortymile Wash is very small in comparison with the recharge of the aquifers from farther north. The increased runoff from the disturbed surface area from the Proposed Action could cause more water to reach Fortymile Wash, and the stormwater detention ponds would represent new areas of temporary water accumulation. As a result, additional infiltration could occur in these locations in comparison with existing conditions. However, the areas potentially subject to increased infiltration would be localized and small in comparison with infiltration that occurred over the entire Fortymile Wash drainage area. Any increase in infiltration would be unlikely to affect overall groundwater recharge or flow patterns.

Surface disturbance along the crest of Yucca Mountain and on the steeper slopes above the proposed repository could present different scenarios for infiltration rate changes because the depth of unconsolidated material (that is, soil and gravel) in these areas is generally thin, and there would be a higher *probability* that disturbance could expose fractured bedrock where precipitation and runoff could enter cracks and crevices and more readily reach deep portions of the unsaturated zone. Ventilation shafts to the subsurface area and access roads to those locations are the primary examples of surface disturbances that would occur in the upper areas of Yucca Mountain. The amount of disturbed land in these areas would be small in comparison with the undisturbed area, and any net change in infiltration would be small.

Subsurface activities could change groundwater recharge rates, primarily due to the amount of water that DOE would pump to the subsurface for dust suppression and tunnel boring during development activities. This potential for increased recharge would be offset by measures to collect and remove accumulating water back to the surface (to the North Construction Portal and the South Portal evaporation ponds), by removal of wet excavated rock to the surface, and by keeping the work areas ventilated, which would promote evaporation of the remaining water. During the excavation of the *Exploratory Studies Facility*, DOE tracked water introduced to the subsurface because water that remained in the subsurface could affect DOE's understanding of postclosure performance of the proposed repository. Tracking of the use of water in the subsurface would continue under the Proposed Action, and DOE anticipates that changes in recharge through Yucca Mountain would have small impacts to the groundwater system.

No additional land disturbance would occur during the monitoring and closure analytical periods, so further effects on infiltration rates would be unlikely. Soil reclamation and revegetation would accelerate a return to more natural infiltration conditions. Monuments that DOE constructed to provide long-lasting markers for the site would probably result in impermeable locations, but the surface area covered by the monuments would be small in relation to the surrounding areas.

4.1.3.2.2 *Potential for Contaminant Migration to Groundwater*

Section 4.1.3.1 discusses the types of contaminants that DOE could use at the proposed repository site and the possibility of spills or releases of these materials to the environment. Adherence to regulatory requirements and a Spill Prevention, Control, and Countermeasures Plan (Section 4.1.3.1) would minimize the potential for spills or releases to occur and would require appropriate responses to clean up or otherwise abate any such incident. Natural conditions, which include depth to groundwater, thickness of *alluvium* in most areas, and *arid* environment, would help ensure that significant contaminant migration did not occur before DOE could take action. Section 4.1.8 discusses the potential for onsite accidents that could involve releases of contaminants. Chapter 5 discusses the postclosure release of contaminants from the waste packages in the repository.

4.1.3.2.3 *Potential for Depletion of Groundwater Resources*

The quantity of water necessary to support the Proposed Action would be greatest during the initial construction analytical period and early in the operations analytical period, when DOE would need water for surface soil compaction and dust suppression as well as subsurface development. The evaluation of impacts for this Repository SEIS addressed potential impacts from this water demand only during these heavy-use periods. Table 4-6 summarizes water demands during these two periods of heavy water use. Water demand during the monitoring and closure analytical periods would be lower and of less concern and would be likely to remain as presented in the Yucca Mountain FEIS.

Table 4-6. Annual water demand for construction and operations.

Analytical period	Duration[a] (years)	Annual water demand (cubic meters)	Annual water demand (acre-feet)[b]
Construction	5	330,000 to 570,000	270 to 460
Operations			
Emplacement plus continued underground development and surface construction[c]	5	220,000 to 410,000	180 to 330
Emplacement and continued underground development	up to 25	270,000 to 300,000	220 to 240
Emplacement	up to 20	240,000	195

a. Several of the project periods are flexible in the number of years they could last. In such cases, values are "up to" with a breakout representative of the maximum length and most conservative high water demand expected. For example, DOE expects the operations analytical period to last up to 50 years; within that period, subsurface development could last up to a total of 30 years. If development took less time, the last phase of emplacement could be longer than 20 years, so the total would still be 50.

b. This table lists acre-feet because of common statutory and public use of this unit of measure for groundwater resources.

c. Although the analysis assumed that the formal construction analytical period would be 5 years, some construction activities could extend into the operations analytical period (Chapter 2, Table 2-1).

Figure 4-1 shows annual water demands during construction and the first few years of the operations analytical period. It shows water demand during the construction analytical period because it would be the period of greatest fluctuation and would include the year of peak water demand. Figure 4-1 also shows estimated water demands for the 3 years prior to the start of repository construction. The first year depicts the minor amount of water that would be necessary to operate and maintain existing facilities. The next 2 years show increased water demand under the assumption that the infrastructure improvements described in Section 4.3 would start before repository construction.

Water demand would be highest during the initial construction analytical period and would range from about 330,000 to 570,000 cubic meters (270 to 460 acre-feet) per year (Table 4-6 and Figure 4-1). During the first 5 years of the operations analytical period, construction of surface and subsurface facilities would occur along with emplacement of spent nuclear fuel and high-level radioactive waste; water demand would range from about 220,000 to 410,000 cubic meters (180 to 330 acre-feet) per year. Other than an increase in the second and third years of this 5-year period, annual water demand would start leveling off to a quantity more representative of the rest of the operations period. Subsurface development could continue for up to the next 25 years, but water demand would generally level off at about 270,000 cubic meters (220 acre-feet) per year. After the development of the subsurface area was complete, the primary operations would consist of waste receipt and emplacement. Water demand would drop slightly to about 240,000 cubic meters (195 acre-feet) per year during this period.

DOE would meet water demand by pumping from existing wells, and possibly one new well, in the Jackass Flats *hydrographic area*. The new well, if installed, would support operations at Gate 510. Table 4-6 and Figure 4-1 do not include Nevada Test Site activities in this area, which would require groundwater during the same period. During the 7-year period from 2000 to 2006, the average Nevada

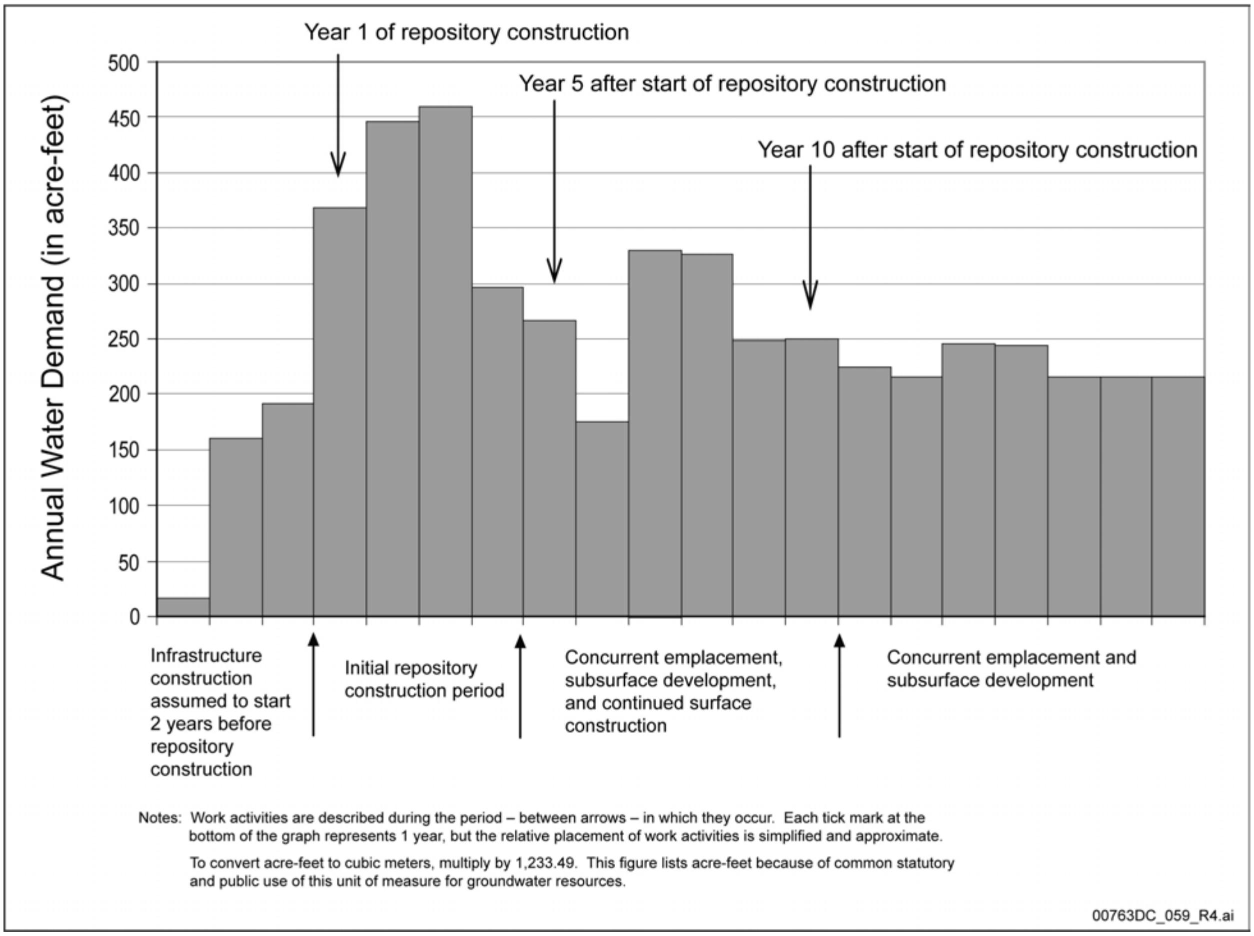


Figure 4-1. Annual water demand during the construction analytical period and the initial phases of operations.

Test Site water withdrawal from this hydrographic area was about 83,000 cubic meters (67 acre-feet) per year (DIRS 181232-Fitzpatrick-Maul 2007, all). In a 2002 analysis, the Test Site indicated there were no planned expansions of existing operations that would affect water use, but potential future programs could involve additional water use (DIRS 162638-DOE 2002, pp. 4-18 and 4-19). The following evaluation assumed that this recent use represents a reasonable estimate of Nevada Test Site water demand from *Jackass Flats*, at least in the near term (5 to 10 years). However, DOE recognizes that Test Site demand could increase in the future. As shown in Table 4-6 and Figure 4-1, water demand for the Proposed Action would generally decrease and level off after completion of surface construction activities. This additional water demand for the Nevada Test Site is part of the *cumulative impacts* analysis in Chapter 8 of this Repository SEIS. At least for the peak water demand years of the Proposed Action, the estimated additional water demand for Nevada Test Site activities would be 83,000 cubic meters (67 acre-feet).

DOE used the three approaches it used in the Yucca Mountain FEIS to evaluate potential impacts of water demand on groundwater resources:

- Comparison with impacts observed or measured during past water withdrawals,
- Comparison of the proposed demand with estimates of perennial yield of the aquifer, and

- Groundwater modeling efforts to assess changes the proposed demand would have on groundwater elevations and flow patterns.

The following paragraphs address potential impacts from the construction and operations analytical periods, when water demand would be highest. Impacts from water demand during the monitoring analytical period would be small in comparison, except during the first 3 years, when they would be comparable to those for operations. Impacts during the closure analytical period would be small in comparison.

4.1.3.2.4 *Comparison with Impacts from Past Water Withdrawals*

The peak water demand would be about 650,000 cubic meters (530 acre-feet) per year [that is, 570,000 cubic meters (460 acre-feet) from the Proposed Action from Table 4-6, plus 83,000 cubic meters (67 acre-feet) for Nevada Test Site needs]. This demand would be 33 percent higher than the peak withdrawal of about 490,000 cubic meters (400 acre-feet) during the past 15 years from the Jackass Flats area (Chapter 3, Section 3.1.4.2.2; DIRS 155970-DOE 2002, Table 3-16, p. 3-66). However, water demand at this level would occur for only 2 years, and the average annual water demand over the 5-year construction analytical period would be about 530,000 cubic meters (430 acre-feet) with the Nevada Test Site needs. This demand would be quite similar to the groundwater withdrawals during the busier period of the Yucca Mountain site characterization activities. During the next 5-year period, when underground development and some surface construction would occur simultaneously with emplacement operations, annual water demand would average about 410,000 cubic meters (330 acre-feet). Based on the past history of groundwater withdrawals from the Jackass Flats hydrographic area and the corresponding minor changes in groundwater elevations (Chapter 3, Table 3-5), the proposed water demand amounts would be unlikely to affect the stability of the *water table* in the area adversely.

4.1.3.2.5 *Comparison with Estimates of Groundwater Perennial Yield*

Perennial yield is the estimated quantity of groundwater that can be withdrawn annually from a basin without depletion of the reservoir. As discussed in Chapter 3, Section 3.1.4.2.1, the estimated perennial yield of the aquifer in the Jackass Flats hydrographic area is between 1.1 million and 4.9 million cubic meters (880 and 4,000 acre-feet). The source of the low end of this range is an estimate of the annual groundwater recharge that occurs in the Jackass Flats hydrographic area, so it includes no underflow that enters the area from upgradient groundwater basins. This low estimate can be further reduced, to be more conservative, by attributing 720,000 cubic meters (580 acre-feet) to the western two-thirds of the Jackass Flats hydrographic area (where the Proposed Action would withdraw water) and 370,000 cubic meters (300 acre-feet) to the eastern one-third. This last reduction accommodates the belief of some investigators that the two portions of Jackass Flats have different general flow characteristics. These yield values (from the low estimates, associated only with local recharge, to the highest estimate, which is more than 4 times greater) occur not only in groundwater studies but also in the Nevada State Engineer’s rulings that address water appropriation requests for Jackass Flats groundwater (DIRS 105034-Turnipseed 1992, pp. 9 and 12).

The peak annual demand of 570,000 cubic meters (460 acre-feet) would be below the lowest estimates of the perennial yield of the Jackass Flats area, even if that is the amount attributable to the western two-thirds of the area. With the addition of water demand for the Nevada Test Site, the peak annual demand would still be below the lowest estimate of yield from the western two-thirds of the area; that is, a demand of 650,000 cubic meters (530 acre-feet) in comparison with the lowest estimate of perennial yield of 720,000 cubic meters (580 acre-feet). A comparison of the peak annual water demand (with the demand from Test Site activities) with the highest estimate of the Jackass Flats perennial yield indicated only 13 percent of the highest value.

Based on these comparisons of the proposed water demand with estimates of the perennial yield of the Jackass Flats area, DOE has concluded that the Proposed Action would not deplete the groundwater reservoir. The Department recognizes that annual recharge can change significantly from year to year, depending on the area weather patterns. For the peak year, water demand could exceed groundwater recharge in the western two-thirds of the Jackass Flats hydrographic area. However, water demand at that high level and similar levels would be relatively short-term. If water demand exceeded local recharge for a few years (longer durations would be unlikely based on the estimates of average annual recharge), there could be some shifting of the general flow patterns in the Jackass Flats area. Shifts in flow patterns would be small because the peak annual water demand would be a small portion of the highest estimate of perennial yield, 4.9 million cubic meters (4,000 acre-feet), which would include underflow from upgradient groundwater basins.

As noted in the Yucca Mountain FEIS, the heaviest water demand in the region of influence for the Proposed Action would be in the Amargosa Desert. The water demand for the Proposed Action would, to some extent, decrease the availability of water in the downgradient area because it would reduce the long-term underflow that reached the Amargosa Desert. However, the peak annual water demand of 650,000 cubic meters (530 acre-feet) for proposed repository and Nevada Test Site activities in Jackass Flats would be small (about 4 percent) in comparison with the average annual withdrawal of 16 million cubic meters (13,000 acre-feet) in the Amargosa Desert between 2000 and 2004 (Chapter 3, Table 3-4) for activities other than the Proposed Action or the Test Site. The demand of repository and Test Site activities in Jackass Flats would be an even smaller fraction of the perennial yield of 30 million to 42 million cubic meters (24,000 to 34,000 acre-feet) in the Amargosa Desert.

Comparisons between water demand and estimates of perennial yield (Chapter 3, Table 3-4) must recognize the wide range of perennial yield estimates for the hydrographic areas of Jackass Flats and Amargosa Desert as well as the adjacent hydrographic areas. One estimate of perennial yield in State of Nevada documentation is 30 million cubic meters (24,000 acre-feet) for the combined area of Jackass Flats, Amargosa Desert, Rock Valley, Buckboard Mesa, and Crater Flat (DIRS 182821-Converse Consultants 2005, p. 100), in comparison with the 30-million-cubic meter estimate just for Amargosa Desert. The state uses estimates of perennial yield as a tool (with other considerations) in the management of groundwater resources and evaluation of requests for groundwater appropriations. The other side of the evaluation of potential impacts on groundwater resources is that, independent of the physical availability of water, the groundwater of the Amargosa Desert is over-appropriated in comparison with many estimates of perennial yield. As noted in Section 3.1.4.2.1, the amount of water actually withdrawn each year from the Amargosa Desert hydrographic area has averaged only about half of the total appropriations in recent years. However, a recent ruling by the Nevada State Engineer (also described in Section 3.1.4.2.1) describes the State's position that the spring discharges in the Ash Meadows area are part of the committed water taken from the hydrographic area along with the amount pumped from wells. Under this scenario, the combined annual water withdrawals and discharges in the Amargosa Desert hydrographic area exceed the perennial yield value of 30 million cubic meters (24,000 acre-feet).

4.1.3.2.6 *Modeled Effects on Groundwater Elevations and Flow Patterns*

This section summarizes the two modeling efforts described in the Yucca Mountain FEIS, one by Thiel Engineering Consultants for DOE (DIRS 145966-CRWMS M&O 2000, all) and the other by the U.S. Geological Survey (DIRS 145962-Tucci and Faunt 1999, all). DOE used the results of these analyses to estimate effects the Proposed Action could have on groundwater elevations and flow patterns. Both modeling efforts generated baseline groundwater conditions from historical water withdrawals from the Jackass Flats area, then generated future groundwater conditions with the assumption of an additional water demand of 530,000 cubic meters (430 acre-feet) per year for the Proposed Action. As indicated in Figure 4-1, the water demand DOE evaluated for the Proposed Action would exceed the model-assumed withdrawal rate for 2 years during repository construction. Because the model conclusions used a long-term withdrawal rate of 530,000 cubic meters per year, those conclusions are very conservative. Over the first 10 years of the Proposed Action, when the peak annual demand would occur, the average annual water demand would be only 390,000 cubic meters (320 acre-feet). Over the life of the Proposed Action, the average annual water demand would be much less. Results from the modeling efforts indicated there would be groundwater elevation differences attributable to the Proposed Action, as follows:

- The Thiel Engineering Consultants study predicted a water elevation decrease of up to 3 meters (10 feet) within about 1 kilometer (0.6 mile) of the Yucca Mountain production wells. The U.S. Geological Survey model predicted a similar water level decrease of less than 2 meters (6.6 feet) at distances a few kilometers from the production wells.

- The models predicted water elevation decreases at the town of Amargosa Valley that ranged from less than 0.4 to 1.1 meters (1.2 to 3.6 feet). [In this case, the predictions were for groundwater roughly at the junction of U.S. Highway 95 and Nevada State Route 373, about 13 kilometers (8 miles) south of well J-12.]

- The Thiel Engineering Consultants study estimated a reduction in the underflow from the Jackass Flats hydrographic area to the Amargosa Desert hydrographic area of about 160,000 cubic meters (130 acre-feet) per year after 100 years of pumping. The U.S. Geological Survey effort estimated an underflow reduction of 180,000 cubic meters (150 acre-feet) per year at steady-state conditions.

The Thiel Engineering Consultants modeling effort looked at numerous locations and pumping scenarios throughout the region and concluded in all areas of the Amargosa Desert that groundwater elevation decreases attributable to the Proposed Action, though possibly moderate by themselves, would be minor in comparison with decreases from the pumping scenarios without the Proposed Action. Both modeling efforts assumed a conservatively high value for the water demand of the Proposed Action, so the predicted impacts, even though moderate in scale, are conservatively high.

4.1.3.3 Summary of Impacts to Hydrology

The following summarize the conclusions of the evaluations in this section:

- Repository construction and operation would result in minor changes to runoff and infiltration rates.

- The potential for flooding at the repository that could cause damage of concern would be extremely small.

- The highest annual water demand for the Proposed Action would be below the Nevada State Engineer's ruling of perennial yield (the amount that can be withdrawn annually without depleting reserves) for the Jackass Flats hydrographic area, including the lowest estimated value of perennial yield [720,000 cubic meters (580 acre-feet)] for the western two-thirds of this hydrographic area. The water demand for the Proposed Action, coupled with that projected for Nevada Test Site activities in Jackass Flats, would still be below the lowest estimated value of perennial yield for the western two-thirds of the hydrographic area.

- The Proposed Action would withdraw groundwater that would otherwise move into aquifers of the Amargosa Desert, but the combined water demand for the repository and Nevada Test Site activities in Jackass Flats would have, at most, small impacts on the availability of groundwater in the Amargosa Desert area in comparison with the quantities of water already being withdrawn there.

4.1.4 IMPACTS TO BIOLOGICAL RESOURCES AND SOILS

The region of influence for biological resources and soils in this Repository SEIS is the area that contains all potential surface disturbances that would result from the Proposed Action plus additional areas to evaluate local animal populations, roughly equivalent in size to the analyzed land withdrawal area that DOE assessed in the Yucca Mountain FEIS, as well as land DOE proposes for an access road from U.S. Highway 95 and land where DOE could construct offsite facilities. The Department has reanalyzed impacts to biological resources and soils for this Repository SEIS based on the modified design that Chapter 2 describes. The evaluation of impacts to biological resources and soils considered the potential for effects to vegetation and wildlife, which included special-status species of plants and animals and their *habitats*; jurisdictional waters of the United States, which included *wetlands*; riparian areas; and soil resources. The evaluation also considered the potential for impacts to migratory patterns and populations of game animals. DOE expects the overall impacts to biological resources would be small because plant and animal species in the Yucca Mountain region are typical of the Mojave and *Great Basin* deserts and generally are common throughout those areas. The removal of vegetation from the area that DOE would require for construction and operation of the repository and the small impacts to some wildlife species from disturbance or loss of individuals or habitat would not affect regional biodiversity and *ecosystem* function.

4.1.4.1 Impacts to Biological Resources from Construction, Operations, Monitoring, and Closure

As discussed in Section 4.1.7 of this Repository SEIS, routine releases of radioactive materials from the repository during its operation would consist mainly of naturally occurring radon-222 and its *decay* products. These releases would result in *doses* to plants and animals around the repository that would be lower than the International Atomic Energy Agency thresholds for detrimental effects to radiosensitive species in terrestrial ecosystems (DIRS 103277-IAEA 1992, p. 53). No detectable impacts to surface biological resources would occur as a result of normal releases of radioactive materials from the repository; therefore, the following sections do not consider these releases.

4.1.4.1.1 *Impacts to Vegetation*

The construction of surface facilities and the disposition of excavated rock from subsurface construction would remove or alter vegetation in the analyzed land withdrawal area and within the 37-square kilometer

(9,100-acre) offsite area directly to the south. Approximately 2.5 square kilometers (620 acres) of the construction would occur in areas (both in the land withdrawal area and in the offsite area to the south) in which site characterization activities had already disturbed the vegetation; however, construction also would occur on as much as 6.5 square kilometers (1,600 acres) of undisturbed areas near the previously disturbed areas. Subsurface construction would continue after emplacement operations began, and the disposal of excavated rock would eliminate vegetation in the area under the excavated rock pile. Table 4-7 lists the amount of land that DOE would clear of vegetation for the majority of repository facilities by land cover type and compares this disturbance to the amounts of each land cover type in the Mojave and Nellis mapping zones in the State of Nevada. Removal of vegetation would result in impacts to small amounts of widely distributed land cover types that are common in the affected mapping zones (Chapter 3, Section 3.1.5.1.1 describes mapping zones), and these impacts would not cause a significant loss to any particular cover type. The largest losses would be to the Sonora-Mojave Creosotebush-White Bursage Desert Scrub land cover type, with disturbance of approximately 0.25 percent of the cover type in the Nellis and Mojave mapping zones in Nevada, and to the Sonora-Mojave Mixed Salt Desert Scrub land cover type, with disturbance of approximately 0.15 percent of the cover type in those mapping zones. Activities during repository construction, operations, monitoring, or closure would not reduce any other land cover type by more than 0.05 percent in the affected mapping zones.

Biological soil crusts likely occur within the region of influence in some areas where there has been no surface disturbance. Because insufficient data exist to assess the amount of biological crusts in the region of influence, and because attempts to locate or map occurrences of biological crusts could result in their disturbance or destruction, it would be extremely difficult for DOE to quantify the predicted impacts of repository construction or operations on biological crusts. However, any biological crusts in areas disturbed by repository construction or operations would be lost.

In cooperation with the U.S. Fish and Wildlife Service, DOE developed a site reclamation plan, in part to satisfy the terms and conditions of the 2001 Biological Opinion. DOE would reclaim lands it no longer needed for repository construction or operations and would monitor those lands to determine if reclamation efforts were successful. As stated in the *Reclamation Implementation Plan*, DOE considers reclamation successful if plant cover, density, and species richness are equal to, or exceed, 60 percent of the value of the same parameters in undisturbed reference areas (DIRS 154386-YMP 2001, pp. 33 and 34). If reclaimed sites meet these criteria, they can be released from further remediation and monitoring. As of April 2007, the Department had successfully reclaimed 119 sites [a total of 0.174 square kilometer (43 acres)] and released them from reclamation monitoring.

Repository construction activities that resulted in land disturbances and removal of vegetation could result in colonization by invasive plant species in additional areas. *Invasive species* that are currently present on the site (Chapter 3, Section 3.1.5.1.1) would be the most likely to colonize disturbed areas. Invasive species could suppress *native species*, although the reclamation actions described above could reduce the likelihood that they would overtake native species on reclaimed lands. To control the spread of undesirable species further, DOE would develop and implement methods to control invasive species and noxious weeds on disturbed sites during construction and operation of the repository.

With an increase in invasive annual plants there could be an increase in fire fuel load from dried annual plants. Because the area that construction activities disturbed would be small in comparison with the total undisturbed vegetated area in the region of influence (Table 4-7), and because DOE would reclaim areas no longer in use as practicable, impacts to native species and the threat of increased fires would be small.

Table 4-7. Land cover types in the region of influence.[a]

Land cover type	Area in Mojave and Nellis mapping zones in the State of Nevada[b]		Disturbed area under the Proposed Action[c]	
	square kilometers	square miles	square kilometers	square miles
Great Basin Pinyon-Juniper Woodland	4,000	1,500	0	0
Great Basin Xeric Mixed Sagebrush Shrubland	6,300	2,400	0.0023	0.00088
Inter-Mountain Basins Big Sagebrush Shrubland	8,000	3,100	0	0
Inter-Mountain Basins Cliff and Canyon	410	160	0	0
Inter-Mountain Basins Greasewood Flat	1,400	540	0.0054	0.0021
Inter-Mountain Basins Mixed Salt Desert Scrub	25,000	9,800	0	0
Inter-Mountain Basins Montane Sagebrush Steppe	20	7.8	0	0
Inter-Mountain Basins Semi-Desert Grassland	78	30	0	0
Inter-Mountain Basins Semi-Desert Shrub Steppe	4,500	1,700	0.15	0.058
Invasive Annual Grassland	55	21	0	0
Mojave Mid-Elevation Mixed Desert Scrub	3,600	1,400	1.7	0.65
North American Warm Desert Active and Stabilized Dune	2.9	1.1	0	0
North American Warm Desert Bedrock Cliff and Outcrop	350	140	0	0
North American Warm Desert Lower Montane Riparian Woodland and Shrubland	24	9.5	0	0
North American Warm Desert Playa	220	85	0.030	0.011
North American Warm Desert Volcanic Rockland	8.2	3.2	0	0
North American Warm Desert Wash	33	13	0	0
Sonora-Mojave Creosotebush-White Bursage Desert Scrub	1,200	480	3.0	1.2
Sonora-Mojave Mixed Salt Desert Scrub	940	360	1.4	0.54
Totals[a]	57,000	22,000	6.3	2.4

Source: Derived from digital land cover map (DIRS 179926-USGS National Gap Analysis Program n.d., all) and land cover descriptions (DIRS 174324-NatureServe 2004, all) with the use of a geographic information system.

a. Numbers are rounded to two significant figures; therefore, totals might differ from sums.

b. Chapter 3, Section 3.1.5.1.1 contains a description of mapping zones.

c. Disturbed land cover area calculated only for disturbances for which a location has been identified. Total disturbance would be approximately 9 square kilometers.

Some invasive species would remain along permanent roads and drainage ditches where reclamation opportunities were limited, and these species could spread and overcome native species under certain conditions. Reclamation or other weed management strategies on long-term topsoil stockpiles and other disturbed areas would help control the abundance of invasive annuals such as red brome (*Bromus rubens*), and would minimize potential fire fuel load and disruption to native plant communities.

The Yucca Mountain FEIS cited studies that indicate that site characterization activities had very small effects on vegetation adjacent to DOE activities at Yucca Mountain. Therefore, impacts to vegetation from construction probably would occur only as a result of direct disturbance, such as during site clearing, and indirect disturbance, such as an increase in invasive annual plants as described above. Little or no disturbance of additional vegetation would occur as a result of monitoring and maintenance activities before closure.

Closure of the repository would involve the removal of structures and reclamation of areas that DOE cleared of vegetation for the construction of surface facilities as practicable and as delineated in the license amendment that DOE would have to obtain before closure. Final reclamation could include backfilling and grading to restore natural drainage patterns and create a stable landform; spreading and contouring topsoil that had been stockpiled during construction; creating erosion-control structures; ripping, seeding, spreading, and anchoring mulch; and fencing to reduce loss of new vegetation to herbivores. Figures 4-2, 4-3, and 4-4 illustrate the reclamation process the Department undertook during site characterization for Yucca Mountain, which has improved the success rate of vegetation reestablishment and helps control encroachment of invasive species. DOE would use such activities in the future to limit impacts of the Proposed Action.

Figure 4-2. Fill material is spread and contoured on the site of a decommissioned borrow area at Yucca Mountain.

Figure 4-3. Decommissioned borrow area at Yucca Mountain that has been recontoured prior to seeding and mulching.

Figure 4-4. Decommissioned borrow area at Yucca Mountain 4 years after reclamation.

4.1.4.1.2 *Impacts to Wildlife*

This section summarizes, incorporates by reference, and updates the Impacts to Wildlife portion of Section 4.1.4.2 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 4-34 and 4-35). *Direct impacts* to wildlife would occur through four mechanisms: (1) loss of habitat from construction of facilities and infrastructure; (2) localized deaths of individuals of some species, particularly burrowing species of small mammals and reptiles, and deaths of individual animals from vehicle collisions; (3) fragmentation of undisturbed habitat that created a *barrier* to wildlife movement; and (4) displacement of wildlife because of an aversion to the noise and activity from construction, operations, monitoring, and closure of the repository.

The effect of these impacts on wildlife would be small because: (1) habitats similar to those at Yucca Mountain (identified by land cover type) are widespread locally and regionally; (2) animal species at the proposed repository site are generally widespread throughout the Mojave or Great Basin deserts, and the deaths of some individuals due to repository construction, habitat loss, and vehicle collisions would have small impacts on the regional populations of those species or on the overall biodiversity of the region; (3) large areas of undisturbed and unfragmented habitat would be available away from disturbed areas; and (4) impacts to wildlife from noise and vibration, if any, would be limited to the vicinity of the source of the noise (for example, heavy equipment, diesel generators, and ventilation fans). Overall, no species would be threatened with extinction, either locally, regionally, or globally. Several animals classified as game species by the State of Nevada [such as Gambel’s quail (*Callipepla gambelii*), chukar (*Alectoris chukar*), and mule deer (*Odocoileus hemionus*)] are present in low numbers in the region of influence. Adverse impacts to these species would be unlikely and hunting opportunities would not change as DOE would continue to prohibit hunting in the area where most construction activities would occur. There would be no impact to desert bighorn sheep (*Ovis canadensis nelsoni*) in the offsite area to the south of the analyzed land withdrawal area, or their winter habitat in the Striped Hills, because the proposed addition to the access road to the Yucca Mountain site is more than 1.6 kilometers (1 mile) west of the nearest potential habitat for sheep and there is no nearby suitable habitat to the west of the road. Construction and operations of other facilities or structures in the offsite area, such as new electric transmission lines, the Sample Management Facility, and a temporary construction camp, would have no impact on desert bighorn sheep because these actions would be far from important bighorn sheep habitat.

To avoid and minimize adverse impacts to migratory birds during repository construction, DOE would implement best management practices, which would include avoidance of groundbreaking activities to the maximum extent practicable in nesting habitat during the critical nesting period, which the Bureau of Land Management defines as May 1 through July 15. If groundbreaking or land clearing activities were necessary during the nesting season, DOE would conduct surveys for migratory bird nests before any such activities. The Department would prohibit all activities that would harm nesting migratory birds or result in nest abandonment.

Wildlife would be attracted to the water in lined evaporation ponds in the vicinity of the geologic repository operations area. Individuals of some species could benefit from the water, but some animals could become trapped in the ponds depending on the depth and the slope of the sides. Previous experience has shown that a wide variety of animal species use such ponds and that DOE could avoid losses of animals by reduction of the pond slopes or by an earthen ramp at one corner of the pond. Appropriate engineering would minimize potential losses to wildlife.

As Chapter 3, Section 3.1.12.1 discusses, DOE could construct a landfill for construction debris and sanitary *solid waste*, although it has not determined a site for it. The landfill could attract scavengers such as coyotes (*Canis latrans*) and ravens (*Corvus corax*). Frequent covering of the *sanitary waste* in the landfill would minimize use by scavenger species.

After the completion of waste emplacement, human activities and vehicle traffic would decline, as would impacts of those actions on wildlife, with further declines in activities and impacts after repository closure. Animal species could reoccupy the areas DOE reclaimed during the closure period.

4.1.4.1.3 *Impacts to Special-Status Species*

This section summarizes, incorporates by reference, and updates as indicated by new references the Impacts to Special Status Species portion of Section 4.1.4.2 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 4-35 and 4-36). The desert tortoise (*Gopherus agassizii*) is the only resident animal species in the analyzed land withdrawal area that is listed as threatened under the *Endangered Species Act* (16 U.S.C. 1531 et seq.). Further, there are no endangered or candidate animal species and no species that are proposed for listing (Chapter 3, Table 3-7). Repository construction would result in the loss of a small portion of desert tortoise habitat at the northern edge of the range of this species in an area where the abundance of tortoises is low.

Based on past experience, DOE anticipates that human activities at the site could directly affect individual desert tortoises. DOE has successfully relocated two tortoise nests and 27 individual tortoises to protect them from potential threats. Since July 1997, three tortoises have been killed on access roads, none by construction activities (DIRS 182586-Spence 2007, all). Therefore, although some tortoises could be killed on roads during repository construction and as a result of increased vehicle traffic during repository operation, DOE anticipates the number of tortoise deaths due to vehicle traffic and construction activities during the repository construction, operations, monitoring, and closure analytical periods would be small. However, the abundance of ravens, which are natural predators of juvenile desert tortoises, could increase as a result of infrastructure construction (the birds could use electric transmission lines and light posts as perches, for example) and could result in increased predation on young tortoises. Frequent covering of the sanitary waste in the potential landfill would limit the attraction of the repository area to ravens.

Although these losses would cause a small decrease in the abundance of desert tortoises in the immediate vicinity of the repository site, they would not affect the long-term survival of the local or regional population of this species. Yucca Mountain is surrounded to the east, south, and west by large tracts of undisturbed tortoise habitat on government property, and desert tortoises are widespread at low densities throughout this region.

The U.S. Fish and Wildlife Service has concluded that tortoise populations are depleted for more than 1 kilometer (0.6 mile) on either side of heavily used roads (DIRS 155970-DOE 2002, p. 4-36). The increase in traffic to Yucca Mountain would contribute to the continued depression of populations along U.S. Highway 95, but would not increase the threat to the long-term survival of tortoise populations in southern Nevada.

As required by Section 7 of the *Endangered Species Act*, DOE has entered into consultations with the U.S. Fish and Wildlife Service on the effects of proposed repository activities on the desert tortoise. The Fish and Wildlife Service issued a Biological Opinion in 2001, which concluded that “construction, operation and monitoring, and closure of a geologic repository at Yucca Mountain is not likely to jeopardize the continued existence of the threatened Mojave population of the desert tortoise. These actions do not affect any area designated as critical habitat; therefore, no destruction or adverse modification of that habitat is anticipated" (DIRS 155970-DOE 2002, Appendix O, pp. 21 to 22). The Biological Opinion included reasonable and prudent measures, and terms and conditions required to achieve these measures, to ensure that implementation of the Proposed Action would not jeopardize the desert tortoise. Chapter 9, Section 9.2.4.1 of the Yucca Mountain FEIS listed these measures and described how DOE is implementing them (DIRS 155970-DOE 2002, pp. 9-9 to 9-11). DOE would reinitiate consultation with the Fish and Wildlife Service if any of the conditions in 50 CFR 402.16 occurred, for example, if DOE exceeded the limit the Biological Opinion specified on the amount of tortoise habitat that DOE could disturb [6.65 square kilometers (1,643 acres)] (DIRS 155970-DOE 2002, Appendix O, p. 29).

The bald eagle (*Haliaeetus leucocephalus*) was observed once on the Nevada Test Site and might migrate through the Yucca Mountain region. If present at all, eagles would be transient and repository activities would not affect them. The State of Nevada classifies the bald eagle as endangered.

Several animal species considered sensitive by the Bureau of Land Management (Chapter 3, Table 3-7) occur in the region of influence. Impacts to bat species would be small because of their low abundance on the site and broad distribution. Impacts to the common chuckwalla (*Sauromalus ater*) and Western burrowing owl *(Athene cunicularia hypugaea)* from disturbance or loss of individuals would be small because they are widespread regionally and are not abundant in the land withdrawal area. Impacts to the Western red-tailed skink (*Eumeces gilberti rubricaudatus*) would be small because it is widespread regionally and occupies small pockets of isolated habitat that would not be overly affected by any proposed disturbances. Giuliani's dune scarab beetle (*Pseudocotalpa giulianii*) has been reported only in the southern portion of the land withdrawal area away from any proposed disturbances and, therefore, would not be affected.

Monitoring and closure activities at the repository would have little impact on desert tortoises or Bureau of Land Management *sensitive species* because the repository workforce would be smaller than during the operations analytical period. Over time, vegetation would recover on disturbed sites and indigenous species would return. As the habitat recovered over the long term, desert tortoises and other special-status species at the repository site could recolonize areas abandoned by humans.

4.1.4.1.4 *Impacts to Wetlands*

This section summarizes, incorporates by reference, and updates the Impacts to Wetlands portion of Section 4.1.4.2 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 4-36 and 4-37). There are no known naturally occurring wetlands subject to permitting requirements under Section 404 of the *Clean Water Act* (42 U.S.C. 1251 et seq.) on the repository site, so no impacts to such wetlands would occur as a result of repository construction, operations, monitoring, or closure. In addition, repository activities would not affect the manmade well pond in the land withdrawal area. Repository-related structures could affect as much as 2.8 kilometers (1.7 miles) of ephemeral washes, depending on the size and location of the facilities. After selecting the location of the facilities, DOE would conduct a formal delineation of waters of the United States near the surface facilities and, if necessary, develop a plan to avoid when practicable and otherwise minimize impacts to those waters. If repository activities would affect waters of the United States, DOE would consult with the U.S. Army Corps of Engineers and obtain permit coverage for those impacts. If the activities were not covered under a nationwide permit, DOE would apply to the Corps of Engineers for a regional or individual permit. By implementation of the *mitigation* plan and compliance with other permit requirements, DOE would ensure that impacts to waters of the United States would be minimized. Appendix C of this Repository SEIS contains a floodplain and wetlands assessment for the proposed repository.

4.1.4.2 Evaluation of Severity of Impacts to Biological Resources

Table 4-8 lists the results of the DOE evaluation of the impacts to biological resources.

Table 4-8. Impacts to biological resources.

Analytical period	Flora	Fauna	Special-status species	Wetlands	Overall
Construction					
	Small; removal of vegetation from up to 9 square kilometers (2,200 acres) in widespread communities; maximum loss to any one land cover type in the affected mapping zones would be 0.25 percent	Small; loss of small amount of habitat and some individuals of some species	Small; loss of small amount of desert tortoise habitatand few tortoises	None	Small; loss of small amount of widespread but undisturbed habitatand small number of individuals
Operations					
	Small; disturbance of vegetation in areas adjacent to disturbed areas	Small; deaths of small number of individuals due to vehicle traffic and human activities	Small; potential deaths of few individuals due to vehicle traffic	None	Small; disturbance of common land cover types and loss of small number of individual animals
Monitoring					
	Small; no new disturbance of natural vegetation	Small; same as for operations, but smaller due to smaller workforce	Small; same as for operations, but smaller due to smaller workforce	None	Small; very small number of individual animals killed by vehicles
Closure					
	Small; decline in impacts due to reduction in human activity	Small; decline in number of individuals killed by traffic annually	Small; decline in number of individuals killed by traffic annually	None	Small; decline in impacts due to reduction of human activity
Overall rating of impacts	Small	Small	Small	None	Small

4.1.4.3 Impacts to Soils from Construction, Operations, Monitoring, and Closure

This section summarizes and incorporates by reference Section 4.1.4.4 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, p. 4-38 and 4-39); there have been no soil surveys that covered the region of influence since completion of the FEIS. The evaluation of impacts to soils considered the potential for soil loss in disturbed areas, recovery of soil viability (that is, the physical, chemical, and biological properties of soil that foster plant growth) after disturbance, and the potential for the spread of contamination due to the relocation of contaminated soils (if present). DOE would use erosion control techniques to minimize erosion. Because soil in disturbed areas would be slow to recover, during the closure analytical period DOE would revegetate the areas it had not reclaimed after the temporary disturbances following construction.

4.1.4.3.1 *Soil Loss*

Activities during the construction, operations, and monitoring analytical periods would disturb varying amounts of land depending on the final design for the repository. DOE would disturb as much as 9 square kilometers (2,200 acres) of land during the construction phase, which could expose bare soil to wind and water erosion.

During earlier activities, DOE established a reclamation program with a goal to return disturbed land to a condition similar to its predisturbance state (DIRS 154386-YMP 2001, all). One of the benefits of such a goal is the minimization of soil erosion. The program includes the implementation and evaluation of topsoil stockpiling and stabilization efforts that would enable the use of topsoil removed during excavation in future reclamation activities. Final reclamation would include spreading and contouring topsoil that was stockpiled during construction; creating erosion control structures; ripping, seeding, spreading, and anchoring mulch; and fencing to reduce loss of new vegetation to herbivores. The reestablishment of vegetation to stabilize stockpiled topsoil would reduce the construction loss of the most critical type of soil.

DOE would use fugitive dust control measures, which would include water spraying, chemical treatment, and wind fences as appropriate, to minimize wind erosion of the stockpiled topsoil and excavated rock. The Department would minimize soil erosion by minimizing areas of surface disturbance and using engineering practices to stabilize disturbed areas. These practices could include such measures as control of stormwater runoff through the use of holding ponds, baffles, and other devices, and the stabilization of disturbed ground, relocated soil, or excavated material. Based on past experience and the continuing topsoil protection and erosion control programs, DOE anticipates little soil loss due to erosion during any period of the project.

4.1.4.3.2 *Recovery*

Studies during the Yucca Mountain site characterization effort and experience at the Nevada Test Site indicate that natural succession on disturbed desert soils would be a very slow *process*. Soil recovery would be unlikely without reclamation. DOE remains fully committed to the reclamation of disturbed areas (DIRS 154386-YMP 2001, Section 1.2).

Land disturbances can compromise or destroy soil viability through salvaging, stockpiling, and compaction. Topsoil handling and stockpiling can have negative impacts on the physical, chemical, and biological properties of the soil, which include decreased soil stability and porosity, increased bulk density, increased ammonium concentrations, decreased nutrients and microbial populations, decreased viable seed populations, and decreased organic matter. While DOE could not avoid most of these impacts, the use of proper techniques for soil handling, stockpiling, and stabilization would minimize them. DOE studied stockpiling and stabilization during site characterization and identified methods that had little effect on chemical and physical proprieties, nutrient content, or microbial content of the soil (DIRS 150174-CRWMS M&O 1999, all). DOE used the study results and information from literature searches to develop a topsoil management plan (DIRS 154386-YMP 2001, Section 4.2). Use of the techniques in this plan would result in minimum impacts on soil viability from salvaging and stockpiling activities.

4.1.4.3.3 *Contamination*

There would be a potential for spills or releases of contaminants under the Proposed Action (Section 4.1.3.1.2), but DOE would implement an updated version of its *Spill Prevention, Control, and Countermeasures Plan for Site Activities* (DIRS 172055-DOE 2004, all) to prevent, control, and remediate soil contamination. The Department would train workers in the handling, storage, distribution, and use of hazardous materials to provide practical prevention and control of potential contamination sources. Fueling operations and storage of hazardous materials and other chemicals would take place in bermed areas and away from floodplains when possible to decrease the probability of unexpected water flow spreading an inadvertent spill. DOE would provide rapid-response cleanup and response capability, techniques, procedures, and training for potential spills.

4.1.5 IMPACTS TO CULTURAL RESOURCES

This section summarizes, incorporates by reference, and updates the information in Section 4.1.5 of the Yucca Mountain FEIS (DIRS 155790-DOE 2002, pp. 4-39 to 4-41). In this Repository SEIS, the region of influence for cultural resources includes the analyzed land withdrawal area, land that DOE proposes for an access road from U.S. Highway 95, and land where DOE would construct offsite facilities.

Cultural resources are nonrenewable resources with values that physical disturbance could diminish. The Yucca Mountain FEIS evaluation of impacts to cultural resources considered the potential for disruption or modification of the character of cultural resources. The evaluation placed particular emphasis on identification of the potential for impacts to archaeological and historic sites and other cultural resources important to sustaining and preserving American Indian cultures.

For this Repository SEIS, direct comparison of disturbed land as the predominant indicator enables determination of impacts to cultural resources. The primary sources of short-term impacts from construction, operations, monitoring, and closure would be facility construction and operations and human activities.

Overall, estimated impacts to cultural resources identified in this Repository SEIS would be small, as the following sections describe.

4.1.5.1 Impacts to Cultural Resources from Construction, Operations, Monitoring, and Closure

The following sections discuss archaeological and historic resources in the region of influence and the American Indian viewpoint on DOE activities related to the proposed repository and their impacts on these resources.

4.1.5.1.1 *Archaeological and Historic Resources*

The Yucca Mountain FEIS identified direct and *indirect impacts* to archaeological and historic resources. Direct impacts would be those from ground disturbances or activities that destroyed or modified the integrity of archaeological or historic sites, and indirect impacts would result from activities that could increase the potential for intentional or unintentional adverse impacts (for example, increased human activity near resources could result in illicit collection or inadvertent destruction). The FEIS concluded that although there could be some indirect impacts, the overall effect of the proposed repository on the long-term preservation of archaeological and historic sites in the analyzed land withdrawal area would be beneficial. Limited access to and use of the area would protect archaeological and historic resources in most of the area from most *human intrusion*.

The Yucca Mountain FEIS recommended that 51 of the 830 archaeological and historic sites were eligible for inclusion in the *National Register of Historic Places*. In consultation with the Nevada State Historic Preservation Office, DOE has revised its recommendation to include 232 sites (DIRS 182189-Rhode 2007, all). The revised number reflects recent investigations for the U.S. Highway 95 access road and a reevaluation of the importance of obsidian artifacts. Recent studies suggest that obsidian artifacts can provide important information on prehistoric American Indian settlement systems. The large increase in the number of eligible archaeological sites since completion of the FEIS reflects this finding and includes extractive (for example, toolstone quarrying, hunting, and seed gathering) and processing (for example, animal butchering, milling plants, or cooking) localities where obsidian toolstone is present.

Potential impacts to National Register-eligible archaeological sites could occur from land disturbances due to construction. An evaluation by the Desert Research Institute identified 57 archaeological sites and 75 isolated artifacts (DIRS 182189-Rhode 2007, all) in the construction areas. Three of these 57 sites have been recommended for inclusion in the *National Register of Historic Places*. The National Register-eligible sites consist of two prehistoric temporary camps and one resource processing locality. Before construction began, DOE would avoid or mitigate impacts to archaeological and historic resources, so direct adverse impacts from construction and operation of the facilities would be small.

Improved access to the area could lead to indirect impacts from unauthorized excavation or collection of artifacts. DOE would mitigate these impacts through personnel training, archaeological and historic site monitoring, and long-term management. These measures would protect archaeological and historic resources from most human intrusions in the analyzed land withdrawal area. This added protection would result in a beneficial effect.

A draft programmatic agreement among DOE, the Advisory Council on Historic Preservation, and the Nevada State Historic Preservation Officer has been prepared for cultural resources management related to activities that would be associated with development of a repository at Yucca Mountain. While this agreement is in ongoing negotiation among the concurring parties, DOE is abiding by the process set forth in Section 106 of the *National Historic Preservation Act of 1966* (16 U.S.C. 470 et seq.).

4.1.5.1.2 *American Indian Viewpoint*

In the Yucca Mountain FEIS, DOE summarized the American Indian view of resource management and preservation, which is holistic in its definition of cultural resources and incorporates all elements of the natural and physical environment in an interrelated context. In the FEIS, DOE committed to continue the Native American Interaction Program throughout implementation of the Proposed Action to enhance the protection of archaeological sites and cultural items important to American Indians. The FEIS reported that construction activities would have no direct impacts on several delineated American Indian sites, areas, and resources in or immediately adjacent to the analyzed land withdrawal area. However, because of the general level of importance that American Indians attribute to these places, which they believe are parts of an equally important integrated cultural landscape, American Indians consider the intrusive nature of the proposed repository to be a significant adverse impact to all elements of the natural and physical environment. Based on Tribal Update Meetings for members of the Consolidated Group of Tribes and Organizations held since the completion of the FEIS, the American Indian viewpoint is unchanged.

4.1.6 SOCIOECONOMIC IMPACTS

This section describes potential socioeconomic impacts from construction and operation of the proposed Yucca Mountain Repository. The analysis for the Yucca Mountain FEIS examined the potential for socioeconomic impacts in Clark, Lincoln, and Nye counties in southern Nevada. For this Repository SEIS, the region of influence consists of Clark and Nye counties (Chapter 3, Section 3.1.7).

Evaluations of the socioeconomic environment—in Nye County where the repository would be and in Clark County where most workers would live—considered changes to employment, population, three economic measures (real personal disposable income, spending by state and local government, and *Gross Regional Product*), housing, and some public services. The evaluation used the Regional Economic Models, Inc. (REMI) model, *Policy Insight*, Version 9, to estimate and project baseline socioeconomic conditions from 2005 to 2067 for employment and population changes that would be due to the Proposed Action. To present a more complete profile of potential impacts, DOE also examined a second residential distribution, where many of the workers would live in Nye County, and analyzed potential impacts to socioeconomic variables from the scenario. The alternative distribution includes an analysis of changes in employment, population, three economic measures, and demand for housing and some public services. Appendix A, Section A.4 contains the results of the analysis.

DOE developed baselines for Gross Regional Product, real disposable personal income, and spending by state and local governments for Clark and Nye counties and for the State of Nevada (DIRS 178610-Bland 2007, all). Chapter 3, Section 3.1.7 presents baseline information that describes the current socioeconomic environment in the region of influence. The potential for changes in the socioeconomic environment would be greatest in the Yucca Mountain region of influence where most of the repository workers would live. Although the analysis focused on regional impacts, DOE acknowledges that Clark County, which has 50 times as many people as Nye County, dominates the region and often obscures impacts in Nye County. DOE has noted when the impact in Nye County would differ meaningfully from regional impacts.

DOE examined the employment that would be necessary for construction and operation of a repository. The Yucca Mountain FEIS analysis projected baseline population and employment in the region of influence to 2035. For this Repository SEIS analysis, DOE included anticipated incremental changes above and below the employment and population projections to 2067 that could result from the Proposed Action. In addition, this section provides estimates and projections through 2067 of baseline values for several economic parameters and estimates of incremental changes attributable to the construction and operation of the proposed repository above and below the baselines for Clark and Nye counties and the State of Nevada.

Socioeconomic impacts described in this Repository SEIS would vary from impacts DOE identified in the Yucca Mountain FEIS because of different underlying assumptions. For the FEIS, the data for analysis of the potential impacts to socioeconomic variables, all of which would be driven by changes in the number of jobs, were based on the employment levels of construction and operations workers assigned to the proposed repository site. That analysis did not include other project jobs, engineering and project safety for example, because those jobs would be off the site, primarily in the Las Vegas area.

The analysis for this Repository SEIS included present and projected offsite workers as well as onsite workers. In addition, estimated worker requirements in this document are specific to the modified repository design and operational plans, while the Yucca Mountain FEIS considered several operating modes and, to bound the evaluation, based potential impacts on the mode that would require the greatest number of workers. The analysis used updated baselines for the evaluated socioeconomic variables. As a result of the refined data, potential impacts to Gross Regional Product, real disposable personal income, spending by state and local governments, housing, and public services from changes in employment and population would be smaller than the impacts the FEIS reported.

4.1.6.1 Socioeconomic Impacts from Construction and Operations

4.1.6.1.1 *Impacts to Employment*

Surface and subsurface construction would begin in 2012. DOE would scale back surface construction in 2016 as emplacement began (in 2017). Subsurface construction would begin in 2012, escalate in 2018, moderate at approximately 170 employees by 2026, and continue until 2042. The number of employees for subsurface construction would be considerably fewer than the number of workers for surface construction. In 2014, the peak year of *direct employment* during the initial construction analytical period, DOE would employ about 2,590 workers (which would represent about 1,090 newly created jobs) for the Proposed Action. About 1,860 of these workers would be employed on the site and 730 workers would work off the site, primarily in the Las Vegas area. Construction workers would include skilled craft workers and professional and technical support personnel (engineering, safety analysis, safety and health, and other field personnel). Onsite employment during construction would peak in 2016 with about

EMPLOYMENT TERMS

Direct Employment:
Jobs that are expressly associated with project activity.

Indirect Employment:
Jobs that are created as a result of expenditures by directly employed project workers (for example, restaurant workers or childcare providers) or jobs that are created by project-related purchases of goods and services (for example, sales manager of a concrete supply store).

Composite Employment:
Sum of direct and indirect employment.

1,920 workers as DOE transferred offsite positions and responsibilities from Clark County sites to the repository in Nye County.

Figure 4-5 shows composite (direct and indirect) employment changes due to construction activities under the Proposed Action by county of residence. Incremental employment increases during the construction analytical period would peak in 2014 with the addition of about 1,000 jobs in the region of influence (about 690 in Clark County and 310 in Nye County). The number of additional jobs in the region of influence would be virtually identical to the number of additional jobs in the State of Nevada because the direct jobs would be confined to Clark and Nye counties, where DOE assumed all workers would reside, and thus new indirect jobs would probably be in the same jurisdictions. The change in the number of new jobs would be less than the number of onsite jobs because some of those would be filled by construction workers who had completed another assignment and some would be filled by individuals who joined the construction industry from another field and were, therefore, part of the baseline employment estimates. Not all project-related jobs would require that individuals move into the region of influence. Employment in the construction industry is constantly in flux and assignments begin and end in a relatively short period, so workers already in the region would fill some repository jobs. The number of onsite jobs would increase as the number of offsite professional and technical positions decreased. The dynamics of the economies in each county and the number of directly employed workers who lived in each county would influence the numbers and locations of indirect jobs. The Proposed Action would increase overall employment in the region of influence from the projected baseline (employment without the repository project) of approximately 1,329,000 jobs to slightly less than 1,330,000 positions—a regional change ofapproximately 0.08 percent, but 1.5 percent in Nye County. These changes would be small. REMI

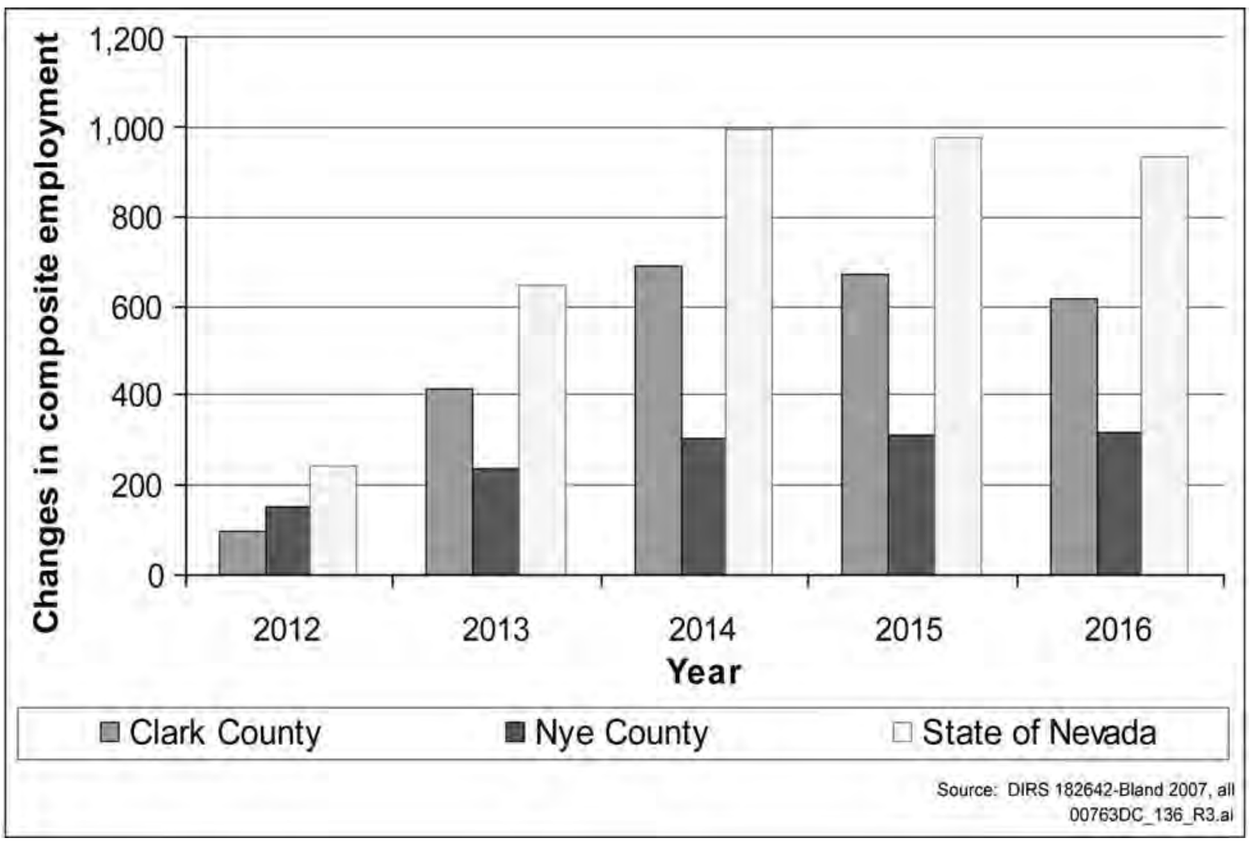


Figure 4-5. Increases in composite regional and State of Nevada employment during construction.

uses historical patterns of spending and in-migration to predict changes. Table 4-9 summarizes peak construction year changes in direct employment by county of worker residence.

Table 4-9. Expected peak construction year (2014) changes in direct employment by county of worker residence.

Area	Employees[a]
Clark County	758
Nye County	328
Region of Influence	1,090

Source: DIRS 182205-Bland 2007, all.
Note: Numbers are rounded to three significant figures.
a. Excludes 216 current onsite workers and 1,286 offsite workers.

Table 4-10 lists the expected distribution of project job locations during the initial construction analytical period. Chapter 3, Section 3.1.7 discusses residential distribution patterns of Yucca Mountain Project workers. Emplacement would begin in 2017. Although subsurface construction would continue until about 2042, this Repository SEIS refers to the period from 2017 to 2067 as the operations analytical period. Emplacement activities could continue for up to 50 years from the beginning of emplacement in 2017 until 2067.

Table 4-10. Repository direct employment during the initial construction analytical period by county of job location.[a]

Area	2012	2013	2014	2015	2016
Clark County (offsite)	709	711	730	648	589
Nye County (onsite)	1,010	1,480	1,860	1,900	1,920
Total project employment	1,720	2,200	2,590	2,550	2,510

Source: DIRS 182205-Bland 2007, all.
Note: Numbers are rounded to three significant figures; therefore, totals might differ from sums.
a. Includes current positions.

Direct operations peak employment would occur in 2019 when repository operations would require about 2,690 workers. About 2,070 of these workers would be on the site, and the remaining 620 would work in the Las Vegas area. Project-related direct employment would range from 2,600 to 2,300 from 2017 to 2024, then range from 2,300 to 2,000 until 2040. Employment levels from 2041 to 2067 would be essentially stable at about 700 workers (DIRS 182205-Bland 2007, all).

Table 4-11 lists the expected distribution of changes in regional employment in the peak year of employment (2021) during the operations analytical period. The table lists the estimated number of repository-induced jobs in Clark and Nye counties and in Nevada in 2021. Employment in the region of influence would peak with approximately 1,300 workers. The employment baselines in Clark and Nye counties have grown rapidly since completion of the Yucca Mountain FEIS. New indirect jobs result from new direct jobs unless there is some capacity of existing business to meet the increased demand for goods and services. The region, especially Clark County, probably has sufficient excess capacity and impacts would be spread over a number of communities in Clark County, such that the number of indirect jobs would be lower. This would result in a small incremental increase of regional employment from the estimated baseline of about 1,425,000 jobs to about 1,426,000 jobs, a change of less than 0.1 percent from the estimated employment baseline for 2021.

Table 4-11. Expected peak year (2021) increases in the operations analytical period composite employment in the region and in the State of Nevada.

Area	Employees	Percent change
Clark County	861	0.06
Nye County	437	2.0
Total increase in jobs in region of influence	1,300	0.09
State of Nevada	1,300	0.07

Note: Numbers are rounded to three significant figures; therefore, totals might differ from sums.
Source: DIRS 182642-Bland 2007, all.

Table 4-12 summarizes direct repository employment from 2017 to 2067 by expected county of job location. Figure 4-6 shows changes in regional employment for Clark and Nye counties and for the State of Nevada. Beginning in 2042, the rate of employment growth in the region would slow as the need for

Table 4-12. Repository direct employment[a] during the operations analytical period by county of job location, 2017 to 2067.

Area	2017	2020	2025	2030	2045	2067
Clark County (offsite)	572	585	470	470	144	108
Nye County (onsite)	1,940	2,000	1,820	1,800	562	421
State of Nevada	2,510	2,590	2,290	2,270	706	529

Source: DIRS 182205-Bland 2007, all.
Note: Numbers are rounded to three significant figures.
a. Includes current positions.

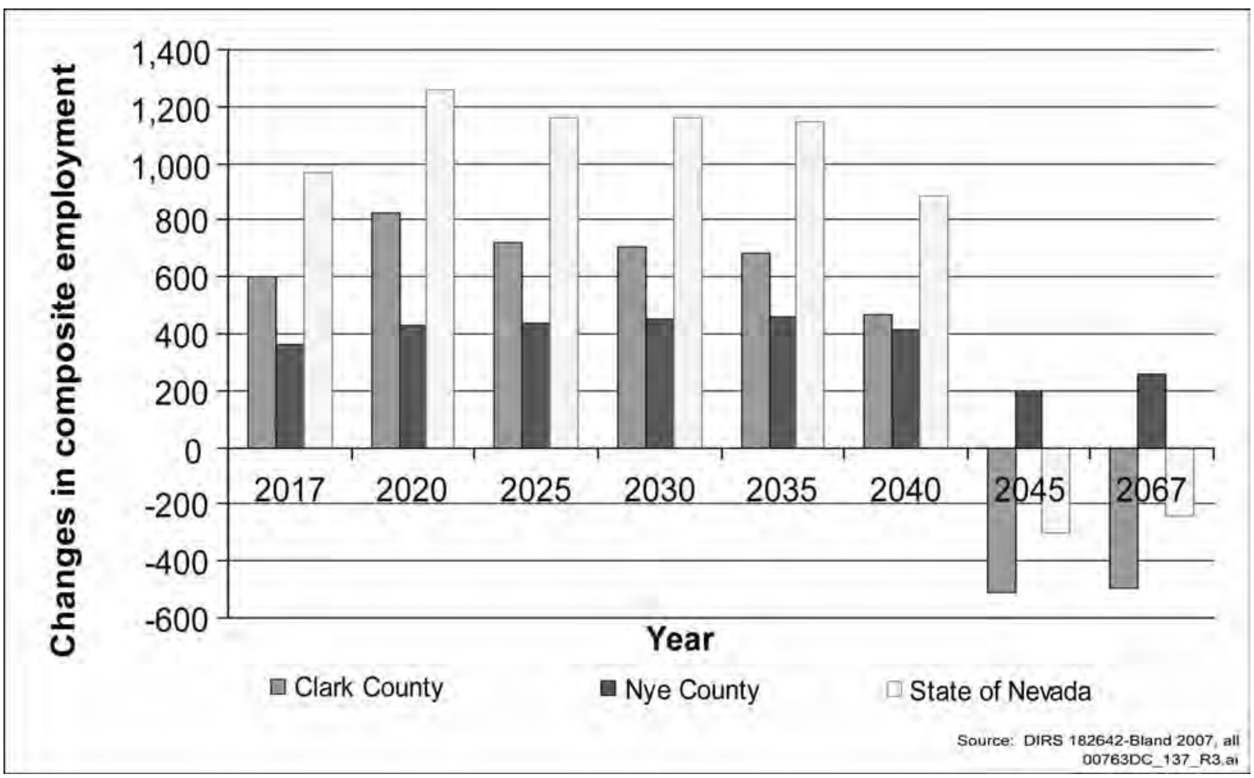


Figure 4-6. Changes in composite regional employment from repository operations activities in the region and in Nevada.

repository workers dropped. The growth would slow by about 148 jobs in 2042, to about 312 jobs in 2045, and would continue slowing by about 230 jobs through 2067. Given the expected economic growth in the region of influence, the region could readily absorb declines in repository employment as subsurface construction and emplacement activities ended. The Yucca Mountain Project would continue to contribute positively to the economy, but losses of offsite jobs would result in the slower growth of jobs in the region. Impacts to regional employment, employment in Clark County and Nevada from repository-related construction and operations would be small, less than 1 percent. Impacts in Nye County would be greater, but not more than 2 percent of the baseline.

4.1.6.1.2 *Impacts to Population*

DOE based assumptions about future residential *distribution* on worker preferences consistent with historical preferences (Chapter 3, Section 3.1.7). Historical patterns of behavior, including choice of preferred county of residence, might not be an accurate barometer of future trends because of the uncertainties in prediction of human behavior. The analysis based estimates of impacts to socioeconomic variables in the region on the assumption that 80 percent of the workers at the site would live in Clark County and 20 percent would live in Nye County. DOE assumed those persons working in Clark County would live in Clark County.

The analysis projected that regional population would grow from about 2,480,000 residents in 2012 to approximately 5,130,000 in 2067 (DIRS 178610-Bland 2007, all). The peak year (2035) population contribution in the region of influence attributable to the repository would be approximately 2,280 people, or about 0.06 percent of the estimated population baseline of 3,630,000 people (DIRS 178610-Bland 2007, all). In general, increases in population occur several years after increases in employment because some workers delay relocation. Clark County would experience the peak increase in population in 2034, and Nye County would experience a peak in 2039. This phenomenon would be largely because Clark County has such a large labor pool, and most project workers and family members would already live there and would not in-migrate to the county. Because the labor force is smaller in Nye County, many project workers or workers who filled the new indirect jobs and who lived in Nye County would represent a new household in the county. The increase in population would represent a small increase, about 1.2 percent of the county’s baseline population in 2039. The Proposed Action would have only small effects on population growth in the region of influence. Figure 4-7 shows the projected population increases from the repository project for Clark and Nye counties and the State of Nevada. Prediction of specific residential preferences for one community over another in a county is inexact, so the estimated and projected residential distribution patterns are at the county and state levels rather than the community level.

Table 4-13 lists estimated incremental population increases that would result from repository activities. The incremental peak population increase in Clark County would be about 0.04 percent. Population growth from repository activities would be more evident in Nye County. The county’s population increase would be approximately 1.2 percent of the projected population of 84,000 (DIRS 178610-Bland 2007, all) for the county in 2035, which would be the peak period for potential repository population impacts.

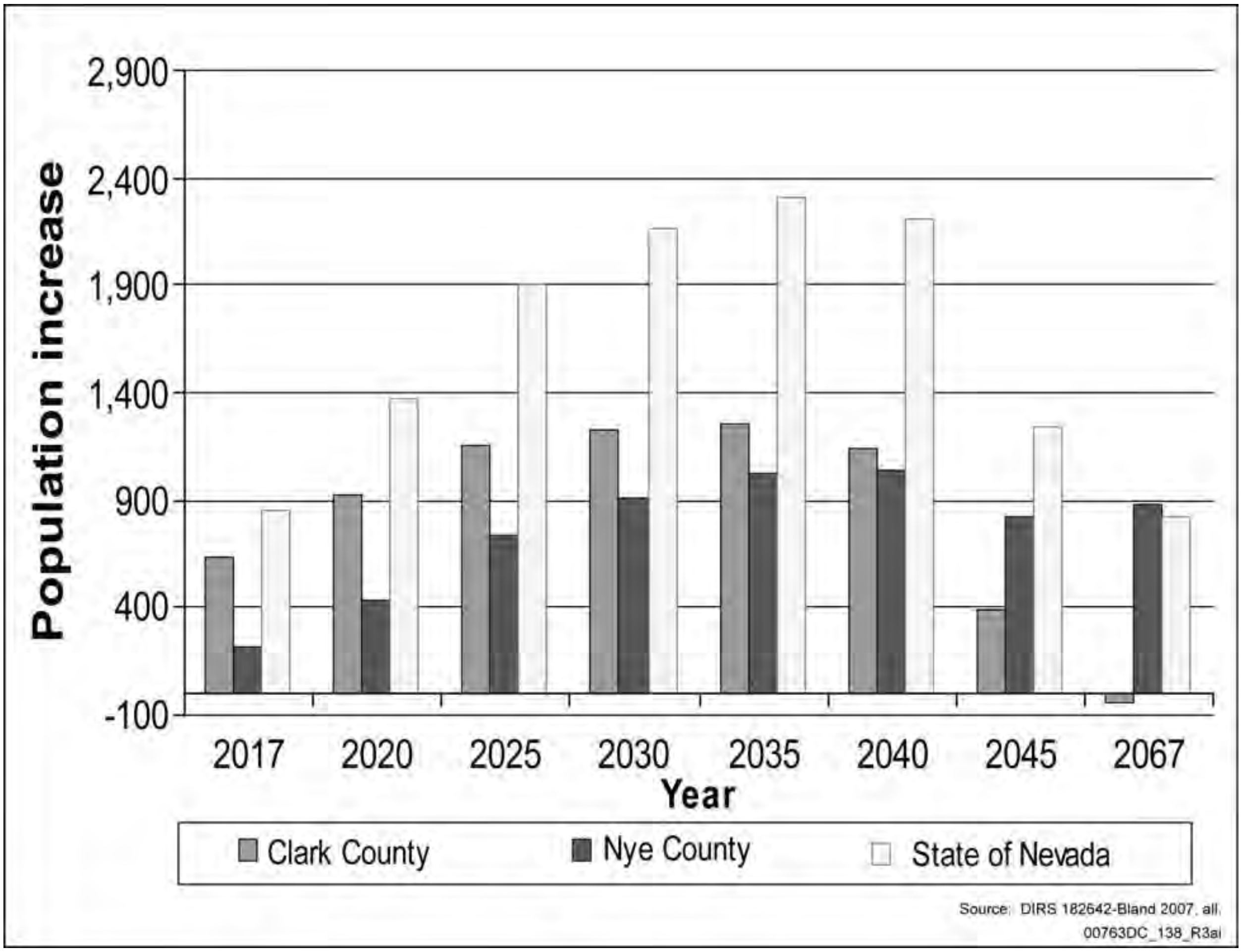


Figure 4-7. Regional population increases from operations, 2017 to 2067.

The estimated changes in population from repository activities would be small in Clark and Nye counties. The workers' choices of place of residence would have a large influence on population increases above the projected baselines. To present a more complete profile of potential impacts, DOE examined a residential distribution where many of the repository workers would live in Nye County. Appendix A, Section A.4 contains the results of that analysis.

Table 4-13. Estimated population increase in Clark County, Nye County, and the State of Nevada from the Proposed Action (2035.

Area	Total population[a]
Clark County	1,260
Nye County	1,020
State of Nevada[b]	2,310

Source: DIRS 182642-Bland 2007, all.
a. Numbers are rounded to three significant figures.
b. Includes population outside of the region of influence.

4.1.6.1.3 *Impacts to Economic Measures*

Table 4-14 lists estimated changes in economic measures that would result from repository activities during the construction analytical period (values are in 2006 dollars). Repository-induced impacts measured by these economic variables would essentially be confined to the region of influence and, therefore, would be the same for the State of Nevada. Increases in real disposable personal income in the

Table 4-14. Increases in economic measures in Clark County, Nye County, and the State of Nevada from repository construction, 2012 to 2016 (millions of 2006 dollars).

Area	2012	2013	2014	2015	2016
Clark County					
State and local government spending	0.2	0.6	1.2	1.8	2.3
Real disposable personal income	4.2	23.9	41.7	40.5	38.4
Gross Regional Product	6.2	33.3	58.9	58.3	54.9
Nye County					
State and local government spending	0.1	0.2	0.4	0.5	0.7
Real disposable personal income	7.6	12.2	16	16.6	17.1
Gross Regional Product	10	16.1	21.6	20.8	22.7
State of Nevada					
State and local government spending	0.3	0.8	1.7	2.4	3
Real disposable personal income	12	36.5	58.3	57.8	56.1
Gross Regional Product	16.2	49.3	80.3	79.1	77.6

Source: DIRS 182642-Bland 2007, all.

region of influence would peak in 2014 with an increase of about $57.8 million or $41.7 million, or 0.05 percent in Clark County and $16.0 million, or 1.1 percent in Nye County. Increases in Gross Regional Product would also peak in 2014 at about $80.5 million. About $58.9 million or 0.05 percent of the change in Gross Regional Project would happen in Clark County. The impact in Nye County would be 1.4 percent above the baseline or $21.6 million. Regional expenditures by the State of Nevada and local governments, which include school districts, would peak at $3 million in 2016. Clark County expenditures would account for $2.3 million of the change in spending. The change in both counties would be less than 0.03 percent. Economic measures for the region of influence would increase by less than 0.1 percent over the projected baseline (estimated economic measures without the repository project).

GROSS REGIONAL PRODUCT

The value of all final goods and services produced in the region of influence.

Table 4-15 lists the changes in economic measures, for representative years that would result from the repository project during the operations analytical period. Increases in Gross Regional Product would peak in 2034 at about $98.7 million, or 0.05 percent in Clark County and $68.9 million, or a small 2.7 percent above the baseline in Nye County for a total of $168 million. Increases in regional real disposable personal income would also peak in 2034 at $85.7 million. Clark County would experience a 0.05-percent increase of $58.3 million and Nye County would experience about $27.4 million, or a 1.3-percent increase.

Increases in regional expenditures by state and local government would peak in 2035 at about $10.7 million. Most of the incremental spending would occur in Clark County, about $5.7 million, which would be a small increase of 0.04 percent. Spending in Nye County would be about $5 million or 1.3 percent of the baseline. The impacts in Nye County would be proportionately greater because the repository would be in Nye County. Economic activity, which would include incidental spending by workers who lived in Clark County but worked in Nye County, would be responsible for this phenomenon. In addition, Nye County would experience many indirect jobs with consequent income and taxes. Economic measures for the region of influence would increase by less than 0.1 percent over the projected baseline. Impacts in the State of Nevada and the region of influence would be essentially the same because changes from economic baselines would be driven largely by changes in employment and population, and those changes would occur almost exclusively in Clark and Nye counties.

Table 4-15. Changes in economic measures in Clark County, Nye County, and the State of Nevada from emplacement activities, 2017 to 2067 (millions of 2006 dollars).

Area	2017	2020	2025	2030	2035	2045	2067
Clark County							
State and local government spending	3.0	4.0	5.0	5.0	5.7	2.0	0.0
Real disposable personal income	40.0	57.0	53.0	55.0	56.2	-34.0	-38.0
Gross Regional Product	58.0	89.0	87.0	92.0	95.0	-92.0	-105.0
Nye County							
State and local government spending	1.0	2.0	3.0	4.0	5.0	4.0	4.0
Real disposable personal income	18.0	21.0	23.0	25.0	27.5	16.0	23.0
Gross Regional Product	34.0	47.0	57.0	63.0	68.8	31.0	42.0
State of Nevada							
State and local government spending	4.0	6.0	8.0	10.0	10.9	6.0	4.0
Real disposable personal income	59.0	79.0	77.0	81.0	84.9	-16.0	-15.0
Gross Regional Product	91.0	136.0	144.0	155.0	164.3	-60.0	-64.0

Source: DIRS 182642-Bland 2007, all.

4.1.6.1.4 *Impacts to Housing*

Given the size of the projected regional employment, the number of workers who would in-migrate to work on the repository would be relatively small. Because the in-migration would be small, the increased demand for housing would be small. Because the maximum change above the population baselines would be so small in Clark County (about 1,260 persons) and in Nye County (about 1,050 persons), demands on the regional housing inventory should be similarly small. In general, housing stock increases at approximately the same ratio as the population. Impacts to housing would be minimal because (1) the expected increase in regional population would be small, (2) the demand would primarily be in metropolitan Clark County, (3) there are no municipal or state growth control measures that limit housing development, and (4) the region of influence has an adequate supply of undeveloped land to meet expected future demands.

Impacts to housing would be more pronounced in Nye County, particularly in Pahrump. Because Nye County and Pahrump have recently experienced rapid and largely unanticipated growth, the county has a limited housing inventory to absorb new workers and worker families. Much of the infrastructure to support housing development is at capacity.

During the late 1990s and early 21st century, the Bureau of Land Management sold approximately 13,500 acres of public land within a specific boundary around Las Vegas. Much of the land was sold to the private sector, and particularly to developers of large master-planned communities. These additional lands have helped to accommodate population growth in the greater Las Vegas area. Nye County has also acquired land to facilitate and accommodate the orderly development of land uses that repository activities could trigger.

DOE analyzed potential impacts to housing at the county level. The Department did not attempt to predict incremental housing demand at the community level because housing preferences (mobile home, modular assembly, stick-built), density or cluster choices (single family, multifamily), and desired lot sizes are difficult to predict. Because the incremental increase in population from repository-related activities would occur over a long period and be more predictable, the private sector housing market could readily adapt. In addition, given the very large housing inventory in the region, the region's baseline growth would mask the changes that were due to the repository.

4.1.6.1.5 *Impacts to Public Services*

Repository-generated impacts to public services such as schools, public safety, and medical services in the region of influence from population changes attributable to construction and operation of the repository would be small. Population changes from repository-related employment would be a small fraction of the anticipated population growth in the region. Even without the addition of repository jobs, the annual regional growth rate would increase by an estimated 1.4 percent through 2050, which would minimize the need to alter plans already in place to accommodate projected growth. As mentioned above, the majority of in-migrating workers would probably live in the many communities of metropolitan Clark County, thereby dispersing the increased demand for public services.

Southern Nye County, particularly Pahrump, would experience an increased demand for public services. However, because the anticipated increases over the baseline population in the county would be small and would occur incrementally over a long period, the county might be able to absorb increased demands in education, law enforcement, and fire protection (public safety) as the local government expanded the levels of these services to accommodate the anticipated non-repository-related growth. The county and communities in the county would continue to provide services as the revenue base grew. Although these public services are currently at capacity, it is uncertain what the infrastructure capacity would be as repository operation began or when the repository-related population increase reached its peak in 2039 with about 1,050 residents or a small increase of 1.2 percent above the baseline. Repository-related population increases in Nye County would be less than 1.3 percent during the entire construction and operations analytical periods. DOE facilities have historically had cooperative agreements with local governments for mutual aid and support of emergency services. If DOE implemented such an agreement in conjunction with the Proposed Action, strains on regional emergency services infrastructure would be reduced. Repository-generated impacts to public services such as education and public safety could require mitigation because the current structure for the generation of local government revenues, primarily from property taxes, would not support the expanded level of services that additional residents would require. The recently opened hospital in Pahrump and the ample services in the metropolitan Las Vegas area could serve to alleviate the scarcity of medical services in Nye County.

4.1.6.2 Summary of Socioeconomic Impacts

For all five socioeconomic parameters that DOE evaluated over the construction and operations analytical periods, the regional impacts would be small, less than 1 percent of the baselines. The operations period would result in higher impacts to employment, population, Gross Regional Product, real disposable personal income, and state and local government spending. Changes in regional employment, which would include direct and indirect workers, would peak in 2021. The increase of about 1,300 workers would represent a 0.09-percent increase above the projected baseline for that year. Gross Regional Product would peak in 2034 because of consumption of goods and services due to construction activities. The estimated increase in Gross Regional Product for 2034 would be about $168 million in 2006 dollars or 0.08 percent of the baseline. Population increases from increased employment opportunities would peak in 2035 at about 2,280 or 0.06 percent of the baseline for that year. Government spending would also peak in 2035 at an increase of $10.7 million or 0.07 percent of the baseline. Real disposable personal income would be highest during the operations period and would peak in 2034 at $85.7 million or 0.07 percent more than the baseline. The regional impacts as measured by all five parameters would be small in all years, as they would be in Clark County. The impacts would be greater, but still small, in Nye County. As a percentage, the greatest population impact would be 1.2 percent in 2034 or 2035, and employment impacts would reach 2.0 percent in 2021. Spending by local government would peak at 1.3 percent in 2019, and real disposal personal income would increase by 1.4 percent in 2019. The Nye County Gross Regional Product would increase by 2.8 percent in 2023.

4.1.7 OCCUPATIONAL AND PUBLIC HEALTH AND SAFETY IMPACTS

This section describes potential health and safety impacts to workers (occupational impacts) and to members of the public (public impacts) from construction, operations, monitoring, and eventual closure of the proposed repository. Members of the public would be outside the land withdrawal area. The analysis estimated occupational health and safety impacts separately for involved and non*involved workers* for each repository analytical period—construction, operations, monitoring, and closure. Involved workers would be craft and operations personnel who were directly involved in facility construction and operation activities, which would include excavation; receipt, handling, packaging, aging, and emplacement of spent nuclear fuel and high-level radioactive waste; monitoring of the conditions and performance of the waste packages; and closure. Noninvolved workers would be managerial, technical, supervisory, and administrative personnel who would not be directly involved in those activities.

CONCEPT OF INVOLVED AND NONINVOLVED WORKERS

Nonradiological Impacts:

Involved workers would be those doing the physical work of constructing, operating, monitoring, and closing the repository.

Noninvolved workers would be managerial, technical, supervisory, and administrative personnel onsite.

There would be no nonradiological impacts to DOE workers at the Nevada Test Site.

Radiological Impacts:

Involved workers would be those directly engaged in developing subsurface facilities during the construction and operations analytical periods and spent nuclear fuel and high-level radioactive waste processing, emplacement and maintenance during operating, monitoring, and closing the repository.

Noninvolved workers would be managerial, technical, supervisory, and administrative personnel on the site and workers engaged in surface construction during the construction analytical period and the first several years of repository operations, when surface and subsurface construction and operations would proceed in parallel.

DOE workers at the Nevada Test Site were treated separately as a noninvolved worker population.

This section summarizes, incorporates by reference, and updates as necessary Section 4.1.7 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 4-48 to 4-63). Potential health and safety impacts to repository workers would include those from industrial hazards common to the workplace, from exposure to naturally occurring and manmade radiation and radioactive materials in the workplace, and from exposure to naturally occurring nonradioactive airborne hazardous materials. Members of the public could be exposed to airborne releases of naturally occurring and manmade *radionuclides* and naturally occurring hazardous materials. The analysis based estimates of public health impacts from nonradioactive sources on the air quality information in Section 4.1.2.

4.1.7.1 Nonradiological Impacts

4.1.7.1.1 *Impacts to Occupational and Public Health and Safety During Construction*

This section describes estimates of nonradiological health and safety impacts to repository workers and members of the public for the 5-year construction analytical period. Activities would include site preparation, infrastructure construction, construction of surface facilities, and initial construction of subsurface facilities. Potential health and safety impacts to workers could occur from industrial hazards, exposure to naturally occurring cristobalite and erionite in the rock at Yucca Mountain, and unexploded ordnance. Potential health impacts to members of the public could occur from exposure to airborne releases of naturally occurring hazardous materials (cristobalite and erionite) and from criteria pollutants.

Occupational Health and Safety Impacts

Industrial Hazards. The Repository SEIS analysis estimated health and safety impacts to workers from industrial hazards using the same method as the Yucca Mountain FEIS (DIRS 155970-DOE 2002, p. 4-50). The Computerized Accident/Incident Reporting System (CAIRS) database provided industrial accident statistics from DOE experience with activities similar to those proposed for repository construction (DIRS 182198-DOE 2007, all; DIRS 182199-DOE 2007, all). DOE uses CAIRS to collect and analyze reports of injuries, illnesses, and other accidents that occur during its operations. Information from the database included two impact categories—*total recordable cases*; and Days Away, Restricted, or On Job Transfer cases. The latter category is equivalent to the U.S. Department of Labor Bureau of Labor Statistics *lost workday cases* category.

INDUSTRIAL HAZARDS TERMINOLOGY

Total Recordable Cases:
The total number of work-related deaths, illnesses, or injuries that resulted in the loss of consciousness, restriction of work or motion, transfer to another job, or required medical treatment beyond first aid (DIRS 182204-DOE 2004, all).

Lost Workday Case:
A case that involves days away from work or days of restricted work activity, or both. Equivalent to Days Away, Restricted, or On Job Transfer case in CAIRS (DIRS 182204-DOE 2004, all).

Fatality:
Any death that results from workplace activities.

Full-Time Equivalent Worker Years:
The number of employees who would be involved in an activity calculated from work hours. Each full-time equivalent worker year consists of 2,000 work hours (the number of hours DOE assumed for one worker in a normal work year).

CAIRS provides total *recordable cases* and lost workday cases incidence rates per 100 full-time equivalent worker years and provides fatality statistics used to calculate fatality incidence rates per 100,000 worker years. Table 4-16 lists the incident rates for involved construction workers and noninvolved workers at DOE facilities from the past 5 years. To estimate impacts to workers from industrial hazards, DOE multiplied those rates by the number of full-time worker years during the construction analytical period for the proposed repository and divided the results by 100. The statistics for noninvolved workers are from the Government and Service Operation categories. CAIRS contains no

Table 4-16. Health and safety statistics for estimation of occupational safety impacts for involved and noninvolved construction workers.[a]

Worker type	Rate of total recordable cases per 100 FTEs	Rate of lost workday cases per 100 FTEs[b]
Involved worker	2.0	0.86
Noninvolved worker	1.5	0.69

Note: Numbers are rounded to two significant figures.
a. Construction worker statistics from 2002 to 2006 from CAIRS (DIRS 182199-DOE 2007, all).
b. Equivalent to Days Away, Restricted, or On Job Transfer in CAIRS.
FTE = Full-time equivalent worker year.

involved construction worker and 1 noninvolved worker fatality at DOE facilities during the past 5 years. The fatality rate for noninvolved workers was calculated as 0.55 per 100,000 full-time equivalent worker years. To be conservative, the analysis used the fatality rate of 0.55 per 100,000 full-time equivalent worker years to estimate worker fatalities from industrial hazards for both involved and noninvolved workers. For comparison, there have been no reported fatalities as a result of workplace activities forthe Yucca Mountain Project. Table 4-17 lists the estimated numbers of full-time equivalent worker years during the construction analytical period for involved and noninvolved workers. Table 4-18 lists the estimated impacts to workers for the construction period from industrial hazards.

Table 4-17. Estimated full-time equivalent worker years during the construction analytical period.

Worker group		Number
Involved workers[a]	Surface construction	5,500
	Subsurface construction	340
	Involved workers total	5,800
Noninvolved workers[a]	Noninvolved workers total	2,200

Source: DIRS 182205-Bland 2007, all.
Note: Numbers are rounded to two significant figures; therefore, totals might differ from sums.
a. Workers at site; does not include employees in Las Vegas offices.

Table 4-18. Impacts to workers from industrial hazards during the construction analytical period.

Worker group	Impact category	Number
Involved workers	Total recordable cases	120
	Lost workday cases[a]	50
	Fatalities	0.032
Noninvolved workers	Total recordable cases	34
	Lost workday cases[a]	15
	Fatalities	0.012
All workers (totals)	Total recordable cases	150
	Lost workday cases[a]	66
	Fatalities	0.044

Note: Numbers are rounded to two significant figures; therefore, totals might differ from sums.
a. Equivalent to Days Away, Restricted, or On Job Transfer in CAIRS.

Naturally Occurring Hazardous Materials. Workers at the Yucca Mountain site could encounter two types of naturally occurring hazardous materials—cristobalite, a form of crystalline silica (silica dioxide), and erionite, a naturally occurring zeolite. Both have the potential to become airborne during repository excavation and tunneling operations, or the excavated rock pile could release them as dust. Cristobalite is in the *welded tuff* at the repository level and makes up between 18 and 28 percent of the tuff mineral content (DIRS 104523-CRWMS M&O 1999, p. 4-81). Erionite is an uncommon zeolite mineral that forms wool-like fibrous masses and occurs in rock layers below the proposed repository level. Based on *geologic* studies to characterize the repository horizon, most repository operations should not disturb erionite because it appears to be absent or rare at the repository level (Chapter 3, Section 3.1.8.3). Erionite could become a hazard during vertical boring operations if the operations passed through an erionite-bearing rock layer (which would be unlikely). Appendix F, Section F.1.2 of the Yucca Mountain FEIS contains more detail on the potential hazards of these minerals (DIRS 155970-DOE 2002, pp. F-12 to F-14).

DOE would use engineering controls (as part of best management practices) during subsurface work to control exposures of workers to silica dust. These controls would include the use of dust shields and air curtains on tunnel boring machines, water sprays and atomizing nozzles, isolated work areas, air stream scrubbing, and provision of fresh air to work areas through duct lines. In addition, DOE would design and operate the ventilation system to control *ambient air* velocities to minimize dust *resuspension*. The Department would monitor the work environment to ensure that dust concentrations did not exceed the applicable limits for cristobalite. If engineering controls were unable to maintain dust concentrations below the limits, DOE would use administrative controls such as access restrictions or respiratory protection until the engineering controls could establish acceptable conditions. The Department would apply similar controls, if necessary, for surface workers. DOE anticipates that exposure of workers to silica dust would be below the applicable limits and potential impacts to subsurface and surface workers would be small.

The engineering controls for exposure to silica dust would apply to potential exposure to erionite. DOE does not expect to encounter erionite layers at the proposed repository depth and location. If there was an erionite encounter, DOE would seal off the area and evaluate remediation methods to eliminate worker exposure throughout the repository tunnels.

Unexploded Ordnance. There have been U.S. Air Force and other military training activities in the region in the past. Portions of the construction area could have unexploded ordnance in surface locations. Unexploded ordnance could include shell casings, projectiles, or fragments, as well as live small arms ammunition, bombs, and rockets. DOE would coordinate with the Air Force about construction activities and would follow standard and established procedures for unexploded ordnance. An unexploded ordnance specialist would develop a plan, including evaluation of potential types of unexploded ordnance, depths, and other factors. Unexploded ordnance technicians would screen areas where there was a potential for unexploded ordnance before construction crews began work.

Public Health Impacts

Naturally Occurring Hazardous Materials. Section 4.1.2.1 presents estimated annual maximum concentrations of cristobalite at the boundary of the analyzed land withdrawal area where exposures to members of the public could occur during the construction analytical period. There are no regulatory limits for public exposure to cristobalite. An EPA health assessment (DIRS 103243-EPA 1996, p. 1-5) stated that the risk of silicosis is less than 1 percent for a cumulative exposure of 1,000 micrograms per cubic meter multiplied by the number of years of exposure. The analysis established a benchmark annual average concentration of 10 micrograms per cubic meter over a 70-year lifetime. The estimated cristobalite concentrations at the boundary of the land withdrawal area would be about 0.048 microgram per cubic meter. Health impacts to the public would be unlikely. Quantities and resultant concentrations of erionite, if present, would be much lower. Health impacts would be unlikely.

Criteria Pollutants. Section 4.1.2.1 presents estimated maximum concentrations of criteria pollutants (carbon monoxide, nitrogen dioxide, sulfur dioxide, and particulate matter) at the boundary of the analyzed land withdrawal area where exposures to members of the public could occur during the construction analytical period. (As Section 4.1.2 describes, the maximum air concentration from repository activities could occur at different locations along the boundary of the land withdrawal area dependent on the release period and the averaging time of a particular criteria pollutant. The maximally exposed individual would be the person at the location with the highest concentration per release period and averaging time.) The analysis estimated that concentrations would be less than 1 percent of the regulatory limits for all criteria pollutants except particulate matter. $PM_{2.5}$ could have a maximum concentration of about 1 percent of the 24-hour regulatory limit, and PM_{10} could have a maximum concentration of about 60 percent of the 24-hour regulatory limit. Although DOE would use dust suppression measures to reduce the PM_{10} concentration, the impact analysis did not consider such measures. Health impacts to the public would be small.

4.1.7.1.2 *Impacts to Occupational and Public Health and Safety During Operations*

This section describes potential health and safety impacts to workers and members of the public during the operations analytical period. For analytical purposes, this period would begin with receipt of a license amendment to receive and possess spent nuclear fuel and high-level radioactive waste and would include waste receipt, handling, aging, emplacement, and monitoring. Subsurface development and surface facility construction would continue during the period. The operations analytical period would last up to 50 years and would end with emplacement of the last waste package. Potential health and safety impacts to workers could occur from industrial hazards and exposure to naturally occurring cristobalite and erionite in the rock at Yucca Mountain. Potential health impacts to members of the public could occur from exposure to airborne releases of naturally occurring hazardous materials and from criteria pollutants.

Occupational Health and Safety Impacts

Industrial Hazards. The analysis used the method DOE established in the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 4-54 and 4-55) to estimate health and safety impacts to workers from industrial hazards. Table 4-19 lists the estimated number of full-time equivalent worker years during the operations analytical period.

Table 4-19. Estimated onsite full-time equivalent worker years during the operations analytical period.

Worker group		Number
Involved workers[a]	Surface construction	2,700
	Subsurface construction	4,300
	Emplacement operations	12,000
	Emplacement operations: Maintenance	4,900
	Involved worker total	23,000
Noninvolved workers[a]	Noninvolved workers total	36,000

Source: DIRS 182205-Bland 2007, all.
Note: Numbers are rounded to two significant figures; therefore, totals might differ from sums.
a. Workers at site; does not include employees in Las Vegas offices.

The incident rates for involved construction workers (which would include subsurface development workers) and noninvolved workers during the operations analytical period would be identical to the incident rates for the construction analytical period (Table 4-16). Table 4-20 lists the incident rates for involved workers who would be engaged in operations activities during the remainder of the operations

Table 4-20. Health and safety statistics for estimation of occupational safety impacts common to the workplace for operations analytical period involved workers.a

Rate of total recordable cases per 100 FTEs	Rate of lost workday cases per 100 FTEs[b]
1.4	0.58

Note: Numbers are rounded to two significant figures.
a. Statistics from 2002 to 2006 for activities at Savannah River Site, Idaho National Laboratory, and Oak Ridge National Laboratory from CAIRS (DIRS 182198-DOE 2007, all).
b. Equivalent to Days Away, Restricted, or On Job Transfer in CAIRS.
FTE = Full-time equivalent worker year.

period. The rates are statistics from similar activities at DOE facilities (Savannah River Site, Idaho National Laboratory, and Oak Ridge National Laboratory) for 2002 through 2006. No fatalities were recorded at the three DOE facilities during the 5-year reporting period. Therefore, to be conservative, DOE used the fatality rate of 0.55 per 100,000 full-time equivalent worker years that it used for repository construction. Table 4-21 lists the estimated industrial hazards impacts to workers for the operations period.

Table 4-21. Impacts to workers from industrial hazards during the operations analytical period.

Worker group		Impact category	Number
Involved workers	Surface construction	Total recordable cases	53
		Lost workday cases[a]	23
		Fatalities[b]	0.015
	Subsurface construction	Total recordable cases	87
		Lost workday cases[a]	37
		Fatalities[b]	0.024
	Emplacement operations	Total recordable cases	160
		Lost workday cases[a]	67
		Fatalities[b]	0.064
	Emplacement operations: Maintenance	Total recordable cases	68
		Lost workday cases[a]	28
		Fatalities[b]	0.027
Noninvolved workers		Total recordable cases	540
		Lost workday cases[a]	250
		Fatalities[b]	0.20
All workers (totals)		Total recordable cases	910
		Lost workday cases[a]	400
		Fatalities[b]	0.33

Note: Numbers are rounded to two significant figures; therefore, totals might differ from sums.
a. Equivalent to Days Away, Restricted, or On Job Transfer in CAIRS.
b. Fatality impacts based on fatality rate from Section 4.1.7.1.1.

Naturally Occurring Hazardous Materials. As Section 4.1.7.1.1 discusses for the construction analytical period, cristobalite and erionite have the potential to become airborne during continuing repository excavation and as fugitive dust from the excavated rock pile. DOE would use engineering controls and, if necessary, administrative measures to control and minimize impacts to workers from releases of cristobalite and erionite during the operations analytical period. Impacts would be small.

Public Health Impacts

Naturally Occurring Hazardous Materials. Section 4.1.2.2 presents estimated annual maximum concentrations of cristobalite at the boundary of the analyzed land withdrawal area where exposures to members of the public could occur during the operations analytical period. The analysis estimated concentrations of cristobalite of about 0.002 microgram per cubic meter. This would be about 0.02 percent of the benchmark concentration of 10 micrograms per cubic meter. Health impacts to the public would be unlikely. Quantities and resultant concentrations of erionite, if present, would be much lower at locations of public exposure.

Criteria Pollutants. Section 4.1.2.2 presents estimated maximum concentrations of criteria pollutants (carbon monoxide, nitrogen dioxide, sulfur dioxide, and particulate matter) at the boundary of the land withdrawal area where exposures to members of the public could occur during the operations analytical period. The analysis estimated that concentrations would be less than 2 percent of the regulatory limit for all criteria pollutants except particulate matter. $PM_{2.5}$ would have a maximum concentration of less than 3 percent of the 24-hour regulatory limit, and PM_{10} would have a maximum concentration of less than 9 percent of the 24-hour regulatory limit. Health impacts to the public would be unlikely.

4.1.7.1.3 *Impacts to Occupational and Public Health and Safety During Monitoring*

This section describes estimated health and safety impacts to workers and members of the public during the monitoring analytical period. For analytical purposes, this period would begin with the emplacement of the final waste package and would continue for 50 years. Activities during this period would include ventilation maintenance; remote inspection of waste packages; retrieval, if necessary, of waste packages to correct detected problems; and investigations to support predictions of postclosure repository performance. Health and safety impacts to workers could occur from industrial hazards and exposure to naturally occurring cristobalite and erionite in the rock at Yucca Mountain. Health impacts to members of the public could occur from exposure to airborne releases of naturally occurring hazardous materials and from criteria pollutants.

Occupational Health and Safety Impacts

Industrial Hazards. The analysis conservatively assumed that health and safety impacts for the monitoring analytical period would be similar to those in the Yucca Mountain FEIS (DIRS 155970-DOE 2002, Table 4-27, p. 4-57) even though the duration of the period in the FEIS was 26 years longer. The total recordable cases for all workers could be 380. The estimated lost workday cases for all workers would be 160, and the estimated fatalities for all workers would be 0.36.

Naturally Occurring Hazardous Materials. Monitoring activities would be unlikely to generate large quantities of dust for extended periods. For the monitoring analytical period, DOE would use engineering controls and administrative worker protection measures such as respiratory protection as necessary to control and minimize impacts to workers from releases of cristobalite and erionite during monitoring activities (Section 4.1.7.1.1).

Public Heath Impacts

Naturally Occurring Hazardous Materials. Section 4.1.2.3 presents air emissions impacts during the monitoring analytical period. After completion of emplacement, DOE would continue monitoring and maintenance activities. Subsurface excavation would be complete, so there would be less emissions of naturally occurring hazardous materials in comparison to previous periods. Cristobalite concentrations at the analyzed land withdrawal area boundary would be substantially lower than those during the construction and operations analytical periods. Health impacts to the public would be unlikely. Quantities and resultant concentrations of erionite, if present, would be much lower than during previous periods.

Criteria Pollutants. During the monitoring analytical period, criteria pollutant emissions would decrease in comparison with previous periods because construction, excavation, and emplacement activities would be complete. Pollutant concentrations at the land withdrawal area boundary would be substantially lower than those for the construction and operations analytical periods. Health impacts to the public would be unlikely.

4.1.7.1.4 *Impacts to Occupational and Public Health and Safety During Closure*

This section describes estimated health and safety impacts to workers and members of the public during the closure analytical period. For analytical purposes, this period would begin with receipt of a license amendment to close the repository, would last 10 years, and would overlap the last 10 years of the monitoring analytical period. Activities during this period would include closure of subsurface repository facilities, backfilling, removal of surface facilities, erection of monuments, and reclamation of disturbed lands. Health and safety impacts to workers could occur from industrial hazards and exposure to naturally occurring cristobalite and erionite in the rock at Yucca Mountain. Health impacts to members of the public could occur from exposure to airborne releases of naturally occurring hazardous materials and from criteria pollutants.

Occupational Health and Safety Impacts

Industrial Hazards. The analysis assumed that health and safety impacts for the closure analytical period would be similar to those in the Yucca Mountain FEIS (DIRS 155970-DOE 2002, Table 4-30, p. 4-59). The estimated total recordable cases for all workers would be 370. The estimated lost workday cases for all workers would be 180. The estimated fatalities for all workers would be 0.2.

Naturally Occurring Hazardous Materials. Closure activities could generate dust (for example, during preparation and emplacement of excavated rock for backfill). The potential for dust generation, especially in the underground environment, would be less than that for subsurface excavation during the construction and operations analytical periods. As necessary, DOE would use the engineering controls and worker protection measures (Section 4.1.7.1.1) it developed for the construction analytical period to control and minimize potential impacts to workers. Potential impacts would be small.

Public Health Impacts

Naturally Occurring Hazardous Materials. Section 4.1.2.4 presents estimated annual maximum concentrations of cristobalite at the boundary of the analyzed land withdrawal area where there could be exposures to members of the public during the closure analytical period. The analysis estimated concentrations of about 0.0026 microgram per cubic meter. This would be less than 0.03 percent of the benchmark concentration of 10 micrograms per cubic meter. Health impacts to the public would be unlikely. Quantities and resultant concentrations of erionite, if present, would be much lower at locations of public exposure.

Criteria Pollutants. Section 4.1.2.4 presents estimated maximum concentrations of criteria pollutants (carbon monoxide, nitrogen dioxide, sulfur dioxide, and particulate matter) at the boundary of the land withdrawal area where there could be exposures to members of the public during the closure analytical period. The estimated concentrations would be less than 0.06 percent of the regulatory limit for all criteria pollutants except particulate matter. $PM_{2.5}$ could have a maximum concentration of about 0.5 percent of the 24-hour regulatory limit, and PM_{10} could have a maximum concentration of about 19 percent of the 24-hour regulatory limit. Health impacts to the public would be unlikely.

4.1.7.1.5 *Total Impacts to Occupational and Public Health and Safety for All Analytical Periods*

This section presents estimates of the total impacts to workers from industrial hazards from activities at the proposed repository. For this analysis, the entire project duration would be 105 years and would consist of a 5-year construction analytical period, a 50-year operations analytical period, a 50-year monitoring analytical period, and a 10-year closure analytical period that would overlap the last 10 years of the monitoring period. As noted above, health impacts to the public from naturally occurring hazardous material and criteria pollutants would be unlikely. Therefore, DOE did not quantify total health impacts to members of the public.

Table 4-22 lists total impacts to workers from industrial hazards for the entire project.

Table 4-22. Total impacts to workers from industrial hazards for all analytical periods.

Worker group	Impact category	Number
Involved workers	Total recordable cases	1,100
	Lost workday cases[a]	490
	Fatalities	0.62
Noninvolved workers	Total recordable cases	680
	Lost workday cases[a]	310
	Fatalities	0.30
All workers (totals)	Total recordable cases	1,800
	Lost workday cases[a]	800
	Fatalities	0.92

Note: Numbers are rounded to two significant figures; therefore, totals might differ from sums.

a. Equivalent to Days Away, Restricted, or On Job Transfer in CAIRS.

4.1.7.2 Radiological Impacts

This section describes potential radiological health and safety impacts to workers and members of the public from construction, operations, monitoring, and closure activities. The analysis estimated health and safety impacts separately for involved and noninvolved workers for each analytical period. The types of potential health and safety impacts to workers would include those from exposure to naturally occurring and manmade radiation and radioactive materials in the workplace. The estimated radiological impacts include potential doses and radiological health impacts for the maximally exposed involved workers and the involved worker populations; radiological health impacts for the maximally exposed noninvolved workers and the noninvolved worker populations; and the estimated collective dose and radiological health impacts for the combined worker population. Radiological health impacts for maximally exposed workers would be the estimated increase in the probability of a *latent cancer fatality* that would result from the received radiation dose. Radiological health impacts for affected populations would be the number of estimated latent cancer fatalities that would result from the collective radiation doses. Annual radiological dose impacts from manmade radioactive materials associated with the spent nuclear fuel and high-level waste to the maximally exposed individual member of the public and worker are included in this section and Appendix D, as part of the application submitted by DOE for construction authorization, to demonstrate that the preclosure performance objectives specified in 10 CFR 63.111(a) and 10 CFR 63.111(b) can be met for the proposed design and operations of repository during normal operations.

There would be exposure of members of the public to airborne releases of naturally occurring and manmade radionuclides from repository activities. The analysis estimated radiation doses and health impacts for the maximally exposed offsite individual and the potentially exposed population. The maximally exposed offsite individual would be a hypothetical member of the public at a point on the analyzed land withdrawal boundary who would receive the highest radiation dose and resultant radiological health impact. This location would be 19 kilometers (12 miles) in the south-southeast direction for releases from the surface geological repository operations area and 18 kilometers (11 miles) in the south-southeast direction for releases from subsurface facilities (DIRS 183160-BSC 2007, Tables 24 and 25).

Appendix D describes the methodology, data, and calculation of estimated radiological health and safety impacts to workers and members of the public and includes detailed results. Chapter 5 discusses the potential human health impacts of postclosure repository performance.

CONSERVATIVE ASSUMPTIONS USED IN RADIOLOGICAL IMPACT ANALYSIS

Radiological Impacts to Workers:

The maximally exposed involved worker would be a worker whose entire working lifetime would span the total operations analytical period up to 50 years for handling of spent nuclear fuel. The involved worker population would be exposed to conservatively estimated dose rates emitted from the casks based on the design-basis commercial spent nuclear fuel characteristics used for shielding design. This conservative approach would result in overestimation of the impacts to workers by a factor of about 3 if dose rates were based on the average spent fuel nuclear fuel characteristics that DOE would process at the proposed repository.

DOE applied no administrative limits to reduce individual exposures for its conservative estimates of involved worker doses.

Impacts to Members of the Public:

The location of the maximally exposed member of the public would be a hypothetical individual who would reside continuously for 70 years at the unrestricted public access area in the prevailing downwind direction from the repository that would receive the highest radiation exposure.

4.1.7.2.1 *Changes Since Completion of the Yucca Mountain FEIS*

The following paragraphs summarize the primary changes from the Yucca Mountain FEIS analysis to that for this Repository SEIS.

Population Distribution Data

The duration of the operations analytical period would be 50 years and would begin in 2017. Because this Repository SEIS assesses radiological impacts to the population within 84 kilometers (52 miles) of the repository, the analysis updated the population projection to 2067 based on projected changes in the region, including the towns of Beatty, Pahrump, Indian Springs, and the surrounding rural areas (Chapter 3, Section 3.1.8).

Airborne Release Radionuclide Composition

To estimate the magnitude of the airborne radioactive releases under normal operations, this Repository SEIS analysis conservatively assumed that all pressurized-water-reactor spent nuclear fuel would consist of the same radionuclide composition as that estimated for a pressurized-water-reactor fuel assembly with 4.2-percent initial enrichment, 50,000 megawatt-days per metric ton of heavy metal (MTHM) burnup rate, and 10 years cooling time, and all boiling-water-reactor spent nuclear fuel would consist of the same radionuclide composition as that estimated for a boiling-water-reactor fuel assembly with 4-percent initial enrichment, 50,000 megawatt-days per MTHM burnup rate, and 10-year cooling time (DIRS 180185-BSC 2007, Section 7). As described in Appendix D, these fuel compositions bound the expected annual average characteristics of the fuel that has the potential to contribute to airborne releases during normal operations in the Wet Handling Facility during TAD canister loading of uncanistered fuel and fuel from dual-purpose canisters (DIRS 180185-BSC 2007, Section 7).

Dose Assessment Computer Programs

The analysis used the GENII computer program (DIRS 179907-Napier 2007, all) and biosphere model parameters developed for Amargosa Valley (DIRS 177399-SNL 2007, all) to calculate estimated doses to the maximally exposed individual of the public from manmade radionuclide releases. GENII Version 2.05 calculates doses from exposure to radionuclides in the environment based on site-specific biosphere model parameters including food consumption rates and periods and external and inhalation exposure times (DIRS 179907-Napier 2007, all).

The analysis used the CAP88-PC computer program (Version 3) (DIRS 179923-Shroff 2006, all), an atmospheric transport model for assessment of dose and risk from radioactive air emissions, to calculate collective dose to the public and the dose from radon releases to the maximally exposed individual. CAP88-PC is EPA-approved for the demonstration of compliance with the *National Emission Standards for Hazardous Air Pollutants* [40 CFR 61.93(a)]. EPA validated the program through comparison of predictions of annual average concentrations with actual environmental measurements at five DOE sites (DIRS 179923-Shroff 2006, Section 1.4). The program provides capabilities for radon release dispersion and exposure calculations that include *receptor* radon progeny concentrations in working levels. It incorporates updated dose factors that follow the Federal Guidance Report 13 method (DIRS 175452-EPA 1999, all). The Federal Guidance Report 13 factors are based on the methods in Publication 72 of the International Commission on Radiological Protection (DIRS 172935-ICRP 2001, all).

Meteorological Data

Meteorological input data to CAP88-PC used the joint frequency distribution of wind speed, direction, and atmospheric stability class based on onsite meteorological measurements from 2001 to 2005 (DIRS 177510-BSC 2007, all and Attachment III).

Updated Latent Cancer Fatality Conversion Factors

For this Repository SEIS analysis, DOE updated the latent cancer fatality conversion factor to 0.0006 latent cancer fatality per *person-rem* for conversion of worker and public doses to health effects. This conversion factor is from current DOE guidance (DIRS 178579-DOE 2004, pp. 22 to 24; DIRS 174559-Lawrence 2002, p. 2 and Appendix D).

4.1.7.2.2 *Radiological Health Impacts During Construction*

Activities during the 5-year construction analytical period would include site preparation and construction of infrastructure that included the Initial Handling Facility, the balance of plant facilities that would support initial receipt of waste, a *Canister Receipt and Closure Facility*, an Aging Facility, the Wet Handling Facility, and initial construction of subsurface facilities for emplacement. DOE would construct the Initial Handling Facility and the balance of plant facilities first; construction of the Canister Receipt and Closure Facility, Aging Facility, and Wet Handling Facility would proceed in parallel.

Radiological health and safety impacts to workers could occur from exposure to naturally occurring radionuclides in the rock and from exposure to airborne releases of naturally occurring radionuclides (radon-222 and its decay products). Column 2 of Table 4-23 (in Section 4.1.7.2.6) lists estimates of radiological impacts to workers for the construction analytical period.

Health Impacts to Workers

There would be no spent nuclear fuel and high-level radioactive waste at the repository site during the construction analytical period, so they would not contribute to radiological impacts. Radiological health impacts to involved and noninvolved workers in subsurface facilities during the construction period would be from two sources: internal exposure from inhalation of radon-222 and its decay products that emanated from the host rock, and external exposure from naturally occurring radionuclides in the drift walls. Measurements in the Exploratory Studies Facility indicated an underground ambient external dose rate from radionuclides in the drift walls of about 50 *millirem* per worker year of 2,000 hours underground (DIRS 155970-DOE 2002, p. 3-99).

During the construction analytical period the only source of radiation would be from naturally occurring radionuclides in the subsurface, so subsurface facility construction workers would incur most of the radiological health impacts to the workforce. The estimated increase in the number of latent cancer fatalities for workers would be about 0.02 and the estimated increase in probability of a latent cancer fatality for the maximally exposed worker would be about 0.0003.

Public Health Impacts

Potential radiological health impacts to the public during the 5-year construction analytical period would come from exposure to airborne releases of naturally occurring radon-222 and its decay products in the subsurface exhaust ventilation air. Column 2 of Table 4-24 (in Section 4.1.7.2.6) lists estimates of radiological impacts to the public for the construction period. The estimated number of latent cancer fatalities in the public from repository construction would be about 0.05 in a projected population of about 117,000 persons within 84 kilometers (52 miles) of the repository. The estimated increase in probability of a latent cancer fatality for the maximally exposed member of the public would be 0.0000025 over the 5-year period.

The increase in radiological impacts to the public population since DOE completed the Yucca Mountain FEIS is primarily a result of the reduced stack height of the subsurface ventilation exhausts from 60 meters (200 feet) to close to ground level. DOE adopted this design change to improve safety in relation to potential external *events* such as an airplane crash, *earthquake*, and high winds. The primary parameters that contribute to the increase are (1) a factor of about 5 from reduced stack height from 60 meters to about ground level, (2) a factor of about 2 from varied changes of site meteorological parameter height data (for wind speed and frequency toward the population centers) from 60-meter height to ground level, and (3) a factor of 1.5 from increased population projection within 84 kilometers (52 miles) of the repository.

4.1.7.2.3 *Estimated Radiological Health Impacts During Operations*

The operations analytical period would begin with the receipt of an NRC license to receive and possess radiological materials and would include receipt, handling, aging, and emplacement of waste. During the operations period, surface facility construction would continue and include a *Receipt Facility* and additional Canister Receipt and Closure Facilities. DOE would add aging pads as needed. The operations period would last up to 50 years and would end with emplacement of the last waste package. Subsurface construction (development) would continue into the operations period for approximately 22 years.

Health Impacts to Workers

Occupational radiological health impacts during the operations analytical period would be a combination of impacts to surface workers during spent nuclear fuel and high-level radioactive waste handling operations and impacts to subsurface workers during development and emplacement operations. The principal contributors to radiological health impacts during the operations period would be surface facility operations, which would involve the receipt, handling, and packaging of spent nuclear fuel and high-level radioactive waste for aging and emplacement. Column 3 of Table 4-23 (in Section 4.1.7.2.6) lists the estimated radiological impacts to workers for the operations period.

The estimated number of latent cancer fatalities in the worker population for up to a 50-year operations analytical period would be 2.6 latent cancer fatalities (Table 4-23 in Section 4.1.7.2.6). The estimated increase in probability of a latent cancer fatality for the maximally exposed worker would be 0.018.

Public Health Impacts

Potential radiological health impacts to the public during the operations analytical period would result from (1) exposure to naturally occurring radon-222 and its decay products in subsurface exhaust ventilation air and (2) exposure to potential releases to the air of gases and particulates from resuspension of radioactive contamination from external surfaces of spent nuclear fuel containers and airborne releases from opening spent nuclear fuel containers during handling operations in the Wet Handling Facility and resuspension of surface contamination from TAD canisters and dual-purpose canisters inside aging overpacks during staging at the Aging Facility. The manmade radionuclides from the spent nuclear fuel would contribute small radiological impacts—less than 0.4 percent of the dose—in comparison with that from radon-222 and its decay products. Column 3 of Table 4-24 (in Section 4.1.7.2.6) lists estimates of radiological impacts to the public for repository operations.

For the operations analytical period, the estimated increase in probability of a latent cancer fatality in the maximally exposed member of the public would be about 0.0002. The estimated number of latent cancer fatalities in the affected population would be about 4.

4.1.7.2.4 *Estimated Radiological Health Impacts During Monitoring*

The monitoring analytical period would begin with emplacement of the last waste package and continue for 50 years. The first 3 years of this period would include decontamination of surface handling facilities. The last 10 years would overlap with the closure analytical period. Columns 4 of Tables 4-23 and 4-24 (in Section 4.1.7.2.6) list the estimates of radiological impacts to workers and the public, respectively, for monitoring the repository.

Health Impacts to Workers

Occupational radiological health impacts during monitoring would be a combination of impacts to surface workers during facility decontamination and subsurface workers during monitoring and maintenance activities. The principal contributor to radiological health impacts would be from subsurface facility monitoring and maintenance activities.

The estimated number of latent cancer fatalities in the worker population for the first 40 years of the monitoring analytical period would be about 0.6. The estimated radiological health impacts to the maximally exposed worker would be 13 *rem*, which would represent an increase in probability of latent cancer fatality of 0.008.

Public Health Impacts

Potential radiological health impacts to the public from monitoring activities would result from exposure to releases of naturally occurring radon-222 and its decay products in subsurface exhaust ventilation air. DOE does not anticipate that decontamination activities would generate releases of radioactive material to the environment or radiation doses to the public.

Table 4-24 in Section 4.1.7.2.6 lists the estimates of dose and potential radiological health impacts to the public for the first 40-years of the monitoring analytical period. The increase in probability of a latent cancer fatality in the maximally exposed member of the public would be 0.00018, and the number of latent cancer fatalities that could occur in the affected population would be 3.7.

4.1.7.2.5 *Estimated Radiological Health Impacts During Closure*

The closure analytical period would begin at the completion of the first 40 years of monitoring and last 10 years.

Health Impacts to Workers

During the closure analytical period, subsurface workers would be exposed to radon-222 in the drift atmosphere, to external radiation from naturally occurring radionuclides in the drift walls, and to external radiation from waste packages. Most of the radiation dose and potential radiological health impacts for this period would be to subsurface workers, and the maximally exposed worker would be a subsurface worker. There would be low potential for exposure of surface workers. Column 5 of Table 4-23 (in Section 4.1.7.2.6) lists the estimated radiological impacts to workers for the closure period. The estimated number of latent cancer fatalities in the worker population for the 10-year closure period would be 0.25. The estimated radiological health impacts to the maximally exposed worker would be 1.6 rem with an increase in probability of latent cancer fatality of 0.001.

Public Health Impacts

Potential radiological health impacts to the public from closure activities would result from exposure to releases of radon-222 and its decay products in the subsurface exhaust ventilation air. The estimated dose and radiological health impacts for this period would be small. Table 4-24, column 5 (in Section 4.1.7.2.6) lists estimates of radiological impacts to the public for the closure period. The increase in probability of a latent cancer fatality in the maximally exposed member of the public for the closure period of 10 years would be about 0.00002. The estimated number of latent cancer fatalities in the affected population would be about 0.5.

4.1.7.2.6 *Estimated Radiological Health Impacts for Entire Project Period*

This section summarizes the radiological human health and safety impacts to workers and members of the public from activities at the proposed repository. The project duration would be 105 years and would include 5 years of construction, 50 years of operations, 50 years of monitoring, and 10 years of closure, which would overlap the final 10 years of the monitoring analytical period. In general, the highest potential health and safety impacts would occur during the operations and monitoring periods.

Radiological Health Impacts to Workers for Entire Project

Table 4-23 (last column) lists total radiation dose and radiological health impacts to workers for the entire project (all analytical periods). Doses and impacts for the maximally exposed worker are for the operations analytical period. The collective dose to the worker population and potential radiological health impacts are for the entire project duration of 105 years.

Table 4-23. Estimated radiation doses and radiological health impacts to workers, each analytical period and entire project.[a]

Worker group and impact category	Construction	Operations	Monitoring[b]	Closure	Entire project[c]
Maximally exposed worker					
Maximum annual dose from manmade radionuclides (rem per year)					
Involved	0.0	1.3	0.20	0.039	1.3
Noninvolved	0.0	0.010	0.00001	0.00001	0.010
Total dose (rem)					
Involved	0.49	30	13	1.6	30
Noninvolved	0.052	0.25	0.21	0.028	0.25
Increase in probability of LCF					
Involved	0.00029	0.018	0.0078	0.00097	0.018
Noninvolved	0.000031	0.00015	0.00012	0.000017	0.00015
Worker population					
Collective dose (person-rem)					
Involved	33	4,200	890	400	5,500
Noninvolved	4.7	190	26	18	240
Nevada Test Site noninvolved	0.12	9.2	8.9	1.2	19
Totals[d]	38	4,400	930	420	5,800
Number of LCFs					
Involved	0.02	2.5	0.54	0.24	3.3
Noninvolved	0.0028	0.12	0.016	0.011	0.14
Nevada Test Site noninvolved	0.000074	0.0055	0.0053	0.00073	0.012
Totals[d]	0.023	2.6	0.56	0.25	3.5

a. Figure D-2 in Appendix D shows the projected worker population for each analytical period.
b. Doses are for the 40-year monitoring analytical period under active ventilation operating mode.
c. Maximally exposed worker doses are for the worker's entire working lifetime spanning the 50-year operations analytical period. Population doses are for the entire 105-year project duration.
d. Numbers are rounded to two significant figures; therefore, totals might differ from sums.
LCF = Latent cancer fatality.

The maximally exposed worker would be a surface facility worker whose entire working lifetime would span the total operations analytical period for handling of spent nuclear fuel. The model assumes this worker would be a cask operator who handled spent nuclear fuel. The estimated radiation dose would be 30 rem if DOE did not apply administrative limits to reduce individual exposures. The increase in probability of a latent cancer fatality would be about 0.02 for this individual.

The estimated total worker population radiation dose for the entire project duration of 105 years would be 5,800 person-rem. Seventy-six percent of the dose would occur during the operations analytical period for the repository workforce. The principal source of exposure would be external radiation from handling of spent nuclear fuel in surface facilities and monitoring and maintenance activities in the subsurface facility. Exposure to naturally occurring radioactive sources would account for 29 percent of the total worker dose. Inhalation of radon-222 and its decay products by subsurface workers would contribute 17 percent of the total dose, and ambient radiation exposure to subsurface workers would contribute 12 percent.

To put the 5,800-person-rem dose to the worker population in perspective, the same worker population, which represents about 86,000 full-time equivalent worker years, would receive 29,000 person-rem from the natural *background radiation* exposure of 340 millirem per year (Chapter 3, Section 3.1.8.1) over the entire project period of 105 years. Therefore, the addition of 5,800 person-rem would represent an increase of about 20 percent due to the Proposed Action. The estimated increase in number of latent cancer fatalities that could occur in the repository workforce from the received radiation doses over the entire project would be 3.5. This can be compared to the 17 latent cancer fatalities that could result from the 29,000 person-rem the same worker population would normally incur over the entire project period from exposure to natural background radiation.

Radiological Health Impacts to the Public for Entire Project

Table 4-24 (last column) lists the estimated radiation dose and potential radiological health impacts to the public for the entire project (all analytical periods). Doses and radiological impacts would be for the offsite maximally exposed member of the public who resided continuously for 70 years at the site boundary location in the prevailing downwind direction. The increase in probability of a latent cancer fatality to this individual from exposure to radionuclides from the repository during the preclosure period would be about 0.0003. About 99.8 percent of the potential health impact would be from exposure to naturally occurring radon-222 and its decay products in subsurface exhaust ventilation air. The highest annual radiation dose would be 7.6 millirem, which is less than 3 percent of the annual average natural background radiation exposure of 340 millirem per year to members of the public (Chapter 3, Section 3.1.8.1). This background radiation dose includes a 200-millirem dose from ambient background levels of naturally occurring radon-222 and its decay products (Chapter 3, Section 3.1.8.2) but excludes potential radiation dose from repository subsurface radon release.

The estimated collective dose for the population within 84 kilometers (52 miles) for the entire project duration of 105 years would be 13,000 person-rem (Table 4-24). The corresponding number of latent cancer fatalities for this collective dose would be 8 in a projected population in 2067 of about 117,000 persons within 84 kilometers of the repository. For comparison, the analysis examined the number of expected cancer deaths that would occur from other causes in the same population during the same periods. The analysis calculated the expected number of cancer deaths that would not be related to the repository project on the basis of current statistics from the Centers for Disease Control and Prevention, which indicated that 24 percent of all deaths in the State of Nevada were attributable to cancer of some type and cause during 1998 (DIRS 153066-Murphy 2000, p. 8). The comparison indicates that over the

Table 4-24. Estimated radiation doses and radiological health impacts to public, each analytical period and entire project from normal operations.[a,b]

Dose and health impact	Construction	Operations	Monitoring[c]	Closure	Entire project[d]
Maximally exposed offsite individual[e]					
Maximum annual dose from manmade radionuclides (millirem per year)	0.0	0.055	0.0029	0.0029	0.055
Maximum annual dose (millirem per year)	1.4	7.6	7.5	7.5	7.6
Total for period duration (millirem)	4.2	310	300	41	530
Probability of latent cancer fatality	2.5×10^{-6}	1.9×10^{-4}	1.8×10^{-4}	2.5×10^{-5}	3.2×10^{-4}
Exposed 84-kilometer (52-mile) population[f]					
Collective dose (person-rem)	85	6,400	6,100	840	13,000
Number of latent cancer fatalities	0.051	3.8	3.7	0.51	8

a. About 99.8 percent of the total dose and impact would be from naturally occurring radon-222 and decay products.
b. Numbers are rounded to two significant figures; therefore, totals might differ from sums.
c. Doses are for the 40-year monitoring analytical period under active ventilation operating mode.
d. Doses are for the entire 105-year project duration.
e. A hypothetical individual who would reside continuously for 70 years at the site boundary location in the prevailing downwind direction.
f. The projected population includes about 117,000 persons within 84 kilometers of the repository.

105-year project duration the incremental chance of latent cancer fatalities among the projected population of about 117,000 would be about 2 in 10,000.

4.1.8 ACCIDENT AND SABOTAGE SCENARIO IMPACTS

This section describes the impacts from potential accident and sabotage scenarios for the Proposed Action. Section 4.1.8.1 discusses changes in the methods and data DOE used to evaluate impacts from potential accidents since it completed the Yucca Mountain FEIS. Sections 4.1.8.2, 4.1.8.3, and 4.1.8.4 describe the analyses for radiological accident impacts, nonradiological accident impacts, and impacts from hypothetical sabotage events, respectively. DOE calculated impacts for (1) the *maximally exposed offsite individual*, (2) the *noninvolved worker*, and (3) the *offsite population*, which, for purposes of this analysis, includes members of the public who resided within about 84 kilometers (52 miles) of the proposed repository. Because all waste handling operations would be remote, involved workers would be in enclosed facility operating rooms isolated from the waste. Involved workers would be unlikely to receive significant exposures to radioactive materials that an accident could release for the following reasons:

- For releases that occurred in waste handling buildings (11 of the 14 accident scenarios), operators would be in enclosed operating areas that would isolate them.

- For the two fire scenarios that would involve low-level radioactive waste and a truck transportation cask, the fire would cause the release to be lofted into the atmosphere, so workers close to the release would not receive meaningful exposure.

- For the *seismic* scenario, the event would be likely to injure or kill workers in the Low-level Waste Facility, and the dose to the noninvolved worker at 60 meters (200 feet) would be representative of the dose to involved workers outside the facility. Appendix E contains details of the analysis method.

The impacts to offsite individuals from repository accidents under 95th-percentile weather conditions (conditions that resulted in doses that would only be exceeded 5 percent of the time) would be small, with calculated doses of 35 millirem or less to the maximally exposed offsite individual. Doses to a noninvolved worker would be higher than those to offsite individuals, up to 3.5 rem.

The accident analysis for this Repository SEIS is consistent with the preclosure safety analysis included in the application that DOE has filed with the NRC for construction authorization for the Yucca Mountain Repository.

4.1.8.1 Changes Since Completion of the Yucca Mountain FEIS

Since it completed the Yucca Mountain FEIS, DOE has acquired new information and analytical tools that have contributed to the understanding of the potential impacts for accident analyses. The following sections describe the changes in potential accident impact analysis. Appendix E provides a more detailed evaluation of these changes.

4.1.8.1.1 *Commercial Spent Nuclear Fuel Characteristics*

The analysis for this Repository SEIS used a commercial pressurized-water-reactor spent nuclear fuel assembly with the bounding radiological characteristics of 80,000 megawatt-days per metric ton of uranium burnup and a 5-year cooling time for accidents that would involve *commercial spent nuclear fuel*. This fuel bounds other commercial fuel types (*boiling-water-reactor* and mixed-oxide spent fuel) because it would result in the highest accident scenario consequences. Appendix E, Section E.3 provides details.

4.1.8.1.2 *Population Distribution*

For this Repository SEIS, the projected duration of the operations analytical period is 50 years, which would begin in 2017. The projected population for the 84-kilometer (52-mile) region of influence would be about 117,000 persons in 2067 (Chapter 3, Section 3.1.8, Figure 3-16).

4.1.8.1.3 *Accident Analysis and Atmospheric Dispersion Models*

For this Repository SEIS, DOE used the GENII computer program to calculate radiation doses from a release of radioactive material (DIRS 100953-Napier et al. 1988, all). These calculations require site-specific dispersion factors (factors that measure the dilution of the downwind atmospheric plume). DOE used an NRC-developed atmospheric dispersion model to develop the dispersion factors. Appendix E, Section E.4.1 discusses the GENII program and the atmospheric dispersion model in more detail.

4.1.8.1.4 *Commercial Spent Nuclear Fuel Oxidation*

Additional information on fuel oxidation has become available since the completion of the Yucca Mountain FEIS. Fuel oxidation could occur during an accident if commercial spent nuclear fuel pellets at an elevated temperature were exposed to air. The oxidation would involve conversion of the uranium dioxide fuel pellet material to uranium trioxide. Uranium trioxide is a powder more respirable than the uranium dioxide fuel pellet material and would increase the downwind dose. For this Repository SEIS, if damaged commercial spent nuclear fuel was involved in an accident, the analysis, when appropriate, modeled that oxidation would contribute to the release over a period of 30 days. It also conservatively modeled that these accidents would occur without any measures to mitigate consequences (for example, evacuation or interdiction of food consumption) for this 30-day period to enable a conservative prediction of the radiological consequences. Appendix E, Section E.3.3.1 discusses fuel oxidation further, and Section E.4.3 provides a quantitative evaluation of the effect of mitigation measures.

4.1.8.1.5 *Radiation Dosimetry*

DOE changed the radiation dosimetry it used to evaluate consequences in this Repository SEIS to incorporate International Committee on Radiation Protection Publication 72 (DIRS 172935-ICRP 2001, all), the most recent dosimetry guidance available from the Committee. Appendix D, Section D.1 contains the details of this change.

4.1.8.1.6 *Latent Cancer Fatalities*

Current DOE guidance recommends that estimates of latent cancer fatalities be based on the received radiation dose and on radiation dose-to-health effect conversion factors recommended by the Interagency Steering Committee on Radiation Standards. For this Repository SEIS, DOE used the updated guidance for workers and members of the public, which is 0.0006 fatality per person-rem (DIRS 174559-Lawrence 2002, p. 2).

4.1.8.1.7 *Location of Maximally Exposed Offsite Individual*

In this Repository SEIS, the analysis used locations for the maximally exposed offsite individual of either 7.8 kilometers (4.8 miles), the nearest location in the southeast sector of the repository, or 18.5 kilometers (11 miles), the nearest location in the south-southeast quadrant of the repository, depending on which location would receive the highest calculated dose from the specific accident scenario using the GENII program. Tables 4-25 and 4-26 later in this section specify the location of the maximally exposed offsite individual for each accident. The analysis determined these locations as those that would produce the highest site boundary doses of any of the 16 radial sectors around the site based on sector-specific dispersion factors that the GENII program uses to calculate doses.

4.1.8.2 Radiological Accidents

The first step in the radiological accident analysis was to examine the initiating events that could lead to facility accidents. These events could be external or internal. External initiators originate outside a facility and affect its ability to confine radioactive material; they can include human-caused events such as aircraft crashes, external fires, and explosions and natural phenomena such as seismic disturbances and extreme weather conditions. Internal initiators occur inside a facility and can include human errors, equipment failures, or combinations of the two. DOE analyzed initiating events applicable to repository operations to define subsequent sequences of events that could result in releases of radioactive material or radiation exposure. For each event in these accident sequences, the analysis estimated and combined probabilities to produce an estimate of the overall accident probability for the sequence. Last, it evaluated the consequences of the accident scenarios by estimating the potential radiation dose and radiological impacts.

The materials at risk for various accident scenarios could include several types of radioactive materials—spent nuclear fuel from boiling- and pressurized-water commercial reactors in TAD or dual-purpose canisters, or uncanistered fuel in transportation casks; *DOE spent nuclear fuel* canisters; *naval spent nuclear fuel* canisters; high-level radioactive waste canisters; and weapons-grade plutonium immobilized in a high-level radioactive waste glass matrix or as *mixed-oxide fuel*, both in canisters. Appendix A of the Yucca Mountain FEIS presented many details on the materials DOE would dispose of in the repository (DIRS 155970-DOE 2002, pp. A-1 to A-71).

Under the Proposed Action, up to 90 percent of the commercial spent nuclear fuel would arrive at the repository in TAD canisters. DOE would handle the remaining fuel as uncanistered spent fuel assemblies in the Wet Handling Facility and place it in TAD canisters for disposal. Appendix E, Section E.3 discusses materials at risk and the *source terms* DOE used for the accident analysis. In addition, the analysis examined accident scenarios that would involve the release of low-level waste that DOE generated and handled at the repository.

The analysis considered radiological consequences of the postulated accidents for the following:

- Noninvolved worker (collocated worker). A worker who would not be directly involved with material unloading, transfer, and emplacement activities, who DOE assumed to be 60 meters (200 feet) downwind of the facility where the release occurred. The 60-meter distance corresponds to the location of the exclusion fence around the waste handling buildings. (Some accidents could result in severe consequences for involved workers).

- Maximally exposed offsite individual. A hypothetical member of the public at a point on the site boundary who would be likely to receive the maximum dose. The analysis determined that the location with the highest potential exposure from an accidental release of radioactive material would be either (1) about 18.5 kilometers (11 miles) from the accident location (at the south boundary of the analyzed land withdrawal area), or (2) about 7.8 kilometers (4.8 miles) from the accident location (at the east boundary of the land withdrawal area).

- Offsite population. Members of the public within 84 kilometers (52 miles) of the repository site (Chapter 3, Section 3.1.8).

A review of the possible hazards and initiating events for the most current design concepts and planned operations identified 14 accident scenarios that DOE analyzed in detail. They included accidents in the Initial Handling Facility, the Wet Handling Facility, a Canister Receipt and Closure Facility, the Receipt Facility, and the Low-Level Waste Facility. The accident scenarios considered drops and collisions that involved transportation casks, TAD canisters, dual-purpose canisters, and uncanistered fuel assemblies; a fire that involved low-level radioactive waste and a transportation cask on a truck; and a seismic event. DOE analyzed the scenarios under average (50th-percentile) meteorological conditions (conditions that result in average doses over the spectrum of possible weather conditions) and unfavorable (95th-percentile) meteorological conditions (conditions that result in higher doses that would be exceeded only 5 percent of the time). Appendix E, Section E.2 contains details of the analysis. For this Repository SEIS, DOE did not evaluate the seismic collapse of a waste handling building that it evaluated in the Yucca Mountain FEIS because the Department intends to enhance the capability of the buildings to withstand ground motion associated with seismic events. Further, no bare fuel assemblies would exist in air in any of the waste handling buildings, so a building collapse would be unlikely to produce large impacts. In addition, DOE did not evaluate the transporter runaway accident it analyzed in the Yucca Mountain FEIS because the event is unlikely and the consequences are expected to be smaller than those of the transporter derailment event analyzed in the FEIS.

Tables 4-25 and 4-26 list the results of the radiological accident scenarios DOE modeled for this Repository SEIS for 95th- and 50th-percentile meteorological conditions, respectively. Impacts to the noninvolved worker would result from the inhalation of airborne radionuclides and external radiation from the passing plume. Impacts to the maximally exposed offsite individual and the offsite population would result from these *exposure pathways* and from long-term external exposure to radionuclides the plume deposited on soil during passage, subsequent ingestion of radionuclides in locally grown food, and inhalation of resuspended particulates. The analysis assumed neither DOE nor other government agencies would implement mitigation measures, such as evacuation, to limit long-term radiation doses. Appendix E, Section E.4.3 evaluates the effect of this assumption.

The accident scenario with the highest consequences in Table 4-25 would involve a seismic event that caused the release of radioactive material from high-efficiency particulate air filters, ducts, and low-level radioactive waste. The estimated health impacts to the offsite population would be 0.19 additional latent cancer fatality in the exposed population of 104,000 in the sector with the largest population (south-southeast) for the 95th-percentile weather condition. The maximum dose to the maximally exposed noninvolved worker could be 3.5 rem, which could result in an increased probability of a latent cancer fatality to the individual of 0.0021.

4.1.8.3 Nonradiological Accidents

A potential release of hazardous or toxic materials would be minimal because the repository would not accept *hazardous waste* under the *Resource Conservation and Recovery Act* (42 U.S.C. 6901 et seq.). However, some potentially hazardous metals, such as arsenic or mercury, could be present in the high-level radioactive waste inventory. Nonradioactive hazardous or toxic substances, such as cleaning solvents, sodium hydroxide, sulfuric acid, and solid chemicals, would be present in limited quantities at the repository as part of operational requirements. Impacts to members of the public would be unlikely due to the limited quantities and because the chemicals would be mostly liquid and solid, so a release would be confined to the site. The generation, storage, and offsite *shipment* of solid and liquid hazardous wastes from operations would represent minimal incremental risk from accidents. Section 4.1.7 describes potential impacts to workers from normal industrial hazards in the workplace (which would include industrial accidents). DOE derived the statistics in the analysis from accident experience at other sites.

4.1.8.4 Sabotage

In response to the terrorist attacks of September 11, 2001, and to intelligence information that has been obtained since then, the United States Government has initiated nationwide measures to reduce the threat of sabotage. These measures include security enhancements to prevent terrorists from gaining control of commercial aircraft, such as (1) more stringent screening of airline passengers and baggage by the Transportation Security Administration, (2) increased presence of Federal Air Marshals on many flights, (3) improved training of flight crews, and (4) hardening of aircraft cockpits. Additional measures have been imposed on foreign passenger carriers and domestic and foreign cargo carriers, as well as charter aircraft.

Table 4-25. Estimated radiological consequences of repository operations accident scenarios for unfavorable (95th-percentile) sector-specific meteorological conditions.

	Expected occurrences over the preclosure period (annual frequency)[a]		Maximally exposed offsite individual[b]		Population		Noninvolved worker	
Accident scenario	Internal events	Seismic events	Dose (rem)	LCF_i[c]	Dose (person-rem)	LCF_p[c]	Dose (rem)	LCF_i[c]
1. Seismic event resulting in LLWF collapse and failure of HEPA filters and ductwork in other facilities	(not applicable)	8×10^{-3} (2×10^{-4})	3.5×10^{-2}	2.1×10^{-5}	3.1×10^{2}	1.9×10^{-1}	3.5×10^{0}	2.1×10^{-3}
2. Breach of sealed HLW canisters in a sealed transportation cask	$< 1 \times 10^{-4}$ ($< 2 \times 10^{-6}$)	$< 1 \times 10^{-4}$ ($< 2 \times 10^{-6}$)	2.6×10^{-5} (2.6×10^{-3})[d]	1.6×10^{-8}	2.1×10^{-1} (2.1×10^{1})[d]	1.3×10^{-4}	3.5×10^{-3} (3.5×10^{-1})[d]	2.1×10^{-6}
3. Breach of sealed HLW canister in an unsealed waste package	$< 1 \times 10^{-4}$ ($< 2 \times 10^{-6}$)	1×10^{-4} (2×10^{-6})	2.6×10^{-4} (2.6×10^{-2})[d]	1.6×10^{-7}	2.1×10^{0} (2.6×10^{-2})[d]	1.3×10^{-3}	3.5×10^{-2} (2.65×10^{-2})[d]	2.1×10^{-5}
4. Breach of sealed HLW canister during transfer (one drops onto another)	1×10^{-2} (2×10^{-4})	$< 1 \times 10^{-4}$ ($< 2 \times 10^{-6}$)	1.0×10^{-4} (1.0×10^{-2})[d]	6.0×10^{-8}	8.5×10^{-1} (8.5×10^{1})[d]	5.1×10^{-4}	1.4×10^{-2} (1.4×10^{0})[d]	8.4×10^{-6}
5. Breach of uncanistered commercial SNF in a sealed truck transportation cask in air	1×10^{-1} (2×10^{-3})	not applicable[e]	1.0×10^{-3}	6.0×10^{-7}	2.7×10^{-5}	1.6×10^{-2}	8.3×10^{-2}	5.0×10^{-5}
6. Breach of uncanistered commercial SNF in an unsealed truck transportation cask in pool	7×10^{-4} (1×10^{-5})	2×10^{-4} (4×10^{-6})	9.4×10^{-4}	5.6×10^{-7}	2.6×10^{1}	1.6×10^{-2}	5.2×10^{-2}	3.1×10^{-5}
7. Breach of a sealed DPC in air	9×10^{-3} (2×10^{-6})	not applicable[e]	9.1×10^{-3}	5.5×10^{-6}	2.5×10^{2}	1.5×10^{-1}	5.5×10^{-2}	3.3×10^{-3}
8. Breach of commercial SNF in unsealed DPC in pool	$< 1 \times 10^{-4}$ ($< 2 \times 10^{-6}$)	2×10^{-4} (4×10^{-6})	8.4×10^{-3}	5.0×10^{-6}	2.3×10^{2}	1.4×10^{-1}	7.4×10^{-1}	4.4×10^{-4}
9. Breach of a sealed TAD canister in pool	2×10^{-3} (4×10^{-5})	not applicable[e]	5.3×10^{-3}	3.2×10^{-6}	1.4×10^{2}	8.4×10^{-2}	4.3×10^{-1}	2.6×10^{-4}

Table 4-25. Estimated radiological consequences of repository operations accident scenarios for unfavorable (95th-percentile) sector-specific meteorological conditions (continued).

Accident scenario	Expected occurrences over the preclosure period (annual frequency)		Maximally exposed offsite individual[a]		Population		Noninvolved worker	
	Internal events	Seismic events	Dose (rem)	LCF_i[b]	Dose (person-rem)	LCF_p[b]	Dose (rem)	LCF_i[b]
10. Breach of commercial SNF n unsealed TAD canister in pool	5×10^{-4} (1×10^{-5})	not applicable[e]	4.9×10^{-3}	2.8×10^{-6}	1.3×10^{2}	7.8×10^{-2}	2.9×10^{-1}	1.7×10^{-4}
11. Breach of uncanistered commercial SNF assembly in pool (one drops onto another)	3×10^{-1} (6×10^{-3})	not applicable[e]	4.7×10^{-4}	2.8×10^{-7}	1.3×10^{1}	7.8×10^{-3}	2.7×10^{-2}	1.6×10^{-5}
12. Breach of uncanistered commercial SNF in pool	$< 1 \times 10^{-4}$ ($< 2 \times 10^{-6}$)	not applicable[e]	2.3×10^{-4}	1.4×10^{-7}	6.4×10^{0}	3.8×10^{-3}	1.4×10^{-2}	8.4×10^{-6}
13. Fire involving LLWF inventory	7×10^{-2} (1×10^{-3})	not applicable[e]	9.0×10^{-4}	5.4×10^{-7}	8.4×10^{0}	5.0×10^{-3}	8.1×10^{-2}	4.9×10^{-5}
14. Breach of a sealed truck transportation cask due to a fire	2×10^{-2} (4×10^{-4})	not applicable[e]	4.4×10^{-3}	2.6×10^{-6}	4.2×10^{1}	2.5×10^{-2}	1.3×10^{0}	7.8×10^{-4}

a. For accident scenarios potentially initiated by more than one Category 2 event sequence, the expected occurrence value is the maximum frequency of those Category 2 event sequences. For accident scenarios potentially initiated by only Beyond Category 2 event sequences, the expected occurrence value is less than the maximum frequency of a Beyond Category 2 event over the preclosure period (i.e. $<1 \times 10^{-4}$).

b. Assumed to be at the analyzed land withdrawal boundary either in the east sector [7.8 kilometers (4.8 miles)] or in the southeast sector [18.5 kilometers (11 miles)], whichever produces the highest site boundary dose. For Accident Scenarios 3 through 10, DOE calculated the highest dose for the southeast sector. For all other accident scenarios, DOE calculated the highest dose for the east sector.

c. LCF_i is the estimated likelihood of a latent cancer fatality for an individual who receives the calculated dose (rem). LCF_p is the estimated number of cancers in the exposed population from the collective population dose (person-rem). These values were computed based on a conversion of dose to LCFs as discussed in Section E.4.1.

d. Unfiltered doses presented to illustrate that filtration systems might not be required for these accident scenarios.

e. The seismic event sequence quantification and categorization analysis (DIRS 183261-BSC 2007, Sect. 6.7 and 6.8) did not identify any seismic initiators for these scenarios.

DPC = Dual-purpose canister.
HEPA = High-efficiency particulate air (filter).
HLW = High-level radioactive waste.
LCF = Latent cancer fatality.
LLWF = Low-Level Waste Facility.
SNF = Spent nuclear fuel.
TAD = Transportation, aging, and disposal (canister).

Table 4-26. Estimated radiological consequences of repository operations accident scenarios for annual average (50th-percentile) sector-specific meteorological conditions.

Accident scenario	Expected occurrences over the preclosure period (annual frequency)[a]		Maximally exposed offsite individual[b]		Population		Noninvolved worker	
	Internal events	Seismic events	Dose (rem)	LCF_i[c]	Dose (person-rem)	LCF_p[c]	Dose (rem)	LCF_i[c]
1. Seismic event resulting in LLWF collapse and failure of HEPA filters and ductwork in other facilities	(not applicable)	8×10^{-3} (2×10^{-4})	6.4×10^{-4}	3.8×10^{-7}	2.5×10^{0}	1.5×10^{-3}	5.8×10^{-1}	3.5×10^{-4}
2. Breach of sealed HLW canisters in a sealed transportation cask	$< 1 \times 10^{-4}$ ($< 2 \times 10^{-6}$)	$< 1 \times 10^{-4}$ ($< 2 \times 10^{-6}$)	4.4×10^{-7}	2.6×10^{-10}	1.5×10^{-3}	9.0×10^{-7}	5.8×10^{-4}	3.5×10^{-7}
3. Breach of sealed HLW canister in an unsealed waste package	$< 1 \times 10^{-4}$ ($< 2 \times 10^{-6}$)	1×10^{-4} (2×10^{-6})	4.4×10^{-6}	2.6×10^{-9}	1.5×10^{-2}	9.0×10^{-6}	5.8×10^{-3}	3.5×10^{-6}
4. Breach of sealed HLW canister during transfer (one drops onto another)	1×10^{-2} (2×10^{-4})	$< 1 \times 10^{-4}$ ($< 2 \times 10^{-6}$)	1.8×10^{-6}	1.1×10^{-9}	5.9×10^{-3}	3.5×10^{-6}	2.3×10^{-3}	1.4×10^{-6}
5. Breach of uncanisterecommercial SNF in a sealed truck transportation cask in air	1×10^{-1} (2×10^{-3})	not applicable[d]	2.6×10^{-5}	1.6×10^{-8}	2.7×10^{-1}	1.6×10^{-4}	2.3×10^{-2}	1.4×10^{-5}
6. Breach of uncanistered commercial SNF in an unsealed truck transportation cask in pool	7×10^{-4} (1×10^{-6})	2×10^{-4} (4×10^{-6})	1.2×10^{-5}	7.2×10^{-9}	1.5×10^{-1}	9.0×10^{-5}	9.0×10^{-3}	5.4×10^{-6}
7. Breach of a sealed DPC in air	9×10^{-3} (2×10^{-6})	not applicable[d]	2.4×10^{-4}	1.4×10^{-7}	2.5×10^{0}	1.5×10^{-3}	2.1×10^{-1}	1.3×10^{-4}
8. Breach of commercial SNF in unsealed DPC in pool	$< 1 \times 10^{-4}$ ($< 2 \times 10^{-6}$)	2×10^{-4} (4×10^{-6})	1.1×10^{-4}	6.6×10^{-8}	1.4×10^{0}	8.4×10^{-4}	8.1×10^{-2}	4.9×10^{-5}
9. Breach of a sealed TAD canister in pool	2×10^{-3} (4×10^{-5})	not applicable	1.4×10^{-4}	8.4×10^{-8}	1.4×10^{0}	8.4×10^{-4}	1.2×10^{-1}	7.2×10^{-5}

Table 4-26. Estimated radiological consequences of repository operations accident scenarios for annual average (50th-percentile) sector-specific meteorological conditions (continued).

	Expected occurrences over the preclosure period (annual frequency)		Maximally exposed offsite individual[a]		Population		Noninvolved worker	
Accident scenario	Internal events	Seismic events	Dose (rem)	LCF_i[b]	Dose (person-rem)	LCF_p[b]	Dose (rem)	LCF_i[b]
10. Breach of commercial SNF n unsealed TAD canister in pool	5×10^{-4} (1×10^{-5})	2×10^{-4} (4×10^{-6})	6.2×10^{-5}	3.7×10^{-8}	7.9×10^{-1}	4.7×10^{-4}	4.7×10^{-2}	2.8×10^{-5}
11. Breach of uncanistered commercial SNF assembly in pool (one drops onto another)	3×10^{-1} (6×10^{-3})	not applicable[d]	5.9×10^{-6}	3.5×10^{-9}	7.5×10^{-2}	4.5×10^{-5}	4.5×10^{-3}	2.7×10^{-6}
12. Breach of uncanistered commercial SNF in pool	$< 1 \times 10^{-4}$ ($< 2 \times 10^{-6}$)	not applicable[d]	2.9×10^{-6}	1.7×10^{-9}	3.8×10^{-2}	2.3×10^{-5}	2.2×10^{-3}	1.3×10^{-6}
13. Fire involving LLWF inventory	3×10^{-1} (6×10^{-3})	not applicable[d]	1.7×10^{-5}	1.0×10^{-8}	7.3×10^{-2}	4.4×10^{-5}	1.3×10^{-2}	7.8×10^{-6}
14. Breach of a sealed truck transportation cask due to a fire	2×10^{-2} (4×10^{-4})	not applicable[d]	5.4×10^{-4}	3.2×10^{-7}	3.4×10^{0}	2.0×10^{-3}	7.1×10^{-1}	4.3×10^{-4}

a. For accident scenarios potentially initiated by more than one Category 2 event sequence, the expected occurrence value is the maximum probability of those Category 2 sequences. For accident scenarios potentially initiated by only Beyond Category 2 event sequences, the expected occurrence value is less that the maximum frequency of a Beyond Category 2 event over the preclosure period (i.e. $<1 \times 10^{-4}$)

b. Assumed to be at the analyzed land withdrawal boundary in the east sector, which would produce the highest site boundary dose at a distance of 7.8 kilometers (4.8 miles).

c. LCF_i is the estimated likelihood of a latent cancer fatality for an individual who receives the calculated dose (rem). LCF_p is the estimated number of cancers in the exposed population from the collective population dose (person-rem). These values were computed based on a conversion of dose to LCFs as discussed in Section E.4.1.

d. The seismic event sequence quantification and categorization analysis (DIRS 183261-BSC 2007, all) did not identify any seismic initiators for these scenarios.

DPC = Dual-purpose canister.
HEPA = high-efficiency particulate air (filter).
HLW = High-level radioactive waste.
LCF = Latent cancer fatality.
LLW = Low Level Waste Facility.
SNF = Spent nuclear fuel.
TAD = Transportation, aging, and disposal (canister).

Over the long term (after closure), deep geologic disposal of spent nuclear fuel and high-level radioactive waste would provide optimal security by emplacing the material in a geologic formation that would provide protection from human intrusion, including potential terrorist activities. The use of robust metal waste packages to contain the spent nuclear fuel and high-level radioactive waste more than 200 meters (660 feet) below the surface would offer significant impediments to any attempt to retrieve or otherwise disturb the emplaced materials.

In the short term (before closure), the proposed repository at Yucca Mountain would offer certain unique features from a safeguards perspective: a remote location, restricted access afforded by federal land ownership and proximity to the Nevada Test Site, restricted airspace above the site, and access to a highly effective rapid-response security force.

NRC regulations (10 CFR 63.21 and 10 CFR 73.51) specify a repository performance objective that provides "high assurance that activities involving spent nuclear fuel and high-level radioactive waste do not constitute an unreasonable risk to public health and safety." The regulations require the storage of spent nuclear fuel and high-level radioactive waste in a protected area such that:

- Access to the material would require passage through or penetration of two physical barriers. The outer barrier must have *isolation* zones on each side to facilitate observation and threat assessment, to be continually monitored, and to be protected by an active alarm system.
- Adequate illumination must be provided for observation and threat assessment.
- The area must be monitored by random patrol.
- Access must be controlled by a lock system, and personnel identification must be used to limit access to authorized persons.

NRC regulations would require a trained, equipped, and qualified security force to conduct surveillance, assessment, access control, and communications to ensure adequate response to any security threat. NRC requires liaison with response forces to permit timely response to unauthorized entry or activities. In addition, the NRC requires (10 CFR Part 63, by reference to 10 CFR Part 72) comprehensive receipt, periodic inventory, and disposal records for spent nuclear fuel and high-level radioactive waste in storage. A duplicate set of these records must be kept at a separate location sufficiently remote from the original records that a single event would not destroy both sets of records.

Whether acts of sabotage or terrorism would occur, and the exact nature and location of the events, or the magnitude of the consequences of such acts if they were to occur is inherently uncertain—the possibilities are infinite. Nevertheless, in response to public comments and to evaluate a scenario that would approximate the consequences of a major sabotage event, DOE analyzed a hypothetical scenario in which a large commercial jet aircraft crashed into and penetrated the repository facility with the largest inventory of radioactive material vulnerable to damage from such an event.

The analysis conservatively modeled that the aircraft impact would compromise the confining capability of the building and the resulting fire would convert 42 spent nuclear fuel assemblies to an oxide powder. The results of this analysis indicate that the maximally exposed offsite individual could receive a dose of 3.0 rem resulting in an estimated likelihood of a latent cancer fatality of 0.0018, and the offsite public in the highest population sector (south-southeast), which in 2067 would consist of an estimated 104,000 individuals, could receive a collective dose of 9,900 person-rem for average weather conditions resulting in an estimated 5.9 latent cancer fatalities. Appendix E, Section E.7 contains details of the analysis.

4.1.9 NOISE AND VIBRATION IMPACTS

This section describes potential noise and vibration impacts to workers (occupational noise) and to the public (nuisance noise) from activities under the Proposed Action. The region of influence for noise and vibration impacts includes the Yucca Mountain site and existing and future residences to the south in the town of Amargosa Valley. Section 4.1.9.1 summarizes and incorporates by reference the noise impacts from construction, operations, monitoring, and closure of the repository in Section 4.1.9.2 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 4-70). Section 4.1.9.2 and Section 4.1.9.3 provide new analyses based on the modified design and operational plan. Section 4.1.9.2 discusses noise impacts from construction of the access road from U.S. Highway 95 and the offsite facilities that DOE would build south of the analyzed land withdrawal area. Section 4.1.9.3 discusses impacts from vibration. Section 4.1.4.1.2 discusses noise impacts on wildlife.

4.1.9.1 Noise Impacts from Construction, Operations, Monitoring, and Closure

Sources of noise impacts in the analyzed land withdrawal area during the construction analytical period would include activities at the site development areas that involved heavy equipment (for example, bulldozers, graders, loaders, cranes, and pavers), ventilation fans, and diesel generators. Sources of noise during the operations and monitoring analytical periods would include diesel generators, cooling towers, ventilation fans, air conditioners, and concrete batch plant activities. Ventilation fans would have noise suppressors that would maintain noise levels below 85 *A-weighted decibels* (dBA) at a distance of 3 meters (10 feet). The Occupational Safety and Health Administration standard for the maximum permissible continuous noise level for workers, without the use of controls, is 90 dBA for a duration of 8 hours per day [29 CFR 1910.95(b)(2)]. The regulation, in calculating the permissible exposure level, uses a 5-dB time-over-intensity trading relationship, or exchange rate. For a person to be exposed to noise levels of 95 dBA, the permissible amount of time at this exposure level must be halved to be within the permissible exposure level. Conversely, a person who is exposed to 85 dBA is allowed twice as much time at this level (16 hours). The National Institute for Occupational Safety and Health and the American Conference of Governmental Industrial Hygienists both recommend an exposure limit of 85 dBA for an 8-hour exposure, with a 3-dB exchange rate. Therefore, a worker can be exposed to 85 dBA for 8 hours, but to 88 dBA for only 4 hours or 91 dBA for only 2 hours.

> **DECIBELS**
>
> **A-weighted decibels (dBA):**
> A measurement of sound that approximates the sensitivity of the human ear, which is used to characterize the intensity or loudness of sound.
>
> **Vibration velocity decibels (VdB):**
> Vibration velocity in decibels with respect to 1 microinch per second. A measurement of root-mean-square velocity for the evaluation of ground vibration as an average or smoothed vibration amplitude on a logarithmic scale.

The point on the boundary of the analyzed land withdrawal area nearest to noise sources at the North Portal area would be about 11 kilometers (7 miles) due west. The distance and direction from the South

Portal development area to the nearest point on the boundary would also be about 11 kilometers due west. The point on the boundary closest to a Ventilation Shaft Operations Area would be about 7 kilometers (4 miles) due west.

To establish the propagation distance of repository-generated noise for this analysis, DOE used a maximum sound level of 132 dBA. It is unlikely that construction activities would generate noise at this high level. For comparison, heavy trucks generate sound levels of 70 to 80 dBA at 15 meters (50 feet). However, the analysis determined that this high level of noise would attenuate to the lower limit of human hearing (20 dBA) at a distance of 6 kilometers (3.7 miles). Therefore, noise impacts to the public would be unlikely outside the analyzed land withdrawal area boundary.

Because the distance between repository noise sources and a hypothetical individual at the land withdrawal area boundary would be large enough to reduce the noise to background levels or below, and because there would be no residential or community receptors at the boundary [the nearest housing is in the town of Amargosa Valley about 22 kilometers (14 miles) from the repository site], DOE expects no noise impacts to the public due to activities at Yucca Mountain under the Proposed Action.

Construction noise is transitory in nature. At times, workers at the repository site would be exposed to elevated levels of noise. Small impacts to workers such as speech interference and annoyance would occur. However, DOE would control noise levels and worker exposures such that impacts (such as hearing loss) would be unlikely. Engineering controls would be the primary method of noise control. Workers would use personal hearing protection as necessary to supplement engineering controls.

Noise impacts during the closure period would be similar to those during construction and operations.

4.1.9.2 Noise Impacts from Construction of Offsite Infrastructure

Sources of noise impacts outside the analyzed land withdrawal area would include construction of the access road from U.S. Highway 95 and multiple facilities south of the Yucca Mountain site near Gate 510. Offsite facilities would include the Sample Management Facility, a training facility, a marshalling yard and warehouse, and temporary housing for construction workers. Construction activities would involve typical construction equipment (for example, bulldozers, graders, loaders, and pavers). This type of construction equipment generates noise levels of about 85 dBA at 15 meters (50 feet). Noise and sound levels would be typical of new construction activities and would be intermittent. The nearest permanent residents would be in the town of Amargosa Valley, which is southwest of the intersection of U.S. Highway 95 and Nevada State Route 373. The closest offsite construction activities to the residents would take place at this intersection, where DOE would relocate the current Gate 510 road intersection with U.S. Highway 95 to line up with the intersection of State Route 373 and U.S. Highway 95. Because of the distance between construction activities and receptors and the temporary and intermittent nature of construction noise, DOE does not anticipate noise impacts to the public from construction of the access road or offsite facilities.

Traffic noise on the access road would not exceed or significantly add to the existing traffic noise on U.S. Highway 95. Noise from operation of the offsite facilities would be typical of commercial environments and would not cause impacts.

4.1.9.3 Vibration Impacts from Construction, Operations, Monitoring, and Closure

Construction activity can result in various degrees of ground vibration dependent on the equipment and construction methods. Construction equipment causes vibrations that spread through the ground and diminish in strength with distance. Activities that typically generate the most severe vibrations are blasting and impact pile driving. DOE could use blasting in the excavation of the shafts and the turnouts to the emplacement drifts. Blasting activity results in a typical velocity level of slightly less than 100 vibration velocity in decibels with respect to 1 microinch per second (VdB) at 15 meters (50 feet). Use of bulldozers and other heavy tracked construction equipment results in typical velocity levels around 93 VdB at 15 meters. However, generalized surface vibration curves show that a vibration with a velocity level of 95 VdB at 3 meters (10 feet) drops to a velocity level of 67 VdB at 91.4 meters (300 feet). The approximate threshold for human perception of vibration is 65 VdB (DIRS 177297-Hanson et al. 2006, all). The point on the analyzed land withdrawal boundary closest to blasting activity would be about 7 kilometers (4 miles) due west. Groundborne vibration during the operations, monitoring, and closure analytical periods would be imperceptible at the boundary. Because of the large distances between Proposed Action activities and sensitive structures, there would be no adverse vibration impacts.

4.1.10 AESTHETIC IMPACTS

This section describes potential aesthetic impacts from the Proposed Action. The region of influence for aesthetics includes the approximate boundary of the analyzed land withdrawal area, an area west of the boundary where ventilation stacks could be seen, and the area south of the boundary where DOE would construct the access road from U.S. Highway 95 and several offsite facilities. The analysis considered the natural and manmade physical features that give a particular landscape its character and value as an environmental factor. It gave specific consideration to scenic quality, visual sensitivity, and distance from observation locations. This section provides a new analysis of the aesthetic impacts of the Proposed Action.

4.1.10.1 Approach

Because of the limited visibility of Yucca Mountain from publicly accessible locations, DOE identified two general locations from which the public could see facilities: one to the south of the repository near the intersection of Nevada State Route 373 and U.S. Highway 95, and the other to the west of the repository where repository ventilation exhaust stacks could be visible. There would be no public access to the north or east of the site to enable viewing of the facilities. DOE used the Bureau of Land Management criteria in Table 4-27 to rate the predicted contrast between existing conditions and conditions DOE expects from the Proposed Action at the two locations. To determine potential aesthetic impacts, the analysis considered if the predicted contrast at these locations would be consistent with the Bureau of Land Management visual resource management objectives in Table 4-28. Depending on the visual resource management objective for a particular location, various levels of contrast are acceptable.

4.1.10.2 Aesthetic Impacts from Construction, Operations, Monitoring, and Closure

The low elevation of the southern end of Yucca Mountain and Busted Butte would obscure the view of repository facilities from the south near the intersection of Nevada State Route 373 and U.S. Highway 95 (location 1), approximately 22 kilometers (14 miles) away. Therefore, from this location, the proposed

Table 4-27. Criteria for determining degree of contrast.

Degree of contrast	Criteria
None	The element contrast is not visible or perceived.
Weak	The element contrast can be seen but does not attract attention.
Moderate	The element contrast begins to attract attention and begins to dominate the characteristic landscape.
Strong	The element contrast demands attention, will not be overlooked, and is dominant in the landscape.

Source: DIRS 173053-BLM 1986, Section III.D.2.a.

Table 4-28. Bureau of Land Management visual resource management classes and objectives.

Visual resource class	Objective	Acceptable changes to land
Class I	Preserve the existing character of the landscape	Provides for natural ecological changes but does not preclude limited management activity. Changes to the land must be small and must not attract attention.
Class II	Retain the existing character of the landscape	Management activities can be seen but should not attract the attention of the casual observer. Changes must repeat the basic elements of form, line, color, and texture of the predominant natural features of the characteristic landscape.
Class III	Partially retain the existing character of the landscape	Management activities can attract attention but cannot dominate the view of the casual observer. Changes should repeat the basic elements in the predominant natural features of the characteristic landscape.
Class IV	Provide for management activities that require major modifications of the existing character of the landscape	Management activities can dominate the view and be the major focus of viewer attention. An attempt should be made to minimize the impact of activities through location, minimal disturbance, and repeating the basic elements.

Source: DIRS 101505-BLM 1986, Section V.B.

repository would cause a weak degree of contrast that is consistent with the management of the Class III lands that surround U.S. Highway 95 (Figure 4-8).

During construction of the access road from U.S. Highway 95 and offsite facilities south of the analyzed land withdrawal boundary, construction-related equipment, facilities, and activities would be potential sources of impacts to visual resources. The presence of workers, vehicles, equipment, temporary accommodations for construction workers, and the generation of dust and vehicle exhaust could be visible or could attract the attention of a casual observer at location 1. Considering the effect of best management practices for construction projects, construction activities would be noticeable but would not dominate the attention of a viewer and, therefore, would create a weak degree of contrast at this location.

A weak degree of contrast is compatible with the Bureau of Land Management objectives for all classes of lands and would cause small project-related visual impacts during construction of the access road and offsite facilities.

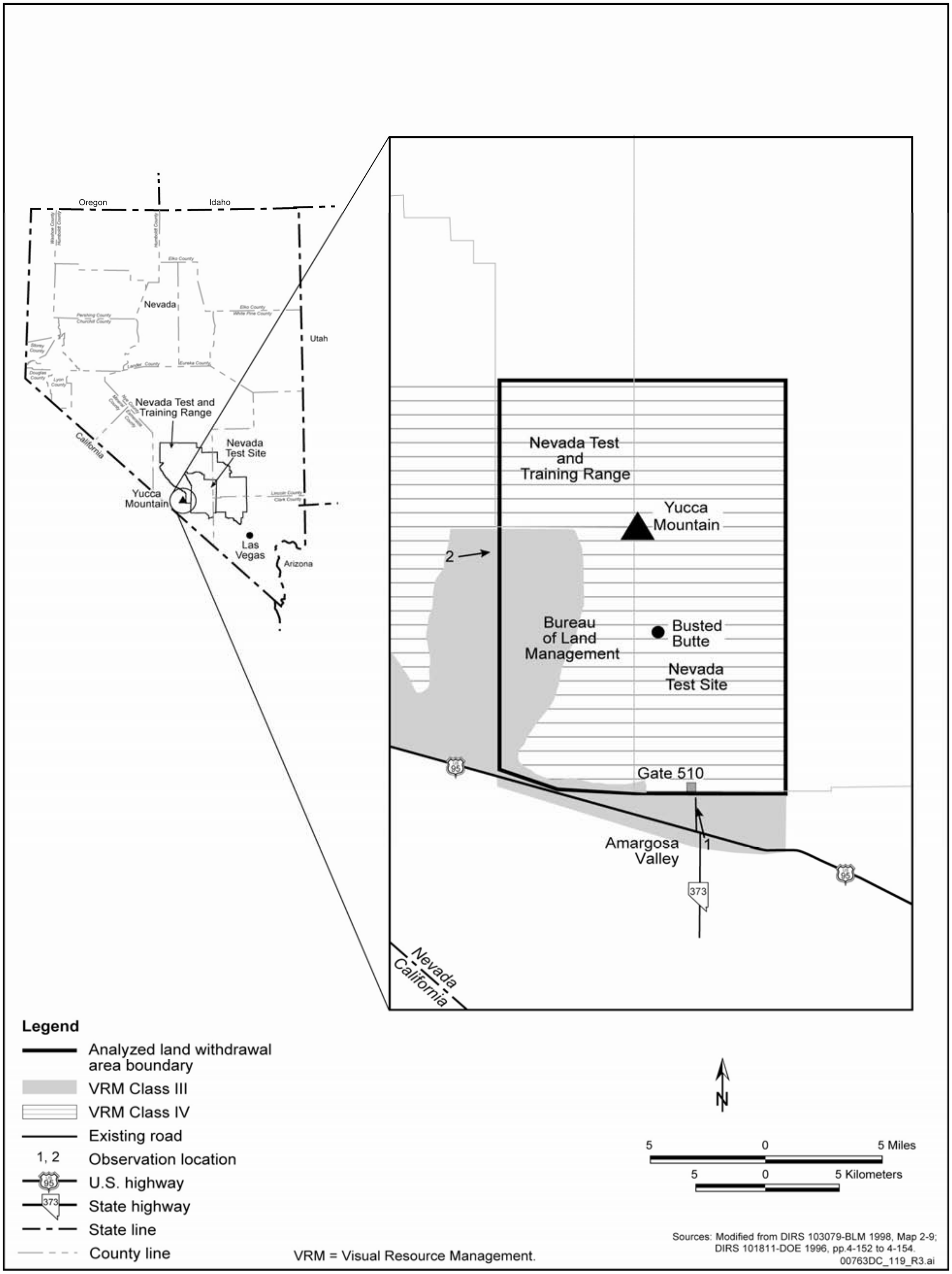


Figure 4-8. Visual resource management classifications in potentially affected areas.

The new access road would intersect U.S. Highway 95 approximately 0.39 kilometer (0.24 mile) to the southeast of the existing access road intersection with U.S. Highway 95 and would line up with the existing intersection of Nevada State Route 373 and U.S. Highway 95. DOE would use simple acceleration and deceleration lanes at the new intersection. Only about 0.049 square kilometer (12 acres) of new land would be necessary for the intersection and approximately 0.097 square kilometer (24 acres) would be necessary for 1.6 kilometers (1 mile) of new road that would be 61 meters (200 feet) wide. The temporary accommodations would occupy about 0.10 square kilometer (25 acres) and would include housing for construction workers; a utility zone for power supply, temporary trash storage, wastewater, and potable water treatment; eating facilities; laundry facilities; and office space. DOE would use gravel fill for roads and parking areas and would install lighting for security and parking. The most visible structures would be the housing facilities. The training facility would require approximately 0.02 square kilometer (5 acres) of land for the facility and associated parking, landscaping, and access. The Sample Management Facility would require approximately 0.012 square kilometer (3 acres). The marshalling yard and warehouse would require some fencing, offices, warehousing, open laydown, and shops on approximately 0.2 square kilometer (50 acres). The access road and offsite facilities would cause a weak degree of contrast against the landscape passing motorists could observe. A weak degree of contrast is consistent with the management of the Class III lands that surround U.S. Highway 95 and would result in small impacts to the visual setting. DOE would remove the temporary accommodations for construction workers and reclaim disturbed areas after they were no longer necessary.

The only structures that could be visible from the west (location 2) and exceed the elevation of the southern ridge of Yucca Mountain would be the ventilation exhaust shafts. The ventilation system would include intake and exhaust stacks, support structures, and access roads near the crest of Yucca Mountain on 0.243 square kilometer (60 acres) of land. The construction of pads and roads to the pads would be on 0.08 square kilometer (20 acres) of undisturbed land. The remaining 0.16 square kilometer (40 acres) is existing disturbed dirt roads that would access these locations. The design includes three intake shafts and six exhaust shafts. The exhaust shafts would contain 15.2- to 18.3-meter (50- to 60-foot) stacks (DIRS 185329-Morton 2007, all). The height of the ventilation intake structures would be lower than the exhaust stacks, and DOE would build these structures at lower elevations. Therefore, the intake stacks would not be as likely as the exhaust stacks to cause aesthetic impacts. The presence of exhaust ventilation stacks on the crest of Yucca Mountain would be seen as an adverse aesthetic impact by American Indians and would cause a moderate degree of contrast. Because of the height of the ventilation stack structures at the top of Yucca Mountain, the U.S. Air Force might require flashing beacon lights at the tops of the stacks. Such beacons could be visible for several miles, especially west of Yucca Mountain, but would not be visible in Death Valley National Park.

DOE would provide lighting for operations areas at the proposed repository and at the offsite facilities. Lighting would be typical for commercial properties except there would be no advertising lighting. Outdoor lighting would be high-intensity-discharge, sodium-vapor lights for roadways, perimeter fencing, and area lighting. Lighting levels would be as low as possible to save operating costs and avoid degradation of the dark character of the night sky, but high enough for security. Repository lighting could be visible outside the analyzed land withdrawal area, especially from the west (location 2) due to the ventilation structures at the top of Yucca Mountain. Repository lighting would be unlikely to affect users of Death Valley National Park. Because the towns of Amargosa Valley, Beatty, and Pahrump lie between the park and the repository, they probably would cause greater impact to the nightly viewshed than operations lighting at the repository. Lighting at the offsite facilities would be visible from location 1 near the intersection of Nevada State Route 373 and U.S. Highway 95. The use of shielded or directional lighting as a best management practice would minimize the amount of light that could be visible from outside the lighted areas and mitigate light pollution and the degradation of the dark character of the night sky. Overall, impacts from lighting would be small.

Closure activities, such as dismantling of facilities and site reclamation, would reduce the project-related contrast. Adverse impacts to visual quality from closure activities would be unlikely.

4.1.11 IMPACTS TO UTILITIES, ENERGY, MATERIALS, AND SITE SERVICES

This section updates the potential impacts to residential water and sewer, energy, materials, and site services from construction, operations, monitoring, and closure activities at the proposed repository. DOE based its reanalysis of impacts to utilities, energy, materials, and site services for this Repository SEIS on the modified design that Chapter 2 describes. The scope of the analysis included the use of electric power; fossil fuels, oil, and lubricants; construction materials; and onsite services such as emergency medical support, fire protection, and security and law enforcement. The analysis compared repository needs to available regional capacity and to anticipated regional demands. It used engineering estimates of requirements for construction materials, utilities, and energy. Construction activities would occur during the construction and operations analytical periods. The region of influence includes the local, regional, and national infrastructure that would supply the needs.

Section 4.1.14 discusses impacts in relation to TAD canister, waste package, and drip shield fabrication. Overall, DOE expects only small impacts from demand on residential water and sewer, energy, materials, and site services from the Proposed Action.

4.1.11.1 Residential Water

The repository facilities would not use water utilities from outside the analyzed land withdrawal area. DOE would use permitted wells to supply water for repository activities. DOE could build facilities (including the Sample Management Facility, training facility, marshalling yard, and warehouse) outside the land withdrawal area and would evaluate the most appropriate water sources once the locations and designs were final.

Population growth that resulted from the Proposed Action could affect regional water resources. The Proposed Action would result in an estimated maximum population increase in Clark County of approximately 1,300 persons in 2034 and an estimated maximum population increase in Nye County of approximately 1,000 persons in 2039. Other counties would be unlikely to have measurable population increases as a result of the Proposed Action. (Section 4.1.6 describes the estimated maximum population increases in Clark and Nye counties in greater detail.) Whether predominantly surface-water sources, as is the case for most of Clark County, or groundwater sources, as for most of Nye County, satisfied domestic water needs, these relatively small increases in population would have small impacts on existing water demands.

The maximum project-related population increase for Clark County would be less than 0.07 percent of the baseline 2005 population of 1.8 million (Chapter 3, Section 3.1.7.1, Table 3-10) and less than 0.04 percent of the county's estimated population in 2034, the year of the maximum population impact from the Proposed Action. The associated increase in water demand in the county as a result of the project would be correspondingly small.

The maximum project-related population increase for Nye County would be less than 3 percent of the baseline 2005 population of 41,000 (Chapter 3, Section 3.1.7.1, Table 3-10) and about 1.2 percent of the county's estimated population in 2039, the year of the maximum population impact from the Proposed Action. For Nye County, estimates of domestic water demand from public water supplies are about 1.32 cubic meters (350 gallons) per day per person (DIRS 173226-Buqo 2004, p. 48). At this rate, the project-related increase in Nye County population would result in an additional water demand of about 500,000 cubic meters (410 acre-feet) of water during the maximum year (2039). This represents about 0.4 percent of the total water use of 120 million cubic meters (101,000 acre-feet) in Nye County in 2000. If 100 percent of the project-related growth in Nye County occurred in Pahrump (the upper bound condition), this would equate to adding about 500,000 cubic meters to Pahrump's annual water demand. This represents about 1.8 percent of the 2000 Pahrump Valley total water use of 28 million cubic meters (23,000 acre-feet). By 2039, when project-related population growth would peak, Pahrump Valley's water demand will have increased above its 2000 level due to growth unrelated to the Proposed Action. The project-related increase in water demand of 500,000 cubic meters would be an even smaller percentage of the total Nye County and Pahrump water usage in 2039 than in 2000.

4.1.11.2 Residential Sewer

The repository facilities would not use sewer utilities from outside the analyzed land withdrawal area. DOE would use septic tanks and leach fields for the sanitary waste system.

Population growth due to the Proposed Action could affect sewer utilities. In Clark County, the maximum project-related population increase would be less than 0.07 percent of the 2005 baseline population. Impacts to the populous areas of the county such as the Las Vegas Valley would be small.

In Nye County, the maximum project-related population increase (in 2039) would be less than 3 percent of the 2005 baseline population. Growth in Nye County from the Proposed Action would likely be primarily in the Pahrump area. Pahrump has no community-wide wastewater treatment system. Individual septic tank and drainage field systems would provide the primary wastewater treatment capacities.

4.1.11.3 Electric Power

During the construction analytical period, the demand for electricity would increase as DOE operated tunnel boring machines and other electrical equipment. The estimated peak demand for electric power during the construction period would be about 32 megawatts. Table 4-29 lists projected electric energy use during the different analytical periods.

The current electric power supply line has a peak capacity of only 10 megawatts. Upgrades to the site electrical system would be part of the Proposed Action.

During the operations analytical period, the development of emplacement drifts would continue in parallel with emplacement activities. During this period, the peak electric power demand would be about 110 megawatts. Construction activities during the period would account for 30 percent of the peak load

Table 4-29. Electricity and fossil-fuel use for the Proposed Action.

Analytical period	Use (years)	
Construction	5	
Operations	Up to 50	
Monitoring	50	
Closure (overlaps last 10 years of Monitoring)	10	
Total	Up to 105	
Peak electric power	(megawatts)	
Construction[a]	32	
Operations[a]	110	
Monitoring[b]	7.7	
Closure[b]	10	
Maximum	110	
Electricity use: annual maximum	(1,000 megawatt-hours)	
Construction	280	
Operations	940	
Monitoring[c]	63	
Closure[c]	72	
Maximum	940	
Fossil fuel	(million liters)	(million gallons)
Construction[d,e]	19	5.0
Operations[d,e]	690	180
Monitoring[e]	53	14
Closure[b]	5.2	1.4
Totals	770	200
Oils and lubricants[b]	(million liters)	(million gallons)
Construction	2.6	0.69
Operations	8.5	2.2
Monitoring	9	2.4
Closure	2	0.53
Totals	22	5.8

Note: Numbers are rounded to two significant figures; therefore, totals might differ from sums.
a. Source: DIRS 185429-BSC 2008, Table 5.
b. Source: DIRS 155970-DOE 2002, p. 4-73.
c. Calculated based on average usage per year as stated in the Yucca Mountain FEIS (DIRS 155970-DOE 2002, p. 4-73).
d. Source: DIRS 182211-Morton 2007, p. 2.
e. Source: DIRS 182210-Morton 2007, all.

and operation of the repository would account for the remaining load of about 75 megawatts. The maximum annual electric power use would be about 940,000 megawatt-hours.

After the completion of construction activities, the peak demand for electric power would drop to about 75 megawatts. The peak demand would continue to decrease after the operations analytical period. The peak demand during the monitoring analytical period would be much less than the 75-megawatt demand during operations. The closure analytical period would last for 10 years, during which the peak electric power demand would be much less than that during operations.

For 2021, during the operations analytical period, Nevada Power Company projects a peak demand of 8,763 megawatts (including planning reserve requirement) (DIRS 185100-Gecol 2007, p.33). The maximum 110-megawatt demand the repository would require would be about 1.2 percent of the projected peak demand in 2021. Although Nevada Power Company has demonstrated the ability to meet customer demand in a high-growth environment through effective planning, it has stated that a projected shortfall between demand and available resources could occur after 2011 and forecasts that additional resources will be necessary. It expects system demand to grow by more than 37 percent from 2007 to 2021 [from 23 million to more than 31 million megawatt-hours (DIRS 185100-Gecol 2007, p. 33)]. DOE did not attempt to identify the specific resources that could be required to meet the projected regional demand. Rather, DOE compared the estimated repository electricity use with the projected electricity requirements of the region to determine the impact the additional repository use would have on regional demands. The repository requirements would be a small percentage of Nevada Power Company's projected electricity demands. The estimated maximum annual power use of 940,000 megawatt-hours for the repository would be about 3 percent of the projected 2021 regional energy requirements.

4.1.11.4 Fossil Fuels and other Petroleum Products

Fossil-fuel use during the construction analytical period would include diesel fuel and gasoline. DOE would use diesel fuel primarily to operate surface construction equipment and equipment to maintain the excavated rock storage pile. Site trucks and automobiles would be the primary users of gasoline. During construction, the estimated maximum annual use of diesel fuel and gasoline would be about 5.5 million and 180,000 liters (1.5 million and 47,000 gallons), respectively. Total fossil-fuel use during the construction period would be about 19 million liters (5.0 million gallons). The supply capacity of diesel fuel is about 1.8 billion liters (480 million gallons) per year for the State of Nevada (DIRS 176397-EIA 2005, Table 4). This value is based on distillate fuel sales from 2004. The supply capacity of gasoline is about 4.1 billion liters (1.1 billion gallons) per year for the state (DIRS 182203-EIA 2006, all). This value is based on gasoline consumption in 2004. About half of the State of Nevada fossil-fuel consumption is in the three-county region of Clark, Lincoln, and Nye counties, with the highest consumption in Clark County (DIRS 155970-DOE 2002, p. 4-76). Table 4-29 lists fossil-fuel and oil and lubricant use during the different analytical periods.

During the construction analytical period, maximum yearly repository consumption of diesel fuel would be about 0.3 percent of the 2004 statewide consumption. Maximum yearly repository consumption of gasoline would be less that 0.005 percent of the 2004 statewide consumption.

DOE would use fossil fuels during the operations analytical period for construction activities, emplacement activities, onsite vehicles, boilers, and electrical generators. Maximum annual diesel fuel use would be about 20 million liters (5.3 million gallons) and maximum annual gasoline use would be about 850,000 liters (220,000 gallons). Total fossil-fuel usage during the operations period would be about 690 million liters (180 million gallons). The maximum annual use of diesel fuel and gasoline would be about 1.1 percent and 0.021 percent, respectively, of the 2004 capacities. The annual use would be highest during full repository operations and would decrease substantially during the monitoring analytical period.

During the closure analytical period, annual fossil-fuel use would be about 27 percent of that for the construction analytical period. During all periods, the projected use of diesel fuel and gasoline would be within the regional supply capacity and would cause little impact.

DOE would use hydraulic oils and lubricants and non-fuel hydrocarbons to support operation of equipment during all periods of the project. Consistent with the analysis in the Yucca Mountain FEIS (DIRS 155970-DOE 2002, p. 4-77), the quantities of these materials used would be about 22 million liters (5.3 million gallons). DOE would recycle and reuse these materials.

4.1.11.5 Construction Material

The primary materials for construction of the repository would be concrete, steel, and copper. DOE would use concrete—which consists primarily of cement, fine and coarse aggregate, and water—for liners in the main tunnels and ventilation shafts in the subsurface and for construction of surface facilities. The Department would use aggregate available in the region for the concrete and would purchase cement regionally. Table 4-30 lists the amounts of concrete and cement. During the construction analytical period, the estimated use of concrete would be about 320,000 cubic meters (420,000 cubic yards). The amount of cement required would be about 130,000 metric tons (about 140,000 tons).

Table 4-30. Construction material use for the Proposed Action.

Analytical period	Use (years)	
Construction	5	
Operations	up to 50	
Monitoring	50	
Closure (overlaps last 10 years of Monitoring)	10	
Total	up to 105	
Concrete	(1,000 cubic meters)	(1,000 cubic yards)
Construction[a]	320	420
Operations[a]	170	220
Monitoring[b]	0	0
Closure[b]	3	3.9
Totals	490	640
Cement	(1,000 metric tons)	(1,000 tons)
Construction[a]	130	140
Operations[a]	65	72
Monitoring[b]	0	0
Closure[b]	1.2	1.3
Totals	190	210
Carbon steel[c]	280 (1,000 metric tons)	310 (1,000 tons)
Copper[c]	0.67(1,000 metric tons)	0.74 (1,000 tons)

Notes: Section 4.1.14 discusses titanium requirements from the manufacture of drip shields. Numbers are rounded to two significant figures; therefore, totals might differ from sums.

a. Source: DIRS 182713-Morton 2007, all.

b. Source: DIRS 155970-DOE 2002, p. 4-74.

c. Source: DIRS 182197-Morton 2007, all.

The average yearly concrete demand for the construction analytical period would be about 65,000 cubic meters (about 85,000 cubic yards). Annual production of concrete in Nevada equals approximately 6.7 million cubic meters (8.8 million cubic yards) per year (DIRS 173400-NRMCA 2004, p. 2). The annual quantity of concrete required during the construction period represents less than 1 percent of concrete use in Nevada in 2004. Cement would be purchased through regional markets and shipped to the site. Regional suppliers of cement have demonstrated the ability to keep pace with the annual production of concrete in Nevada. DOE expects little or no impact from increased demand for concrete and cement in the region.

For the Proposed Action, DOE would need as much as 280,000 metric tons (310,000 tons) of carbon steel for uses that would include rebar, piping, and track and about 670 metric tons (740 tons) of copper for uses that would include electrical cables. DOE did not categorize the requirements for carbon steel and copper by analytical period in Table 4-30 because total use would be very small in relation to annual domestic production. The total use of carbon steel at the repository would be less than 0.3 percent of the annual domestic production capability of about 100 million metric tons (about 110 million tons). The total use of copper at the repository would be less than 0.07 percent of the annual domestic mine production. Although worldwide demand for steel is increasing due to economic growth overseas (primarily in China), the markets for steel and copper are worldwide in scope. DOE anticipates little or no impact from increased demand for steel and copper in the region.

4.1.11.6 Site Services

DOE would rely on the existing support infrastructure during an emergency at the proposed repository (Chapter 3, Section 3.1.11.3) until it completed new onsite facilities during the construction analytical period. Once completed, the new facilities would provide onsite services.

The primary onsite response would occur through the multifunctional Fire, Rescue, and Medical Facility, which would provide space for fire protection and firefighting services, underground rescue services, emergency and occupational medical services, and radiation protection. The facility would have the capability to provide complete response to most onsite emergencies. A helicopter pad would enable emergency medical evacuation. DOE would coordinate the operation of this facility with facilities in Nye County and at the Nevada Test Site to increase response capability, if necessary. Nye County developed the *Nye County Public Safety Report* to recommend that Nye County and DOE integrate public safety services for the repository site and the area just beyond the repository boundary to mitigate potential repository impacts to public safety services. The report is summarized and incorporated by reference (DIRS 182710-NWRPO 2007, all).

As stated in the Yucca Mountain FEIS, a site security and safeguards system would include surveillance and safeguards functions to protect the repository from unauthorized intrusion and sabotage (DIRS 155970-DOE 2002, p. 4-78). The system would include site security barriers, gates, and badging and automated surveillance systems operated by trained security officers. Support would be available from the Nevada Test Site security force and the Nye County Sheriff’s Department, if necessary.

The emergency response system would provide responses to accident conditions at or near the repository site. The system would maintain emergency and rescue equipment, communications, facilities, and trained professionals to respond to fire, radiological, mining, industrial, and general accidents above or below ground.

The planned onsite emergency facilities would be able to respond to and mitigate most onsite incidents, which would include underground incidents, without outside support. Therefore, there would be no meaningful impacts to the emergency facilities of surrounding communities or counties.

4.1.12 MANAGEMENT OF REPOSITORY-GENERATED WASTE AND HAZARDOUS MATERIALS

This section describes the management of waste that DOE could generate as a result of construction, operations, monitoring, and closure activities. The region of influence for waste and hazardous materials consists of on- and offsite areas that include landfills and hazardous and radioactive waste processing and disposal sites, in which DOE would dispose of waste it generated under the Proposed Action. The evaluation of waste management impacts used available information to consider the potential for the generation of particular waste types and estimates of the quantities that these activities could generate. The types of waste the Proposed Action would generate would include sanitary and *industrial waste*, *industrial wastewater*, low-level radioactive waste, sanitary sewage, and hazardous waste. DOE based the estimates for the amount of generated waste in this section on construction and operating experience, engineering data, material use estimates, and number of workers. The Department did not generate estimated quantities for mixed and *transuranic waste* because it anticipates that routine operations would not produce these waste types. However, this section does discuss the management of such waste, if generated.

DOE determined that modifications in the repository design and operational plans would require a new analysis of repository-generated waste. Therefore, DOE has revised the construction and demolition debris, sanitary sewage, and low-level radioactive waste estimates since completion of the Yucca Mountain FEIS to reflect the modified design and operational plan changes. These changes have resulted in the proposed construction of more but smaller facilities and slight changes in the estimated number of workers for the project. DOE has also revised the low-level radioactive waste estimates to reflect the implementation of the use of TAD canisters. The Department extrapolated revised waste estimates from a variety of sources, including the FEIS, to calculate total waste over the duration of the project. The industrial wastewater and sanitary and industrial waste estimates have not changed because the operational aspects DOE used to generate these estimates for the FEIS are essentially the same. Therefore, the estimates for these waste types are incorporated by reference from the Yucca Mountain FEIS.

This section analyzes impacts from the disposal of repository-generated waste against current disposal waste capacities for offsite and regional waste facilities.

4.1.12.1 Waste and Hazardous Materials Impacts from Construction, Operations, Monitoring, and Closure

Table 4-31 lists the waste and hazardous materials that DOE could generate during the construction, operations, monitoring, and closure analytical periods. The estimates reflect the repository design and operations aspects that are in the application DOE has submitted to NRC. The construction and demolition debris estimates include the dismantling of the temporary structures at the North Portal and the existing Sample Management Facility at the Field Operations Center.

DOE would use one or more of the following to manage construction and demolition debris: disposal at existing landfills at the Nevada Test Site, nearby municipal landfills, or a State-permitted landfill on the Yucca Mountain site. In addition to the landfills at the Nevada Test Site, there are 20 operating municipal solid waste landfills, which include four industrial landfills, in Nevada (DIRS 184969-NDEP 2007, Appendix 3).

Table 4-31. Total waste quantities expected to be generated.

Waste type	Total amount
Construction and demolition debris[a]	476,000 cubic meters (620,000 cubic yards)
Industrial wastewater[b]	1.2 million cubic meters (320 million gallons)
Sanitary sewage	2.0 million cubic meters (530 million gallons)
Sanitary and industrial waste[b,c]	100,000 cubic meters (130,000 cubic yards)
Hazardous waste[b]	8,900 cubic meters (12,000 cubic yards)
Low-level radioactive waste[d]	74,000 cubic meters (97,000 cubic yards)

a. Estimate based on materials used.
b. Value remains unchanged from the Yucca Mountain FEIS.
c. Does not include construction and demolition debris.
d. Estimate includes liquid low-level waste and emptied dual-purpose canisters managed as low-level waste.

DOE would use four onsite evaporation ponds or a wastewater treatment facility to manage industrial wastewater. Industrial wastewater from surface facilities would flow to an evaporation pond in the vicinity of the surface geologic repository operations area; wastewater from the subsurface would flow to evaporation ponds at the South Portal development area and the North Construction Portal; and wastewater from oil-water separators and superchlorinated water from maintenance of the drinking water system would flow to evaporation ponds at the central operations area. The evaporation ponds would be lined; DOE would test, treat, and dispose of residual sludge as appropriate, depending on the results of the testing. Section 4.1.3 discusses the evaporation ponds. A wastewater treatment facility is not an element of the modified design; if DOE did incorporate this facility, it could use it to treat specifically identified industrial wastewater streams and sanitary sewage. The discharges would be permitted; DOE would test, treat, and dispose of the associated sludge as appropriate, depending on the results of the testing. Appendix A discusses the benefits and potential environmental impacts of a wastewater treatment facility.

DOE would use septic systems or possibly a wastewater treatment facility to manage sanitary sewage. DOE would test, treat, and dispose of sludge from the septic systems as appropriate, depending on the results of the testing. DOE would manage sanitary and industrial waste in the same manner it would manage construction and demolition debris.

DOE would manage hazardous waste by shipment off the site for treatment and disposal. Hazardous waste would be primarily from laboratories, health clinics, and vehicle maintenance shops; examples include solvents, fuels, paints, corrosives, and cleansers. DOE would treat, store, and dispose of waste from these substances appropriately in accordance with federal and state regulations. The Department would not dispose of hazardous waste on the site. It would contract with permitted hazardous wastes transporters to ensure the safe transport of all hazardous wastes from its facilities to a permitted offsite hazardous waste facility for treatment or disposal. The transportation of hazardous materials would be in accordance with federal and state regulations. The U.S. Department of Transportation Office of Hazardous Materials Safety prescribes the regulations for the safe transportation of hazardous materials (40 CFR Part 49).

DOE would control and dispose of site-generated low-level radioactive waste in a DOE low-level waste disposal site, a site in an *Agreement State*, or an NRC-licensed site, subject to the completion of the appropriate review pursuant to the *National Environmental Policy Act* (NEPA). Disposal in an Agreement State site or in an NRC-licensed site would be consistent with applicable portions of 10 CFR Part 20. Low-level radioactive waste would be in the form of solids and liquids from operations such as

WASTE TYPES

Industrial waste:
Solid waste that is neither hazardous nor radioactive such as construction and demolition debris, rubber, and miscellaneous plastic products. Examples of construction and demolition debris include soil, rock, masonry materials, and lumber.

Industrial wastewater:
Liquid wastes from industrial processes that do not include sanitary sewage. Repository industrial wastewater would include water for dust suppression, rinse water from concrete production and transport, and process water from building heating, ventilation, and air conditioning systems.

Sanitary sewage:
Domestic wastewater from sinks, showers, kitchens, floor drains, restrooms, change rooms, and food preparation and storage areas.

Sanitary waste:
Solid waste that is neither hazardous nor radioactive. Sanitary waste streams include paper, glass, and discarded office material. (State of Nevada waste regulations define this waste stream as household waste.)

Hazardous waste:
Waste designated as hazardous by U.S. Environmental Protection Agency or State of Nevada regulations. Hazardous waste, defined under the *Resource Conservation and Recovery Act*, is waste that poses a potential hazard to human health or the environment when improperly treated, stored, or disposed of. Hazardous wastes appear on special EPA lists or possess at least one of the following characteristics: ignitability, corrosivity, toxicity, or reactivity. Hazardous waste streams from the repository could include certain used rags and wipes contaminated with solvents.

Low-level radioactive waste:
Radioactive waste that is not classified as high-level radioactive waste, transuranic waste, byproduct material containing uranium or thorium from processed ore, or naturally occurring radioactive material. The repository low-level radioactive waste would include personal protective clothing, air filters, solids from the liquid low-level waste treatment process, adiological control and survey waste, and used canisters (dual-purpose).

Transuranic waste:
Waste materials (excluding high-level radioactive waste and certain other waste types) contaminated with alpha-emitting radionuclides that are heavier than uranium with half-lives greater than 20 years and that occur in concentrations greater than 100 nanocuries per gram. Transuranic waste results primarily from treatment and fabrication of plutonium and from research activities at DOE defense installations.

cask, facility, and equipment decontamination with wipes and chemicals; pool system skimming and filtration operations; used dual-purpose canisters; tooling and clothing; facility heating, ventilation, and air conditioning filtration; chemical sumps; and carrier and transporter washing (DIRS 179303-BSC 2006, pp. 5 to 27). Activities during the operations, monitoring, and closure analytical periods would generate about 74,000 cubic meters (97,000 cubic yards) of low-level waste. Dual-purpose canisters would make up about 9,800 cubic meters (13,000 cubic yards) of low-level waste.

DOE would either process liquid low-level radioactive waste to remove contamination until it met release limits for discharge to an evaporation pond or process the waste until it met applicable requirements for shipping it offsite for treatment or disposal (DIRS 179303-BSC 2006, p. 26). This analysis assumed the Department would process liquid low-level radioactive waste for offsite shipment in order to generate a conservatively high quantity of waste for offsite disposal. The estimated quantity of liquid low-level waste is included in the 74,000-cubic-meter (97,000-cubic-yard) total. DOE does not anticipate the generation of mixed or transuranic waste during routine operations, but if unusual activities generated such waste it, would be minimal (DIRS 182319-Morton 2007, all), and DOE would dispose of it at an offsite permitted facility.

4.1.12.2 Overall Impacts to Waste Management

Impacts from construction and demolition debris and sanitary and industrial wastes would be small because of the number and capacity of offsite solid waste landfills. DOE could build onsite solid waste facilities to accommodate the nonhazardous waste that repository activities generated. In addition, the Department would implement best management practices to reduce waste generation and to avoid or minimize the amount of waste disposed of at the Nevada Test Site or regional solid waste facilities. Because DOE would minimize waste as much as possible, the additional waste disposed of at the Nevada Test Site or regional facilities would be small, and these facilities have enough capacity to accommodate such waste.

The regional capacity for treatment and disposal of hazardous waste is greater than the quantity that DOE would generate. The estimated disposal capacity for hazardous wastes in western states is about 50 times the demand for landfills and 7 times the demand for incineration until at least 2013 (DIRS 103245-EPA 1996, pp. 32, 33, 36, 46, 47, and 50). Based on this information, impacts to regional hazardous waste facilities from waste generated from repository activities would be small.

Impacts to licensed disposal facilities from low-level radioactive waste would be small because the amount of such waste would be small. Repository-related activities would generate approximately 638 cubic meters (834 cubic yards) of low-level waste annually over the life of the project. For comparison, this accounts for only about 0.5 percent of the low-level waste disposed of in 2005 at commercial low-level waste facilities nationwide (DIRS 182320-NRC 2007, all).

4.1.13 ENVIRONMENTAL JUSTICE

This section describes the DOE analysis of *environmental justice* (the potential for impacts to be disproportionately high and adverse to minority or *low-income populations*). The region of influence for environmental justice varies with resource area and corresponds to the region of influence for each resource area. Since completion of the Yucca Mountain FEIS, the NRC has issued *Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions* (69 FR 52040–52048, August 24, 2004). For this Repository SEIS, DOE has chosen to follow the NRC guidance. In addition, the analysis used 2000 Census data available since the Yucca Mountain FEIS to identify low-income population blocks.

4.1.13.1 Impact Assessment Methodology

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, and the associated implementing guidance establish the framework for identification of impacts to low-income and *minority populations*. The Executive Order directs federal agencies to identify and consider disproportionately high and adverse human health, social, economic, or environmental effects of their actions on minority and low-income communities and American Indian tribes and provide opportunities for community input to the process, which includes input on potential effects and mitigation measures.

DOE performs environmental justice analyses to identify if any high and adverse impacts would fall disproportionately on minority or low-income populations in accordance with guidance from the Council on Environmental Quality. The potential for environmental justice concerns exists if the following occur (DIRS 177702-CEQ 1997, pp. 26 and 27):

> "Disproportionately high and adverse human health effects: When determining whether human health effects are disproportionately high and adverse, agencies are to consider the following three factors to the extent practicable:
>
> a) Whether the health effects, which may be measured in risks and rates, are significant (as employed by NEPA [42 U.S.C. 4321 et seq.]), or above generally accepted norms. Adverse health effects may include bodily impairment, infirmity, illness, or death; and
>
> b) Whether the risk or rate of hazard exposure by a minority population, low-income population, or Indian tribe to an environmental hazard is significant (as employed by NEPA) and appreciably exceeds or is likely to appreciably exceed the risk or rate to the general population or other appropriate comparison group; and
>
> c) Whether health effects occur in a minority population, low-income population, or Indian tribe affected by cumulative or multiple adverse exposures from environmental hazards
>
> Disproportionately high and adverse environmental effects: When determining whether environmental effects are disproportionately high and adverse agencies are to consider the following three factors to the extent practicable:
>
> a) Whether there is or will be an impact on the natural or physical environment that significantly (as employed by NEPA) and adversely affects a minority population, low-income population, or Indian tribe. Such effects may include ecological, cultural, human health, economic, or social impacts on minority communities, low-income communities, or Indian tribes when those impacts are interrelated to impacts on the natural or physical environment; and
>
> b) Whether environmental effects are significant (as employed by NEPA) and are or may be having an adverse impact on minority population, low-income populations, or Indian tribes that appreciably exceeds or is likely to appreciably exceed those on the general population or other appropriate comparison group; and
>
> c) Whether the environmental effects occur or would occur in a minority population, low-income population, or Indian tribe affected by cumulative or multiple adverse exposures from environmental hazards."

The DOE analysis of environmental justice for this Repository SEIS considered the results of analyses of potential impacts to the different resource areas that focused on consequences to resources that could affect human health or the environment for the general population. In addition, the Department determined if unique exposure *pathways*, sensitivities, or cultural practices would result in different impacts on minority or low-income populations. If either assessment identified impacts, the environmental justice analysis compared the impacts on minority and low-income populations to those on the general population. In other words, if significant impacts on a minority or low-income population would not appreciably exceed the same type of impacts on the general population, disproportionately high and adverse impacts would be unlikely.

The Repository SEIS definition of a minority population is in accordance with the Bureau of the Census racial and ethnic categories. The "Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions" (69 FR 52040–52048; August 24, 2004) states:

> "…a minority or low-income community is identified by comparing the percentage of the minority or low-income population in the impacted area to the percentage of the minority or low-income population in the County (or Parish) and the State. If the percentage in the impacted area significantly exceeds that of the State or the County percentage for either the minority or low-income population then [environmental justice] will be considered in greater detail. "Significantly" is defined by staff guidance to be 20 percentage points. Alternatively, if either the minority or low-income population percentage in the impacted area exceeds 50 percent [environmental justice] matters are considered in greater detail."

Clark and Nye counties had a low-income population of 11 percent in the 2000 Census, as did the State of Nevada. Inyo County had a low-income population of 14 percent. Twenty census block groups are within the 84-kilometer (52-mile)-radius around Yucca Mountain. No census block group exceeded the 20 percentage-point poverty level and, therefore, no low-income population significantly exceeds that of the state or county. Analysis of block data demonstrated several blocks where the minority population equaled or exceeded 50 percent in all three counties (Chapter 3, Figure 3-19).

Regions of influence, and therefore potentially affected areas, vary with each resource area. If there would be no significant impacts in a resource area's region of influence, or if identified significant impacts would not fall disproportionately on low-income or minority populations, there would be no environmental justice impacts. DOE has identified land use, air quality, cultural resources, socioeconomics, and public health and safety as resources that could be of particular interest to minority or low-income populations. The following sections summarize the impacts to those resource areas.

4.1.13.2 Construction, Operations, Monitoring, and Closure

4.1.13.2.1 *Land Use*

Direct land use impacts from the Proposed Action would be small due to the existing and future restriction of site access for most affected areas (Section 4.1.1). There are no communities with high percentages of minority populations in the region of influence for land use.

4.1.13.2.2 *Air Quality*

Impacts to air quality from the Proposed Action would be small (Section 4.1.2). Further, DOE would use best management practices for all activities, particularly ground-disturbing activities that could generate fugitive dust.

4.1.13.2.3 *Cultural Resources*

DOE has implemented a worker education program on the protection of archaeological sites and artifacts to limit direct and indirect impacts to them. The Department would work collaboratively with the Consolidated Group of Tribes and Organizations to involve tribal representatives in the worker education program. Before construction began, DOE would avoid archaeological resources or mitigate its actions, so any direct adverse impacts from construction and operation of the facilities would be small. DOE would include American Indian monitors in all surveys to identify cultural sites in the affected areas. In addition, the Department would conduct such activities in a manner that would preclude improper disclosure of, or adverse impacts to, sensitive cultural sites or resources covered by applicable laws and regulations (Section 4.1.5).

4.1.13.2.4 *Socioeconomics*

Socioeconomic impacts from repository construction and operation would be small. Regional employment would increase an estimated 0.1 percent above baseline levels. Changes to the baseline regional population would be no greater than 0.06 percent. Potential impacts to the Gross Regional Product, real disposable personal income, and expenditures by state and local governments would be small. While several communities have minority populations greater than 50 percent, there would be no disproportionately high socioeconomic impacts on those communities (Section 4.1.6).

4.1.13.2.5 *Public Health and Safety*

The analysis determined that impacts that could occur to public health and safety would be small throughout the Proposed Action (Section 4.1.7). There would be no nonradiological adverse health effects for the public within the 84-kilometer (52-mile) radius around the repository. The elapsed time between initiation of repository construction and closure would be 105 years. No subsection of the population, including minority populations, would receive disproportionate impacts.

4.1.13.3 Environmental Justice Impact Analysis Results

As in the Yucca Mountain FEIS, this Repository SEIS analysis used information from Sections 4.1.1 to 4.1.12. DOE has not identified any high and adverse potential impacts to members of the general public. Further, DOE has not identified subsections of the population, including minority or low-income populations, that would receive disproportionate impacts, and it has identified no unique exposure pathways, sensitivities, or cultural practices that would expose minority or low-income populations to disproportionately high and adverse impacts. Therefore, this SEIS concludes that no disproportionately high and adverse impacts would result from the Proposed Action.

4.1.13.4 An American Indian Perspective

In 1987, DOE initiated the Native American Interaction Program to solicit input from tribes and organizations on the characterization of the Yucca Mountain site and the possible construction and operation of a repository for spent nuclear fuel and high-level radioactive waste. These tribes and organizations—Southern Paiute; Western Shoshone; and Owens Valley Paiute and Shoshone people from Arizona, California, Nevada, and Utah—have declared traditional ties to the Yucca Mountain area. The Native American Interaction Program is part of DOE's implementation of the Council on Environmental Quality's *Environmental Justice Guidance Under the National Environmental Policy Act* that "agencies should recognize the interrelated cultural, social, occupational, historical, or economic factors that may amplify the natural and physical environmental effects of the proposed agency action" (DIRS 177702-CEQ 1997, all).

In the Yucca Mountain FEIS, DOE acknowledged that people from American Indian tribes have used the proposed repository area as well as nearby lands, and that lands around the site contain cultural, animal, and plant resources important to those tribes. The tribes presented their views in *American Indian Perspectives on the Yucca Mountain Site Characterization Project and the Repository Environmental Impact Statement*, which states (DIRS 102043-AIWS 1998, p.2-9):

> "…we have the responsibility to protect with care and teach the young the relationship of the existence of a nondestructive life on Mother Earth. This belief is the foundation for our holistic view of the cultural resources, i.e., water, animals, plants, air, geology, sacred sites, traditional cultural properties, and artifacts. Everything is considered to be interrelated and dependent on each other to sustain existence."

American Indian views on environmental justice are presented in Section 3.4.2.4. DOE acknowledges the concerns of the American Indians and has consulted with the tribes. The Department would continue to consult with the Consolidated Group of Tribes and Organizations throughout the life of the project. If DOE implemented the Proposed Action, the Department would work closely with American Indians to ensure that a Mitigation Action Plan was developed and to ensure compliance with Section 106 of the *National Historic Preservation Act*.

4.1.14 IMPACTS FROM MANUFACTURING REPOSITORY COMPONENTS

This section discusses the potential environmental impacts from the manufacture of components that DOE would require to move and dispose of spent nuclear fuel and high-level radioactive waste at a geologic repository at Yucca Mountain. Repository components would include canisters, waste packages, emplacement pallets, drip shields, aging overpacks, *shielded transfer casks*, and transportation casks. Other repository-related items (for example, cranes and other heavy equipment, miscellaneous mechanical components, electrical components, structural materials) are standard, commercially available components that DOE could buy from several vendors. As a result, there would be no offsite manufacturing environmental impacts specifically attributed to these other types of repository equipment and components and they are not included in this evaluation. This section updates information in the Yucca Mountain FEIS and summarizes and incorporates by reference Section 4.1.15 of the FEIS (DIRS 155970-DOE 2002, pp. 4-91 to 4-105). The primary updates or modifications since the FEIS evaluation are the addition of TAD canisters to the list of repository components, slight changes in the numbers of other components, updated information on the environmental and socioeconomic settings of the reference manufacturing facilities, and expansion of the analysis of air quality impacts to include $PM_{2.5}$.

Section 4.1.14.1 provides an overview of the analysis basis. Section 4.1.14.2 discusses the components that offsite manufacturers would fabricate and the manufacturing schedule. Section 4.1.14.3 describes the components in detail. Section 4.1.14.4 discusses environmental settings for air quality, health and safety, and socioeconomics. Section 4.1.14.5 describes environmental impacts on air quality, health and safety, socioeconomics, waste generation, and environmental justice; in addition, this section contains an evaluation of materials use that addresses the potential for impacts to materials markets and supplies.

4.1.14.1 Overview

This analysis and the corresponding analysis in the Yucca Mountain FEIS used the overall approach, analytical methods and, in some cases, baseline data from the *Department of the Navy Final Environmental Impact Statement for a Container System for the Management of Naval Spent Nuclear Fuel* (DIRS 101941-USN 1996, all). The evaluation addressed ways in which the manufacture of repository components could affect environmental attributes and resources at a representative manufacturing site. DOE did not perform a site-specific evaluation because more than one manufacturer probably would be necessary to meet the production schedule and, until competitive bidding was complete, the Department would not know the locations of specific manufacturing facilities.

The analysis used a representative manufacturing site based on five existing facilities that produce casks, canisters, and related hardware for the management of spent nuclear fuel with the use of NRC-certified designs. The facilities, which are the same as those the Navy used in its EIS (DIRS 101941-USN 1996, p. 4-17), are in Westminster, Massachusetts; Greensboro, North Carolina; Akron, Ohio; York, Pennsylvania; and Chattanooga, Tennessee. Although the analysis used the existing facilities from the earlier evaluation, it used updated information to characterize the environmental settings for the facility locations.

The analysis assumed that the manufacturing facilities and processes at these locations are similar to the facilities and processes that would be necessary to produce the repository components. Although the five reference facilities might not fabricate components from titanium (which DOE would use in the drip shields), the fabrication processes of rolling plate, forming, and welding that would be necessary to produce a drip shield would be similar to the processes for casks and canisters from other structural material. The analysis also assumed that manufacture of all components would occur at one representative site. Although this is unlikely, it is conservative because potential impacts would be concentrated and higher than if they were in several locations.

4.1.14.2 Components and Product Schedule

Table 4-32 lists the components and the quantities of components DOE included in the analysis; the table includes TAD canisters (Section 4.1.14.3), which the Yucca Mountain FEIS did not address. The table includes all repository components for naval spent nuclear fuel that the Department would emplace at Yucca Mountain, but does not include the transportation casks, which the Navy would manufacture as owner and manager of that spent fuel. The Navy EIS (DIRS 101941-USN, 1996, all) discusses these casks and the potential environmental impacts of their production.

Table 4-32. Quantities of offsite-manufactured components for the Yucca Mountain Repository.

Component	Description	Number to be manufactured[a]
Rail transportatoin casks or overpacks	Storage and shipment of SNF and HLW	79
Truck transportation casks	Storage and shipment of uncanistered fuel	30
Waste packages	Outside container for SNF and HLW emplacement in the repository	11,200
TAD canisters	TAD canisters for commercial SNF	7,400[b]
Emplacement pallets	Support for emplaced waste packages	11,200[c]
Drip shields	Titanium covers for waste packages	11,500
Aging overpacks	Metal and concrete storage vaults for aging[d]	2,500
Shielded transfer casks	Casks for transfer of canisters between and in site facilities	6–10

a. The number of components is an approximation based on the best available estimates.
b. Total number of empty TAD canisters includes those shipped to generator sites and to the repository.
c. The number of emplacement pallets includes about 10,030 of the standard length and 1,150 of the short length.
d. Only the metal components of the aging overpacks would be manufactured offsite.
HLW = High-level radioactive waste.
SNF = Spent nuclear fuel.
TAD = Transportation, aging, and disposal (canister).

The analysis assumed the manufacture of all the components except drip shields would occur over 24 years to support the maximum rate of emplacement. The operations analytical period would last as long as 50 years (Chapter 2, Table 2-1), so component manufacturing likely would be on a longer schedule and still keep up with demand. However, the assumed faster pace is conservative because it concentrates estimated impacts into a shorter timeframe. Manufacturing activity would begin 2 years before repository operations started, would build up during the first 5 years, then would remain nearly constant through the remainder of the 24-year period. Because DOE would not need the drip shields until the closure analytical period, the analysis assumed the period for manufacture and delivery of them would be 10 years and would not coincide in any year with the manufacture of the other components.

4.1.14.3 Components

4.1.14.3.1 *Waste Packages*

The waste package (which the Yucca Mountain FEIS called the disposal container) would be the final outside container DOE would use to package the spent nuclear fuel and high-level radioactive waste for emplacement in the repository. The basic design remains as it was in the FEIS; that is, it would be a cylindrical vessel with an outer layer of corrosion-resistant, nickel-based alloy (*Alloy 22*) and an inner liner of Stainless Steel Type 316. Both the inner liner and the outer layer would have lids of the corresponding materials at both ends. The bottom lids would be welded to the cylindrical body at the fabrication shop and the top inner and outer lids would be welded in place at the repository after insertion of the canister (or canisters) with spent fuel or high-level radioactive waste. DOE has eliminated a third lid for the closure end from the design in the FEIS.

The Yucca Mountain FEIS described the proposed use of about 10 different waste package configurations to accommodate the different types of spent nuclear fuel and high-level radioactive waste. Although the basic waste package design would be the same for the various waste forms, DOE has reduced the number of configurations to six by standardizing the waste package for commercial spent nuclear fuel. The

Department accomplished this standardization through the introduction of a TAD canister, which is described below. In addition to waste package changes to accommodate the TAD canister and to eliminate the third closure lid, other changes in proposed waste package configurations resulted in changes to the size and mass of material. A notable change in several of the configurations was a slight elongation of the package to allow a thick inner lid that also serves as a shield plug. The discussions in this section incorporate these and other minor changes. The six waste package configurations range in length from 3.7 to 5.9 meters (12 to 19 feet), with outside diameters of 1.8 to 2.1 meters (6 to 7 feet). The mass of empty waste packages would range from 22 to 34.2 metric tons (24 to 38 tons).

4.1.14.3.2 *Transportation, Aging, and Disposal Canisters*

Management of commercial spent nuclear fuel would be more standardized by the use of TAD canisters, which the Yucca Mountain FEIS did not consider. TAD canisters would be cylindrical containers, approximately 5.4 meters (18 feet) long with an outer diameter of about 1.7 meters (5.5 feet). The shell of the canister would be stainless steel and the inner basket would be configured differently for different types of spent nuclear fuel. The inner basket would include borated stainless steel to act as a *neutron* absorber. The mass of an empty TAD canister would range from about 29 to 31 metric tons (32 to 34 tons) depending on the internal basket configuration. Under the Proposed Action, about 90 percent of the commercial spent nuclear fuel would travel to the repository in TAD canisters; generator sites would load and seal these canisters. The remaining 10 percent of the commercial spent fuel would be transported in other types of canisters, or as uncanistered fuel (in casks), and DOE would repackage it in TAD canisters at the repository site. This analysis includes TAD canisters as repository components because they are an element of the repository design and the commercial nuclear facilities would have to use them as appropriate.

4.1.14.3.3 *Casks for Rail and Truck Shipments*

DOE would mainly use rail casks to ship spent nuclear fuel and high-level radioactive waste to the proposed repository, but would also use some truck casks. The Department would tailor the design of a specific cask to the type of material it would contain. As in the Yucca Mountain FEIS, a typical rail or truck cask or overpack would consist of inner and outer cylinders of stainless or carbon steel with a depleted uranium or lead liner between the cylinders. The vessel bottom would have a similar layered construction of plates welded to the cylinder ends. A cask would probably have an inner structure to keep the contents secure, and an overpack would have no internal structures because it would be sized for a specific *disposable canister*. A polypropylene sheath would be around the outside of the cylinder for neutron *shielding*. After the spent nuclear fuel or high-level radioactive waste was placed inside the cask or overpack, a cover with lead or depleted uranium shielding would be bolted to the top of the cylindrical vessel. Large removable impact limiters of aluminum honeycomb or other crushable material would be placed over the ends of the casks or overpacks for added protection during *shipment*. Typical casks and overpacks would range from 4.5 to 6 meters (15 to 20 feet) long and about 0.5 to 2 meters (1.6 to 6.6 feet) in diameter. Empty truck casks could weigh from 21 to 22 metric tons (about 23 to 24 tons) and empty rail casks would typically weigh from 59 to 91 metric tons (65 to 100 tons).

4.1.14.3.4 *Emplacement Pallets*

The emplacement pallets would support the waste packages in the repository and would allow close spacing [to within 10 centimeters (4 inches)] of the end-to-end waste packages. The design of these components is essentially unchanged from that in the Yucca Mountain FEIS. The pallets would have V-shaped supports at either end on which the waste package would rest, and the end pieces of the pallets would connect with structural tube members. The pallet assemblies would be a combination of Alloy 22 components (primarily plates) and stainless-steel tubes. Surfaces that would contact the waste package would be Alloy 22. The shorter pallet would be 2.5 meters (8.2 feet) long and have a mass of 1.7 metric tons (1.9 tons) (DIRS 184918-Morton 2007, all); DOE would use them only for the shortest waste package for DOE spent nuclear fuel and high-level radioactive waste. The longer pallet would be 4.15 meters (13.6 feet) long and have a mass of 2 metric tons (2.2 tons) (DIRS 184918-Morton 2007, all); DOE would use this pallet for all other waste packages.

4.1.14.3.5 *Drip Shields*

The drip shields would be rigid structures above the waste packages that would divert water around them and provide protection from rockfalls. It would consist of Titanium Grade 7 surface plates, Titanium Grade 29 structural members, and Alloy 22 for the base. DOE included palladium, a small-percentage constituent of Titanium Grade 7, in the evaluation of materials in Section 4.1.14.5.4 because of its potential market impact. DOE would install the continuous drip shield in sections, with one that overlapped and interlocked with the opposite end of the next section. Each section would be 5.8 meters (19 feet) long by 2.5 meters (8 feet) wide by 2.9 meters (9.5 feet) high with a mass of 4.9 metric tons (5.4 tons) (DIRS 184918-Morton 2007, all).

4.1.14.3.6 *Aging Overpacks*

Aging overpacks (which the Yucca Mountain FEIS called *dry storage* casks) would hold TAD canisters of commercial spent nuclear fuel for aging to meet waste package thermal limits. Vertical and horizontal aging overpacks would consist of an inner liner of about 5-centimeter (2-inch)-thick carbon steel surrounded by a roughly 76-centimeter (30-inch)-thick layer of reinforced concrete, which might, depending on the vendor, have an exterior carbon-steel shell of 2.5- to 5-centimeter (1- to 2-inch) thickness (DIRS 184918-Morton 2007, all). This evaluation considered as components only the carbon-steel shells that would be manufactured off the site. It assumed the carbon-steel elements of the aging overpack would weigh about 43 metric tons (47 tons).

4.1.14.3.7 *Shielded Transfer Casks*

DOE would use shielded transfer casks to transfer TAD canisters and other canisters between and in the site facilities. These components would essentially be transportation casks without impact limiters. The analysis took estimates of their size and materials of manufacture directly from information on casks that DOE would use for rail shipment, with a slight reduction to account for the fact that they would have no impact limiters.

4.1.14.4 Existing Environmental Settings at Manufacturing Facilities

DOE based the assessment of potential impacts from the manufacture of repository components, as it did in the Yucca Mountain FEIS, on the premise that existing facilities would meet the manufacturing requirements. Therefore, there would be no new or expansion construction. As a result, there would be no change in land use, and cultural, aesthetic, and ecological resources would remain unaffected. Minor increases in noise, traffic, or utilities would be likely, but would not result in impacts on the local environment. Water consumption and wastewater discharges would be typical of a heavy manufacturing facility, and the proposed manufacturing of repository components would probably result in minor changes to existing rates. In the case of wastewater discharges, nothing unique would be likely as a result of the Proposed Action that could cause difficulty in compliance with applicable local, state, and federal regulatory limits. The following sections contain information on environmental settings for air quality, health and safety, and socioeconomics. Section 4.1.14.5 describes potential environmental impacts for a representative site.

DOE recognizes that the basic assumption of no new or expansion construction might not be the eventual situation because the number of components to manufacture is large. However, at the current stage of the Proposed Action, it would be highly speculative to assume construction would be necessary. In addition, there would be too much uncertainty to attempt to address specific facility impacts that could be associated with construction.

4.1.14.4.1 *Air Quality*

The analysis evaluated the ambient air quality status of the representative manufacturing location by examining the air quality of the areas of the existing reference facilities. As the Yucca Mountain FEIS described, most of the typical container and cask manufacturing facilities are in *nonattainment areas* for ozone; that is, locations where ambient air quality standards are not being met and, as a result, are subject to more stringent regulations. Since the completion of the FEIS, the EPA has established attainment and nonattainment designations for ambient air concentrations of $PM_{2.5}$. As of May 30, 2007, the EPA still identified the five counties of the reference manufacturing facilities as being in nonattainment for ozone and four of the five counties as being in nonattainment for $PM_{2.5}$ (DIRS 181914-EPA 2007, all). Each of the counties was in attainment for ambient air quality standards for the other criteria pollutants (carbon monoxide, nitrogen dioxide, sulfur dioxide, and lead). Volatile organic compounds and nitrous oxides are precursors for ozone and are indicators of likely ozone production and, because ozone was the only nonattainment air pollutant at the time, they were the only air pollutants that DOE evaluated in the Yucca Mountain FEIS. DOE has expanded the current evaluation to include $PM_{2.5}$. The five counties released an average of approximately 2,730 metric tons (3,000 tons) of volatile organic compounds, 5,500 metric tons (6,100 tons) of nitrous oxides, and 1,140 metric tons (1,300 tons) of $PM_{2.5}$ to the environment in 1999 (DIRS 181916-EPA 1999, all; DIRS 181917-EPA 1999, all; DIRS 181918-EPA 1999, all; DIRS 181919-EPA 1999, all; DIRS 181920-EPA 1999, all).

4.1.14.4.2 *Health and Safety*

As in the Yucca Mountain FEIS, DOE based data on the number of accidents and fatalities in relation to cask and canister fabrication at the representative manufacturing location on national incident rates for the relevant sector of the economy. The FEIS used incident rates from 1992 of 3 fatalities per 100,000 workers and 6.3 incidents of reportable occupational illness or injury per 100 full-time workers. For this evaluation, DOE has updated these rates with more recent data from the U.S. Department of Labor Bureau of Labor Statistics. The incident rate for this Repository SEIS evaluation is 3.3 fatalities per 100,000 workers, which is the average of the 2003 to 2006 values for the standard industrial code for boiler, tank, and shipping container manufacturing (DIRS 181921-BLS n.d., all; DIRS 181922-BLS n.d., all; DIRS 181924-BLS n.d., all; DIRS 185184-BLS 2008, all). The analysis used an incidence rate for reportable occupational illness or injury in the evaluation of 9.1 per 100 full-time workers, which is the average of the 2001 to 2006 values for the same standard industrial code (DIRS 181925-BLS n.d., all;

DIRS 181926-BLS 2003, all; 181927-BLS 2005, all; DIRS 181928-BLS 2005, all; DIRS 181929-BLS 2006, all; DIRS 185185-BLS 2008, all).

As noted in the Yucca Mountain FEIS, facilities with extensive experience in similar types of work; well-established procedures; appropriate equipment for fabrication of large, *heavy metal* components; and experienced and trained personnel would perform the manufacture of repository components. As a result, DOE anticipates that injury and illness rates would be equal to or lower than industry rates.

4.1.14.4.3 *Socioeconomics*

The five reference manufacturing facilities are in U.S. Bureau of the Census Metropolitan Statistical Areas. Where available, this analysis used data for the Statistical Areas to define the affected socioeconomic environment for each facility. This differs slightly from the analysis in the Yucca Mountain FEIS, which used socioeconomic data for the counties of location. The populations of the *affected environments* for the five facilities ranged from about 410,000 to 780,000 in 2005 (DIRS 181931-Bureau of the Census 2006, all). In 2002, output (the value of sales, shipments, receipts, revenue, or business produced in the five areas) ranged from $21 billion to $50 billion (DIRS 182017-Bureau of the Census 2005, all; DIRS 182018-Bureau of the Census 2005, all; DIRS 182020-Bureau of the Census 2005, all; DIRS 182021-Bureau of the Census 2005, all; DIRS 182022-Bureau of the Census 2005, all; DIRS 182023-Bureau of the Census 2005, all; DIRS 182024-Bureau of the Census 2005, all; DIRS 182026-Bureau of the Census 2005, all; DIRS 182027-Bureau of the Census 2005, all; DIRS 182028-Bureau of the Census 2005, all). The income (wages, salaries, and property income) ranged from $11 billion to $26 billion in 2002, and the labor force ranged from 220,000 to 400,000 in 2004 (DIRS 181932-Bureau of the Census n.d., all; DIRS 181933-Bureau of the Census n.d., all). Based on averages of this information, DOE estimated the representative manufacturing location would have a population of about 610,000, a labor force of about 320,000, local income of about $18 billion in 2002, and local output of about $35 billion in 2002.

4.1.14.5 Environmental Impacts

As noted above, this evaluation assumed the use of existing manufacturing facilities, so DOE only analyzed environmental impacts to air quality, health and safety, socioeconomics, material use, waste generation, and environmental justice.

4.1.14.5.1 *Air Quality*

As in the Yucca Mountain FEIS, the analysis used the methods from the Navy EIS (DIRS 101941-USN 1996, Section 4.3) to estimate air emissions from manufacturing sites for the production of repository components. However, DOE updated baseline data if available rather than using those in the original methodology. The objective of the evaluation was to estimate emissions for comparison with typical regional or countywide emissions to determine potential impacts on local air quality.

The evaluation addressed air emissions in relation to the manufacture of repository components that were of most concern to the representative manufacturing location; that is, emissions that could aggravate ambient air conditions already in nonattainment of applicable air quality standards. Based on the reference locations, DOE assumed the representative manufacturing location would be in an area of nonattainment for ozone and $PM_{2.5}$ standards, but in compliance with standards for other criteria pollutants (Section 4.1.14.4). Ozone normally forms in a reaction of precursor chemicals (which include volatile organic compounds and nitrous oxides) and sunlight, so this evaluation addresses emissions of these precursors as well as of $PM_{2.5}$.

DOE used the emissions from the manufacture of similar components to develop estimates for emissions of volatile organic compounds and nitrous oxides (DIRS 101941-USN 1996, p. 4-6) and normalized, or adjusted, them to the scale of the repository components in relation to the number of work hours for the manufacturing process, as it did in the Yucca Mountain FEIS analysis. The Navy EIS (DIRS 101941-USN 1996, all) did not include emissions of $PM_{2.5}$ in the record of emission from the manufacture of similar components; DOE found no applicable emission rates in normal sources for such data, so it developed an estimated emission rate from available local and national records. EPA maintains a database of air emissions that contains data sortable by geographic area, emissions sources, and standard industrial codes (DIRS 181916-EPA 1999, all; DIRS 181917-EPA 1999, all; DIRS 181918-EPA 1999, all; DIRS 181919-EPA 1999, all; DIRS 181920-EPA 1999, all). County emission records were queried for each reference manufacturing location and for sources that involve the manufacture of metal products. $PM_{2.5}$ emissions tended to vary in proportion to nitrous oxide emissions more consistently than with those of volatile organic compounds. Another query of the same records found that, on a nationwide basis, the standard industrial code for metal plate fabrication was responsible for emissions of 286 metric tons (315 tons) of $PM_{2.5}$ and 220 metric tons (240 tons) of nitrous oxides in 1999. Based on this information, the evaluation assumed a ratio of 315 to 240 (the original values) to that of nitrous oxide to estimate the $PM_{2.5}$ emissions.

Table 4-33 lists the estimated annual average and estimated total emissions from the manufacture of repository components. Estimated annual average emissions of volatile organic compounds would be 2.58 metric tons (2.8 tons) a year for the 24-year period and 0.646 metric ton (0.71 ton) per year for the

Table 4-33. Air emissions at the representative manufacturing location.

Period	Measure	Emissions (metric tons)[a] and de minimis values (percent)		
		Volatile organic compounds	Nitrous oxides	$PM_{2.5}$
24-year period[b]	Annual average	2.58	3.34	4.38
	24-year total	62	80	110
	Percent of de minimis[c]	28%	37%	4.8%
10-year period[d]	Annual average	0.646	0.837	1.1
	10-year total	6.5	8.4	11
	Percent of de minimis[c]	7.1%	9.2%	1.2%

a. To convert metric tons to tons, multiply by 1.1023.
b. The 24-year manufacturing period would be for all components except drip shields and would begin 2 years before emplacement.
c. De minimis level for an air quality region in extreme nonattainment for ozone is 9.1 metric tons (10 tons) per year of volatile organic compounds or nitrogen compounds, and for any nonattainment for $PM_{2.5}$ it is 91 metric tons (100 tons) per year of $PM_{2.5}$.
d. The 10-year manufacturing period would be for drip shields only and would occur at repository closure.

$PM_{2.5}$ = Particulate matter with an aerodynamic diameter of 2.5 micrometers or less.

10-year drip shield manufacturing period. Nitrous oxide emissions would be 3.34 metric tons (3.7 tons) a year for the 24-year period and 0.837 metric ton (0.92 ton) a year for the 10-year drip shield manufacturing period. $PM_{2.5}$ emissions would be 4.38 metric tons (4.8 tons) a year for the 24-year period and 1.1 metric tons (1.2 tons) a year for the 10-year drip shield manufacturing period. Annual average emissions from component manufacturing would be 0.09 percent, or less, of the typical regional emissions of volatile organic compounds of 2,730 metric tons (3,000 tons) per year (Section 4.1.14.4); 0.06 percent, or less, of regional nitrous oxide emissions of 5,500 metric tons (6,100 tons) per year; and 0.4 percent, or less, of regional $PM_{2.5}$ emissions of 1,140 metric tons (1,300 tons) per year. Emissions from the manufacture of repository components would contain relatively small amounts of ozone precursors and $PM_{2.5}$ in comparison to other sources.

If the emissions were from new sources, they would be subject to emission threshold levels (levels below which conformity regulations do not apply) set under 40 CFR 51.853. For an air quality region to be in extreme nonattainment for ozone (most restrictive levels), the emission threshold level for both volatile organic compounds and nitrous oxides is 9.1 metric tons (10 tons) per year and for any level of nonattainment for $PM_{2.5}$ the emission threshold level (for $PM_{2.5}$) is 91 metric tons (100 tons) per year. Table 4-33 lists the percentage of volatile organic compounds, nitrous oxides, and $PM_{2.5}$ from the manufacturing of repository components in relation to the applicable emission levels (the analysis assumed extreme nonattainment is the applicable threshold in the case of ozone). It is unlikely that component manufacturing would fall under the conformity regulations because the closest emission to the applicable threshold, or de minimis, levels is 37 percent. However, DOE would ensure the implementation of the appropriate conformity determination processes and written documentation for each manufacturing facility.

States with nonattainment areas for ozone or $PM_{2.5}$ could place requirements on stationary pollution sources to achieve attainment in the future. This could include a variety of controls on emissions of volatile organic compounds, nitrous oxides, and $PM_{2.5}$. Options such as additional scrubbers, afterburners, carbon filters, or physical filters would be available to control emissions of these compounds to comply with limitations.

4.1.14.5.2 *Health and Safety*

The analysis used updated data from the Bureau of Labor Statistics to compile baseline occupational health and safety information for industries that fabricate large metal objects similar to the repository components. It computed the expected number of injuries and fatalities by multiplying the number of work years by the injury and fatality rate for the applicable occupation. Table 4-34 lists the expected number of injuries and illnesses and fatalities. Estimated incidents of reportable injury and illness would be approximately 1,700 during the entire manufacturing period, but the probability of a fatality would be less than 1.

Table 4-34. Occupational injuries, illness, and fatalities at the representative manufacturing location.[a]

Parameter	Estimated values
Total work years (using 2,000 hours per labor year)	18,500
Injuries and illnesses	1,700
Fatalities	0.61

a. Impacts from 24 years for manufacture of all components except drip shields and 10 years for manufacture of drip shields.

The required number of repository components would not place unusual demands on existing manufacturing facilities, so the action would be unlikely to lead to a deterioration of worker safety and a resultant increase in accidents. In addition, nuclear-grade components are typically built to higher standards and with methods that include detailed procedures, both of which lead to improved worker safety.

4.1.14.5.3 *Socioeconomics*

The assessment of socioeconomic impacts from manufacturing activities involved three elements:

- Per-unit cost and labor data for the components (Table 4-32),
- Total number of components (Table 4-32), and
- Economic data for the environmental setting for each facility to calculate direct and secondary economic impacts of repository component manufacturing on the local economy:
  - The local economy would be directly affected as manufacturing facilities purchased materials, services, and labor for manufacturing.
  - In addition, the local economy would experience secondary effects as industries and households that supplied the industries that were directly affected adjusted their own production and spending behavior in response to increased production and income, which would thereby generate additional socioeconomic impacts.

The analysis measured impacts in terms of output (the value of sales, shipments, receipts, revenue or business), income (wages, salaries, and property income), and employment (number of jobs).

For the Yucca Mountain FEIS, the socioeconomic analysis of manufacturing used state-level economic multipliers for fabricated metal products for each of the five states of the reference manufacturing plants. The multipliers of interest were for products, income, and employment (DIRS 155970-DOE 2002, Table 4-48); DOE used them to account for direct and secondary effects on an area's economy. For the FEIS analysis, DOE obtained the state multipliers (DIRS 152803-Bland 1998, all) in accordance with guidelines from the Bureau of Economic Analysis for use of the Regional Input-Output Modeling System, and averaged them to produce composite multipliers for a representative manufacturing location. The composite multipliers were as follows:

- Final demand multiplier for products (dollar value) – 2.2233
- Final demand multiplier for earnings (dollar value) – 0.6308
- Direct effect multiplier for number of jobs – 2.5705

The evaluation of manufacturing for this Repository SEIS included an informal run of the same Regional Input-Output Modeling System that used more recent, national level socioeconomic data as a sensitivity analysis for the economic multipliers used previously. The results indicated that the multipliers DOE used for the Yucca Mountain FEIS evaluation were still reasonable and that a formal modeling effort to update the numbers for each of the reference manufacturing locations would provide little value.

The analysis estimated the direct and secondary impacts of manufacturing activities, but did not include impacts on local jurisdictions such as county and municipal government and school district revenues and expenditures. Because the analysis assumed that manufacturing activities would occur at existing facilities alongside existing product lines, substantial population increases due to workers moving into the vicinity would be unlikely. As a result, impacts to demographics (that is, to characteristics of the population) would be small and meaningful change in local government or school districts would be unlikely. The analysis did not consider impacts on other areas of socioeconomic concern that population increases would drive, such as housing and public services.

The analysis calculated average annual impacts for the manufacturing period of 10 years for drip shields and 24 years for all other components. It compared the impacts to the baseline information from Section 4.1.14.4, with escalation to 2006 dollars. Because the analysis was not site-specific, it made no attempt to forecast local population or economic growth or inflation rates for the reference locations. Table 4-35 lists impacts of component manufacturing on output, income, and employment at the representative manufacturing locations. The table includes a comparison, in terms of percent, of the values for component manufacturing to comparable baseline values for the representative location. As listed in Table 4-35, socioeconomic impacts at the representative manufacturing location would involve relatively minor increases to existing conditions. The largest forecasted increase would be an addition of as much as 4.7 percent to the area's output. Estimated impacts to the area's average income and average employment would be less.

Table 4-35. Socioeconomic impacts at the representative manufacturing location.

Economic parameter and descriptions of assessment values	24-year period[a]	10-year period[b]
Average annual output		
Baseline output escalated to 2006 dollars (in $ millions)[c]	39,200	39,200
Output associated with manufacture of components (in $ millions)	1,800	890
Percent impact	4.7	2.3
Average annual income		
Baseline income escalated to 2006 dollars (in $ millions)[c]	20,000	20,000
Income associated with manufacture of components (in $ millions)	520	250
Percent impact	2.6	1.3
Average annual employment		
Baseline labor force (persons)[c]	320,000	320,000
Employment associated with manufacture of components (persons)	2,000	500
Percent impact	0.63	0.16

a. The 24-year manufacturing period would be for all components except drip shields and would begin 2 years before emplacement.
b. The 10-year manufacturing period would be for drip shields only and would occur at repository closure.
c. Baseline output, income, and labor force values from Section 4.1.14.4. DOE applied an escalation factor of 1.12 to the 2002 baseline output and income dollars to obtain the 2006 dollars listed in the table.

4.1.14.5.4 *Impacts on Materials Use*

The Yucca Mountain FEIS analysis based calculations of the quantities of materials for the manufacture of each repository component, to the extent available, on engineering specifications for each hardware component. DOE obtained the information and applicable references from the manufacturers of systems either designed or under licensing review or from conceptual design specifications for technologies still in the planning stages. This Repository SEIS evaluation started with the same information and augmented it with preliminary design drawings of waste packages with minor modifications to the designs in the FEIS and with specifications (DIRS 185304-DOE 2008, all) for the TAD canisters and specific items of support hardware (transportation overpacks and aging overpacks). The analysis combined data on per-unit material quantities for each component with information on the required number of components. In addition, it assessed the impact of component manufacturing on total U.S. production (or availability if not produced in this country) of each relevant input material.

Table 4-36 lists the total quantities of materials DOE would need for the manufacture of repository components and the average annual requirement for each material. The largest materials requirement by weight would be steel at about 343,000 metric tons (378,000 tons). Table 4-36 also lists the annual U.S. production or import (nickel and titanium) quantities from 2007 (DIRS 185186-USGS 2008, all) for most of the materials. The exception is the quantity for depleted uranium, which is from the 1996 Navy EIS (DIRS 101941-USN 1996, p. 4-10). With the exceptions of nickel palladium, and titanium, the requirement for each material would be less than 2 percent of the annual U.S. production. Therefore, the use of aluminum, chromium, copper, lead, molybdenum, depleted uranium, or steel would not produce a noteworthy increased demand and would not have a meaningful effect on the supply of these materials. [Note: The Draft Repository SEIS presented the annual chromium demand as 3.4 percent of the annual U.S. production. This value has dropped significantly, as listed in Table 4-36, because the most recent source for the annual production values (DIRS 185186-USGS 2008, all) includes a change to the evaluation method for chromium production. The new source document shows revised, higher production values for past years as well as the higher value for 2007.]

Table 4-36. Total and annual materials use and comparison to annual production.

Materials	Annual U.S. production or ***imports***[a] (metric tons)[b]	Materials required for repository components: Total (metric tons)	Annual (metric tons)	Percentage of annual production
Aluminum	3,900,000	850	81	0.002
Chromium[c]	240,000	100,000	4,200	1.8
Copper	1,350,000	140	5.9	0.0004
Depleted uranium	14,700	1,500	61.4	0.42
Lead	1,310,000	1,100	47	0.004
Molybdenum[d]	59,400	27,000	1,100	1.9
Nickel[e, f]	***140,000***	120,000	5,000	3.6
Palladium[g]	13.5	80	8.0	59
Steel (and iron)[h]	97,800,000	343,000	14,300	0.015
Titanium[f, i]	***24,200***	54,000	5,400	22

Sources: Depleted uranium: DIRS 101941-USN 1996, p. 4-10; other materials: DIRS 185186-USGS 2008, year 2007 data, pp. 22, 48, 54, 94, 112, 114, 86, and 180.

a. Annual values include, as applicable, primary and secondary production.
b. To convert metric tons to tons, multiply by 1.1023.
c. Required chromium estimated as 18 percent of stainless steel and 22 percent of high-nickel alloy.
d. Required molybdenum estimated as 2.5 percent of stainless steel and 14.5 percent of high-nickel alloy.
e. Required nickel estimated as 57.2 percent of high-nickel alloy and 12 percent of stainless steel.
f. Production values for nickel and titanium are import quantities from 2007 (see explanation in text).
g. Required palladium estimated as 0.19 percent of Titanium Grade 7.
h. Required steel estimated as 100 percent of carbon steel and 52 percent of stainless steel. The data source identified steel and iron as a single category, but noted that more than 95 percent of produced iron moves in molten form to steelmaking furnaces at the same site, so the combined quantity is appropriate for comparison. The corresponding materials requirements are for steel.
i. Required titanium estimated as 100 percent of Titanium Grade 7 and 90 percent of Titanium Grade 29.

The estimated annual requirement for nickel as a component in stainless-steel and corrosion-resistant, high-nickel alloy would be about 3.6 percent of the annual use, which in this case is all imported material. The materials production data provide no U.S. production values for nickel, but rather lists a W, which indicates the values were withdrawn to avoid disclosure of proprietary data. This indicates U.S. production is limited and values could be easily tied to a specific production company (or companies). In addition to the quantity of imported nickel listed in Table 4-36, there is a relatively large

U.S. market for nickel scrap. In 2007, 207,000 metric tons (228,000 tons) of this scrap were purchased and about 57 percent of the nickel was recovered from it during the year (DIRS 185186-USGS 2008, p. 114). The sum of the imported nickel (Table 4-36) and the recovered nickel is 259,000 metric tons (285,000 tons). The annual requirement for nickel to support the manufacture of repository components would be 1.9 percent of that value. The world mine production for nickel was at an all-time high in 2007, but barely kept up with demand (DIRS 185186-USGS 2008, p. 114). Although 1.9 percent would be a small portion of the U.S. nickel market, potential impacts on supply would depend on the ability to maintain import levels. Canada is a major world supplier of nickel and the largest U.S. supplier.

The estimated annual requirement for palladium as a constituent in the titanium drip shields (specifically as a constituent of Titanium Grade 7) at only about 8.0 metric tons (8.8 tons) would be about 59 percent of the annual U.S. mine production. The sum of domestic production of palladium in 2007 (Table 4-36) and the amount imported in 2007 is 118 metric tons (130 tons) (DIRS 185186-USGS 2008, p. 126). The annual requirement for palladium to manufacture repository components would be only 6.8 percent of that value. Assuming imports remained at current levels, repository use of palladium would have a more moderate, though significant, effect on supply. As noted for the manufacture of drip shields, DOE would not need these materials until the repository closure analytical period, so there would be up to 90 years to complete production or import additional material in advance of the need. Therefore, the annual requirement for palladium listed in Table 4-36, which DOE based on an assumed 10-year production rate, could be less by almost a factor of 10, and potential impacts on markets would be small.

The annual requirement for titanium for drip shields would be approximately 5,400 metric tons (6,000 tons) and, at 22 percent, the most critical quantity, along with palladium, in terms of its available supply in 2007. As with nickel, the titanium production in Table 4-36 is all in the form of imported material. Similar to nickel, the materials production data provide no U.S. production values for titanium, but rather lists a W to indicate the companies withdrew the values to avoid disclosure of proprietary data, which in turn indicates limited U.S. production. The data indicate that the United States imports about 64 percent of the titanium it uses or exports (DIRS 185186-USGS 2008 p. 6), so the total quantity of titanium used in the United States in 2007 was about 38,000 metric tons (42,000 tons) and the annual amount required for production of repository components would decrease to 14 percent of the larger quantity. Because of increasing demand for titanium in the world market, producers are adding capacity. In the United States, two production facilities increased production in 2007, and a new facility should start production in 2008. Between these three facilities, estimated annual production would be about 31,000 metric tons (34,000 tons) by the end of 2008 in comparison to a 2007 U.S. capacity of about 20,200 metric tons (22,300 tons) per year (DIRS 185186-USGS 2008, p. 181). If the projected 2008 capacity represented all U.S. production and imports continued at current levels, titanium use in the United States would increase to about 55,200 metric tons (60,800 tons) per year and the annual amount for production of repository components would decrease to 9.8 percent. In addition, DOE would not need the drip shields until the repository closure analytical period, so there would be adequate time (up to 90 years) to complete production of titanium or import additional material in advance of the need. Taking advantage of this schedule, the assumed 10-year production rate for the annual titanium requirement could be less by almost a factor of 10, and potential impacts on markets would be small.

4.1.14.5.5 *Impacts of Waste Generation*

The primary materials for the manufacture of repository components would be stainless steel, carbon steel, high-nickel alloy, aluminum, copper, and titanium along with either depleted uranium or lead for shielding. The manufacture of shielding would generate a hazardous waste or low-level radioactive waste, depending on the material. DOE has identified other types and quantities of waste the manufacturing activities would generate. The analysis based estimates of annual quantities of waste generation at the representative location on the methodology and data in the Navy EIS (DIRS 101941-USN 1996, p. 4-13). It evaluated potential impacts in terms of existing and projected waste handling and disposal procedures and regulations of relevant state and federal regulatory agencies. Manufacturers would comply with existing regulations to control the volume and toxicity of the liquid and solid waste they would produce. They would implement pollution prevention and reduction practices. The analysis evaluated only waste from the manufacture of repository components from component materials; it did not consider waste from mining, refining, and processing raw materials into component materials. The analysis assumed that component materials would be available from supplier stock regardless of the status of the repository project.

Liquid Waste

Liquid waste from manufacturing would consist of used lubricating and cutting oils from machining operations and cooling of cutting equipment. Consistent with typical existing facilities, manufacturers would recycle this material. They would treat water from cooling and washing operations and from ultrasonic weld testing by filtration and *ion* exchange, which would remove contaminants and permit its discharge to the sanitary sewer system. Table 4-37 lists the estimated amounts of liquid waste manufacturers would generate by shaping, machining, and welding the repository components. The average amount of liquid waste would be 7.5 metric tons (8.3 tons) per year during the 24-year manufacturing period and 4.5 metric tons (5.0 tons) per year during the 10-year period. The small quantities of waste from manufacturing would not exceed the capacities of existing equipment for waste stream treatment at the manufacturing facility.

Table 4-37. Annual average waste generated (metric tons) at the representative manufacturing location.

Measure		Liquid waste quantity		Solid waste quantity	
		(metric tons)	(tons)	(metric tons)	(tons)
24-year period[a]	Annual average	7.5	8.3	1.0	1.1
10-year period[b]	Annual average	4.5	5.0	0.62	0.68

a. The 24-year manufacturing period would be for all components except drip shields and would begin 2 years before emplacement.

b. The 10-year manufacturing period would be for drip shields only and would occur at repository closure.

Solid Waste

Table 4-37 lists the solid waste that manufacturing operations would generate. The average annual amount of solid waste would be about 1 metric ton (1.1 ton) per year during the 24-year manufacturing period and about 0.62 metric ton (0.68 ton) per year during the 10-year period. The primary waste constituents would probably be metals: steel, nickel, molybdenum, chromium, and copper. Manufacturers could add these metals to existing manufacturing waste streams for treatment and disposal or recycling.

The analysis assumed that depleted uranium would arrive at the manufacturing facility properly shaped to fit as shielding for a transportation cask. As a result, the representative manufacturing location would not generate or recycle depleted uranium waste and there would be no radiological health impacts. Lead for shielding would be cast between stainless-steel components for the transportation casks. It is unlikely that lead waste would occur in substantial quantities, and the manufacturers would recycle it.

4.1.14.5.6 *Environmental Justice*

DOE performed the environmental justice assessment to determine if high and adverse health or environmental impacts from the manufacture of repository components would disproportionately affect minority or low-income populations, as Executive Order 12898 requires. A disproportionately high impact (or risk of impact) in a minority or low-income community would be one that exceeded the corresponding impact on the larger community to a meaningful degree. This section summarizes the Navy EIS analysis (DIRS 101941-USN 1996, Section 4.8), which DOE adapted to the manufacturing of components for the proposed repository. It is the same analysis as that for the Yucca Mountain FEIS.

The assessment used demographic data from the areas of the five reference facilities to provide information on the degree to which minority or low-income populations could receive disproportionate effects. It used a geographic information system linked to 1990 Census data to define the composition of populations living within approximately 16 kilometers (10 miles) of the five facilities and to identify the percentage of minority and low-income individuals in each area. The assessment used the percentages of minority and low-income persons that comprise the population of the states in which the facilities are located as a reference.

The original analysis indicated that in one manufacturing facility location the proportion of minority population was higher than the proportion of the minority population in the state. The difference between the percentage of the minority population within the 16-kilometer (10-mile) radius and in the state was 1.5 percent (DIRS 101941-USN 1996, p. 4-18). DOE did not update the detailed evaluation in the Yucca Mountain FEIS, but evaluated more recent data to determine if there were notable changes to minority population distributions. According to Bureau of the Census data for 2003 (DIRS 181937-Bureau of the Census n.d., all; DIRS 181938-Bureau of the Census n.d., all), only one of the Metropolitan Statistical Areas in which the reference facilities are located had a higher percent minority population than the applicable state as a whole. The difference in minority populations between the smaller area and of the state was 1.6 percent. Based on this more current census data, distribution of minority populations has probably remained similar to that for the FEIS. The conclusion remains the same; that is, DOE anticipates small impacts for the total population from manufacturing activities, so there would be no disproportionately high and adverse impacts to the minority population near the location of the representative facility.

The original analysis indicated that in one reference manufacturing facility location the proportion of low-income population was higher than the proportion of the low-income population in the state. The difference was 0.9 percent (DIRS 101941-USN 1996, p. 4-18). As noted above, DOE did not update the evaluation in the Yucca Mountain FEIS, but evaluated more recent data. Bureau of the Census data for the 1999-to-2000 timeframe (DIRS 181939-Bureau of the Census 2006, Table C-2; DIRS 181940-Bureau of the Census n.d., Table 690) indicate none of the Metropolitan Statistical Areas had a percent of low-income individuals higher than the applicable state as a whole. Based on the more recent data, distribution of low-income populations probably has remained similar, and possibly even improved, in comparison to that for the FEIS assessment. DOE anticipates small impacts to individuals and to the total population, and no special circumstances would cause disproportionately high and adverse impacts to the low-income population near the representative facility.

The analysis for this Repository SEIS determined that no high and adverse health and environmental impacts would occur to the population as a whole from the manufacture of repository components.

Further, there were no identified impact pathways that would be specific to minority or low-income populations. Therefore, no high and adverse impacts to minority or low-income populations would be expected from these activities.

4.1.15 AIRSPACE RESTRICTIONS

The region of influence is the airspace over the analyzed land withdrawal area and airspace immediately adjacent, within approximately 48 kilometers (30 miles) of the repository's North Portal. This section describes DOE's requirement for airspace restrictions and the impacts of those restrictions.

4.1.15.1 Requirement for Airspace Restrictions

During the operations analytical period, there would be spent nuclear fuel in buildings, in transportation casks, or on aging pads in protective overpacks at the proposed repository. DOE evaluated the potential for an aircraft crash into these areas to determine the probability of a release of radioactive material from the repository (Section 4.1.8 and Appendix E). Aircraft flights in the vicinity of the site are an important consideration in the accident analysis DOE conducted as part of this Repository SEIS and in the safety analysis documentation that DOE has prepared to support the application for construction authorization. That analysis considered commercial, military, and general aviation aircraft activity in the area of the repository. It included specification of limits on military aircraft flight altitude and number of flights per year over the repository. Specifically, the analysis assumed that a maximum of 1,000 fixed-wing military aircraft flights per year would cross the airspace defined by a 9.0-kilometer (5.6-statute-mile) radius from the North Portal of the repository at an altitude of at least 4,300 meters (14,000 feet) above mean sea level. It also assumed that no aircraft fly below 14,000 feet mean sea level within a 9.0-kilometer (5.6-statute-mile) radius of the North Portal.

As Chapter 3, Section 3.1.1.4 describes and Figure 4-9 shows, much of the airspace in the vicinity of Yucca Mountain is special-use restricted airspace. DOE has controlling authority over restricted airspace R-4808N, shown in Figure 4-9. Controlling authority means that DOE authorizes and specifies the use of the airspace although it does not provide air traffic control. Less than one-quarter of the airspace defined by a 9.0-kilometer (5.6-statute-mile) radius from the North Portal of the repository is not presently designated as restricted airspace. This "triangle" covers approximately 48 square kilometers (19 square miles) and is denoted on Figure 4-9 as "proposed special-use airspace." This area is currently categorized as Class A and Class G airspace but is not subject to overflight by aviation traffic following point-to-point routes because such routes would infringe on the adjoining restricted areas. The Class A and Class G airspace between the restricted areas and the military operations area (Figure 4-9) where commercial, military, and general aviation aircraft fly point-to-point routes, is outside the 9.0-kilometer (5.6-statute-mile) radius of the North Portal.

As noted above, the majority of the airspace within a 9.0-kilometer (5.6-statute-mile) radius of the North Portal is already in DOE restricted airspace. Flight activities in the DOE restricted airspace are coordinated to accommodate the needs of the U.S. Air Force and DOE. Because the air traffic restrictions for the repository would not be required for a number of years, DOE would monitor and take into consideration any modifications or additions to flight activities with the special-use airspace over the repository during the construction analytical period.

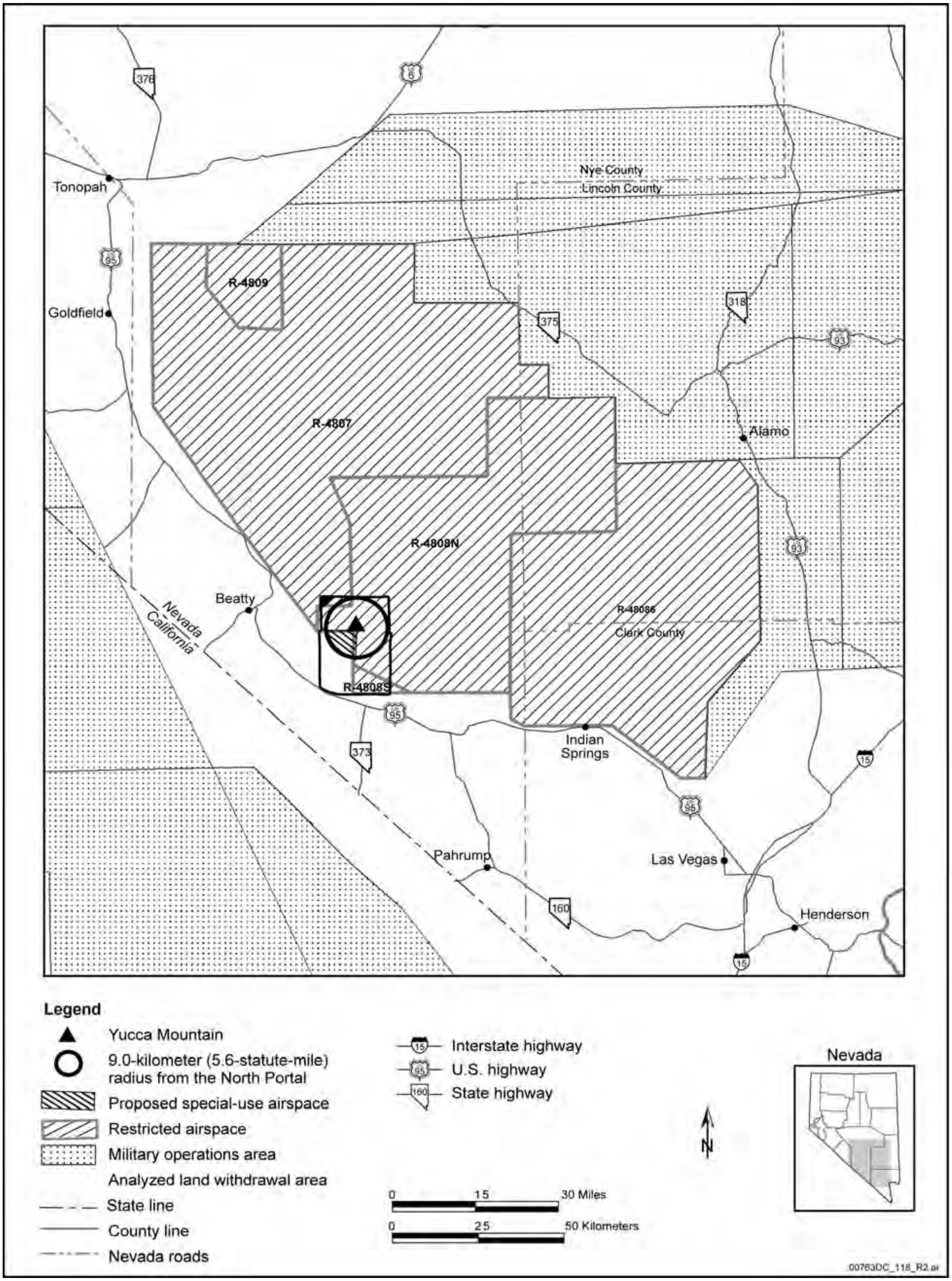


Figure 4-9. Proposed airspace use near Yucca Mountain.

If necessary to support repository operations, DOE would seek a special-use airspace designation from the Federal Aviation Administration for the 48-square-kilometer (19-square-mile) area described above. In addition, airspace restrictions could include agreements with the U.S. Air Force and other users to manage traffic in the vicinity of the repository. The accident analysis conducted as part of this Repository SEIS (Section 4.1.8 and Appendix E) assumed that such flight restrictions would occur.

Depending on the type of special-use airspace requested, Federal Aviation Administration regulations might not require additional analyses under NEPA. DOE has analyzed the impacts of designating the 48-square-kilometer area as special-use airspace in this Repository SEIS for completeness. The requested special-use airspace designation of the 48-square-kilometer (19-square-mile) resource area is not applicable to other resource areas.

4.1.15.2 Impacts to Airspace Use

If DOE acquired a special-use airspace designation as described above, the Department would gain exclusive control and use of the approximate 48-square-kilometer (19-square-mile) area in addition to the existing 4,400-square-kilometer (1,700-square-mile) restricted airspace of the Nevada Test Site (Chapter 3, Section 3.1.1.4). This would result in less than a 1.4-percent increase in DOE special-use airspace in the area, and less than a 0.3 percent increase in DOE and U.S. Air Force combined restricted airspace.

The designation of the proposed airspace as special-use airspace would prohibit flights in a small portion of the west low-altitude tactical navigation area used by U.S. Air Force A-10 aircraft and helicopters; there are currently about 30 flights per week.

Use of the airspace by the public is relatively light in comparison with other areas in Nevada due to the airspace being bounded on the north and east by the existing restricted areas of the Nevada Test and Training Range and the Nevada Test Site. Due to the small area of the proposed special-use airspace and the shape of the surrounding restricted areas, there would be little to no impact on general aviation aircraft that could fly within this area (small piston-engine aircraft, helicopters, and gliders). There would be no impact on commercial or general aviation flying point-to-point routes in the area, because these aircraft do not fly in this airspace. Overall, impacts to airspace use from designation of the proposed special-use airspace would be small.

In a separate action, DOE would continue to work with the U.S. Air Force to accommodate its need to fly through the Nevada Test Site airspace. DOE would authorize specific Air Force activities over the repository consistent with the repository safety analysis. DOE plans to continue to allow military flights over the repository by fixed-wing aircraft with the following restrictions:

- A maximum of 1,000 flights per year above 4,300 meters (14,000 feet) above mean sea level altitude;
- A prohibition of maneuvering of aircraft—flight is to be straight and level;
- A prohibition of carrying ordnance over the flight-restricted airspace; and
- A prohibition of electronic jamming activity over the flight restricted airspace.

Based on coordination with and input from the U.S. Air Force, impacts to military airspace use of the Nevada Test Site airspace from the restrictions listed above would be small.

4.2 Short-Term Environmental Impacts from the Implementation of a Retrieval Contingency

Section 122 of the *Nuclear Waste Policy Act*, as amended (NWPA) (42 U.S.C. 10101 et seq.) requires DOE to maintain the ability to retrieve emplaced spent nuclear fuel and high-level radioactive waste. The NRC specifies further that DOE must be able to maintain a retrieval period for at least 50 years after the start of emplacement [10 CFR 63.111(e)]. Although DOE does not anticipate the need to retrieve spent nuclear fuel or high-level radioactive waste and retrieval is not part of the Proposed Action per se, DOE would, as required, retain the ability to retrieve waste for at least 50 years after the start of emplacement or until there was a decision to close the repository permanently. For this reason, the Yucca Mountain FEIS analyzed potential impacts to environmental resources from retrieval.

According to *Concepts for Waste Retrieval and Alternate Storage of Radioactive Waste* (DIRS 182322-BSC 2007, all), the current concept for waste retrieval has not changed from that DOE analyzed in the Yucca Mountain FEIS. Operations to retrieve spent nuclear fuel and high-level radioactive waste from the repository to the surface would continue to be the reverse of those for emplacement using equipment, such as the transport and emplacement vehicle, as Chapter 2, Section 2.1.2.1.8 of this Repository SEIS describes. As before, DOE would move waste packages to the surface, load them into concrete storage modules, and move them to the Waste Retrieval and Storage Area. Because the concept of retrieval has not changed from that in the Yucca Mountain FEIS, the environmental impacts DOE reported in Section 4.2 of that document continue to represent those that could occur during retrieval.

4.3 Infrastructure Improvements

DOE identified the need to repair, replace, or improve certain elements of the infrastructure that currently exist on the site to help ensure safety under a high level of activity. The Department based these proposed safety improvements on assessments of the condition of the existing infrastructure; some parts of the infrastructure at Yucca Mountain are nearing, or in some cases have exceeded, their design and operational lifetimes. Because DOE has mandated operational restrictions on continued scientific activities, testing, and maintenance to maintain the safety of workers, regulators, and visitors, the infrastructure improvements would be necessary before construction of the Yucca Mountain Repository if DOE decided to lift current operational restrictions.

The proposed infrastructure improvements are subsets of larger actions DOE has defined as part of the Proposed Action. In the Proposed Action, DOE has identified the need for two 138-kilovolt transmission lines (with a capability of boosting to 230-kilovolts, if needed). Under the proposed infrastructure improvements, DOE would construct one 138-kilovolt transmission line. The Proposed Action defines a four-lane paved access road, while the proposed infrastructure improvements are for a two-lane road.

Section 4.3.2 summarizes the potential environmental impacts of the infrastructure improvements in the context of the larger elements of the Proposed Action. The applicable subsections of Section 4.1 address the corresponding Proposed Action elements. Because the infrastructure improvements would generally be smaller in scope and have shorter construction analytical periods, the potential impacts would generally be less than those for the corresponding actions under the Proposed Action. Because the proposed infrastructure improvements would occur before construction of the repository, the potential impacts would not be concurrent with those of construction and operation of the repository. Chapter 10 covers short-term uses, long-term productivity, and irreversible or irretrievable commitment of resources as part of the Proposed Action.

In June 2006, DOE issued the *Draft Environmental Assessment for the Proposed Infrastructure Improvements for the Yucca Mountain Project, Nevada* (DIRS 178817-DOE 2006, all). DOE has since decided not to finalize the environmental assessment, but rather to incorporate the actions it evaluated into this Repository SEIS. In the draft environmental assessment, DOE provided two route and construction options for the improvement of access roads and a 138-kilovolt transmission line (DIRS 178817-DOE 2006, all), as well as the improvement of several facilities. Since the issuance of the draft environmental assessment, DOE has identified additional transmission line routes but has developed little detail. In the draft environmental assessment, DOE identified two options for access road improvements. This Repository SEIS discusses only DOE's preferred option. The road improvement option to the preferred option differed only in the length of the road; it would be about 13 kilometers (8 miles) longer than that for the preferred option. The Department concluded that the second option in the draft environmental assessment would not be technically practicable or economically feasible. The draft environmental assessment serves as the basis for identification of proposed infrastructure improvements, but the design and operational plans for these improvements, along with any potential options, are under development.

DOE developed the following proposed infrastructure improvements after completion of the Yucca Mountain FEIS:

- The building of new and replacement roads that would include a two-lane access road from U.S. Highway 95 at its intersection with Nevada State Route 373 to Gate 510. This is the preferred option in the draft environmental assessment, but the preferred option did not align the access road with State Route 373, as is the current proposal. Chapter 2, Section 2.1.6.1 describes roads under the Proposed Action. DOE did not include Option B as described in the draft environmental assessment in the Repository SEIS because it no longer considers it a reasonable option.

- The building of a new 138-kilovolt transmission line to existing facilities from the Lathrop Wells switch station. This was the preferred option in the draft environmental assessment. Chapter 2, Section 2.1.4.4.1 describes the electrical power and distribution system under the Proposed Action. DOE has identified several other options to provide upgraded electrical services to the Yucca Mountain Repository before the start of construction, if needed. Other options could start on the Nevada Test Site and then move to the central operations area. Because DOE could require additional switchyards and substations, options would require further definition in cooperation with one or more electric power vendors and, therefore, are uncertain at this time.

- The development of a central operations area to replace the existing infrastructure that has outlived its design life. Chapter 2, Section 2.1.4.3.6 describes the central operations area under the Proposed Action.

- The repair of erosion damage to the existing 0.061-square-kilometer (15-acre) Equipment Storage Pad. This pad is not within either the North or South Portal areas and its improvement is not part of the Proposed Action.

- The building of a Sample Management Facility near Gate 510 of the Nevada Test Site on Bureau of Land Management land outside the analyzed land withdrawal area. Chapter 2, Section 2.1.6.2 describes the sample management facility under the Proposed Action.

If DOE did not implement these proposed infrastructure improvements in the near term, it would continue to use the existing infrastructure with appropriate mitigation measures to protect worker health and safety to operate the Yucca Mountain Project. The Department would continue maintenance and replacement of infrastructure on an as-needed basis only, until the NRC decided whether to authorize construction of a repository at Yucca Mountain.

4.3.1 PROPOSED INFRASTRUCTURE IMPROVEMENTS

Sections 4.3.1.1 through 4.3.1.5 describe each proposed infrastructure improvement.

4.3.1.1 Road Construction

DOE would build several new roads and replace several existing roads (Figure 4-10), which would total about 40 kilometers (25 miles) of new and replacement paved roads. DOE would first build a new 13.7-kilometer (8.5-mile), two-lane paved access road from a point 3.7 kilometers (2.3 miles) north of Gate 510 on the Nevada Test Site to a point about 0.8 kilometer (0.5 mile) east of Fortymile Wash. Second, the Department would build a new 2.1-kilometer (1.3-mile), two-lane paved road to the crest of Yucca Mountain. DOE would move the existing access road to Gate 510 approximately 0.39 kilometer (0.24 mile) to the southeast to line up with the State Route 373 and U.S. Highway 95 intersection (Figure 4-10). A total of about 0.55 square kilometer (135 acres) would be disturbed.

Road construction would require borrow material that DOE would obtain from the existing excavated rock storage pile near the North Portal, existing aggregate pits west of H Road along Fran Ridge, a new borrow site at an unspecified location, or a combination of these sources.

DOE would drill cores along the centerline of each new roadbed at intervals based on field conditions. Workers would remove vegetation and about 15 centimeters (6 inches) of topsoil by blading and would stockpile the soil for use in reclamation. Heavy machinery would level high points along the roadbeds and move the excess material to low points to balance cut and fill. DOE would install road shoulders, erosion controls, drainage culverts, *riprap*, and ditches in accordance with best management practices. Construction and safe operation of part of the new road to the crest of Yucca Mountain could require drilling and blasting and retaining walls. A strip 11 meters (36 feet) wide for the crest road and 15 meters (50 feet) wide for the access road would be compacted and paved. A 46-centimeter (18-inch)-thick layer of fill would be placed on the roadbed and compacted, after which a 41-centimeter (16-inch)-thick layer of aggregate would be placed over the fill and compacted; last, an 18-centimeter (7-inch)-thick layer of asphalt would be applied to the road surface. The total width of the disturbance for these new roads and shoulders would be about 37 meters (120 feet) for the access road and about 18 meters (60 feet) for the crest road.

DOE would replace about 19 kilometers (12 miles) of existing access road (H Road) and about 4.7 kilometer (2.9 mile) of the existing crest road with two-lane asphalt roads. The replacement would include construction of a culvert (generally designed to accommodate a 100-year flood) at Fortymile

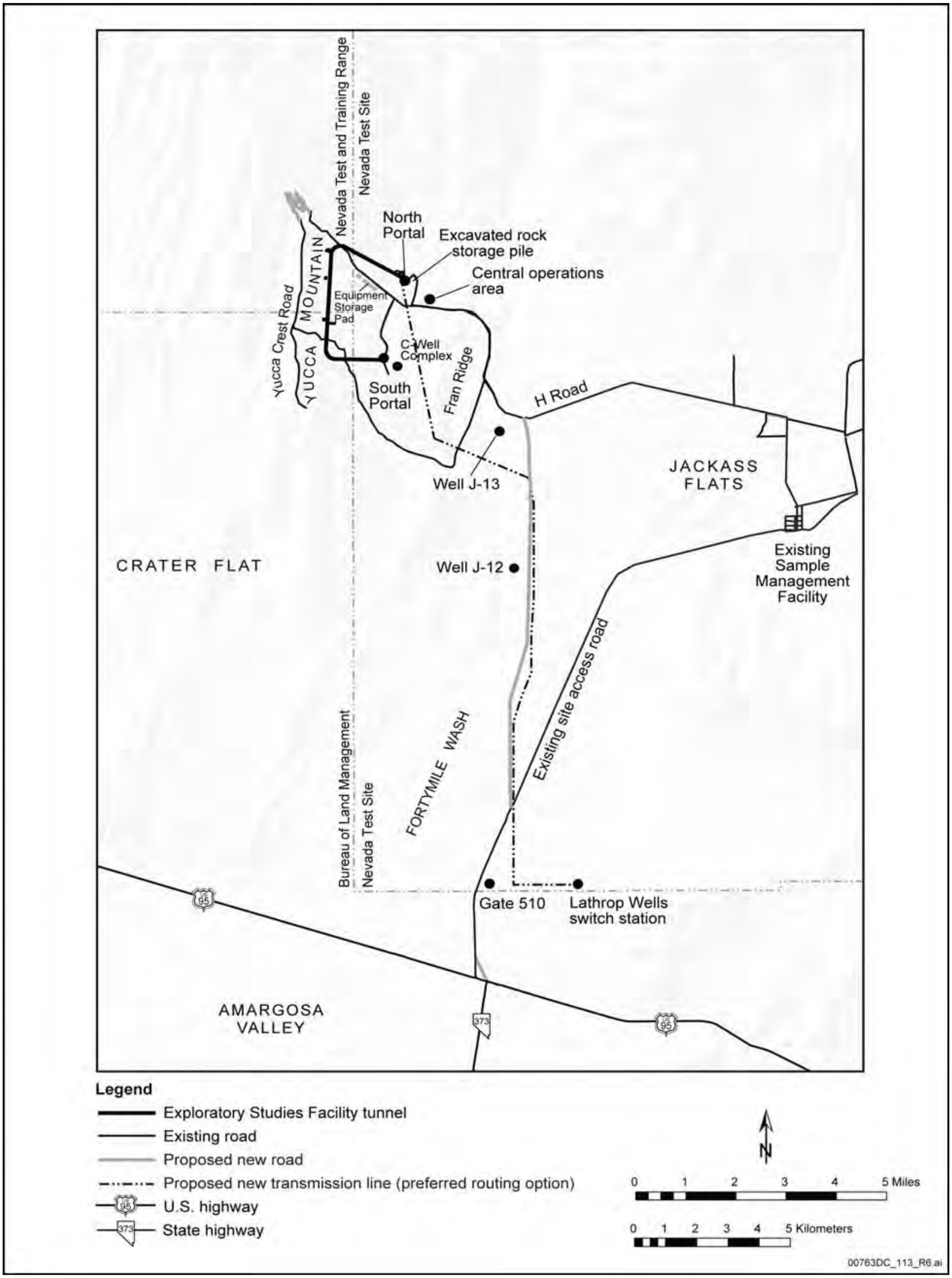


Figure 4-10. Proposed infrastructure improvements.

Wash. The existing asphalt roadbed would be excavated and stockpiled for possible use as fill material. A total of about 0.34 square kilometers (85 acres) would be disturbed.

4.3.1.2 Transmission Line Construction

DOE proposes to install a 138-kilovolt transmission line from the existing Lathrop Wells switch station to a proposed substation at the central operations area (Figure 4-10). DOE's preferred routing for the transmission line would follow utility corridors parallel to the site access road. The total length of the transmission line from the Lathrop Wells switch station to the central operations area would be about 29 kilometers (18 miles). From the switch station, the transmission line would extend due west about 2.4 kilometers (1.5 miles) before it intersected the proposed new access road. From this point, the transmission line would extend 14 kilometers (0.5 mile) east of Fortymile Wash. From this point, the transmission line would extend another 8.9 kilometers (5.5 miles) along the existing access road, cross Fortymile Wash, and end at the central operations area.

4.3.1.3 Central Operations Area

The Department would develop a central operations area about 0.8 kilometer (0.5 mile) southeast of the North Portal for all operations, which would include support and replacement of underground infrastructure in the Exploratory Studies Facility (Figure 4-10). Proposed construction would occur on about 0.12 square kilometer (30 acres) of land DOE has used for equipment storage and lay down. On completion of this construction, the Department would dismantle and dispose of existing temporary structures and utilities at the North Portal and the existing Field Operations Area, which would be obsolete. The improvements for the replacement of existing infrastructure would enhance the safety margins for continued near-term scientific exploration, testing, and maintenance.

DOE would transport as much as 115,000 cubic meters (150,000 cubic yards) of fill material to the area, compacted, and graded for proper drainage. The fill material would be from the excavated rock storage pile near the North Portal, existing aggregate pits (west of H road along Fran Ridge), a new borrow site at an unspecified location, or a combination of these sources. The fill would be crushed and screened at the source location. After placement and grading of the fill material, DOE would construct five new support buildings and install utilities (power, water, sewer, and communications). The five support buildings would include a 4,000-square-meter (43,000-square-foot) field operations center for offices, training, computer operations, and emergency facilities; a 930-square-meter (10,000-square-foot) incident-response station for fire and medical support; a 4,000-square-meter craft shop and annex for maintenance and repair operations; a fuel and vehicle wash facility; and a 3,300-square-meter (35,000-square-foot) warehouse and material storage yard. The fuel facility would have space for refueling islands to supply diesel, gasoline, propane, and compressed natural gas and a separate facility to wash vehicles. DOE would pave the areas around each building with asphalt to control dust. The entire site would be fenced and exterior lighting would be installed. These buildings would replace the more than 100 temporary structures (for example, storage containers, trailers, and tents) that DOE currently uses for workshops, equipment fabrication and repair, warehousing, and offices.

The existing options for the disposal of temporary structures would include the Nevada Test Site landfills in Areas 23 and 9, and the Crestline landfill in Lincoln County and Apex landfill in Clark County, which the counties operate. Nye County is in the process of siting new landfill locations, so DOE could work cooperatively with the county to site and permit a new facility. Chapter 3, Section 3.1.12.1 provides information on solid waste disposal sites and their capacities.

4.3.1.4 Equipment Storage Pad

DOE would repair the 0.061-square-kilometer (15-acre) equipment storage pad approximately 1.6 kilometer (1 mile) southwest of the North Portal, which has been damaged over the years by natural erosion (Figure 4-10). The Department would repair this damage and improve drainage on the storage pad by leveling the area with up to 3,800 cubic meters (5,000 cubic yards) of borrow material from the existing excavated rock storage pile near the North Portal, existing borrow pits, a new borrow site at an unspecified location within 24 kilometers (15 miles), or a combination of these sources.

4.3.1.5 Sample Management Facility

DOE would construct a new Sample Management Facility near Gate 510 on Bureau of Land Management land outside the analyzed land withdrawal area. This facility would house a variety of samples from studies that included rock cores. Land disturbance would affect about 0.012 square kilometer (3 acres).

4.3.2 ENVIRONMENTAL IMPACTS

This section describes the potential environmental impacts for the proposed infrastructure improvements. Table 4-38 lists the estimated land disturbances, water requirements, and workforce for each proposed improvement.

Table 4-38. Estimated disturbances, water requirements, and workforce.

Infrastructure improvement	Disturbances[a] (square kilometers)	(acres)	Water requirements[b] (acre-feet)	Estimated new workers during construction[c]
Roads	0.89	220	200	40
Transmission line	0.12	30	6	16
Central operations area	0	0	47	100
Equipment storage pad	0	0	< 1	10
Sample Management Facility	0.012	3	< 1	30
Totals	1.0	253	255	196

Source: DIRS 178817-DOE 2006, p. 15.

a. Some of the land in this category has experienced small disturbances from previous activities.

b. The analysis assumed that construction would take 2 years, even though in some cases the activities would be completed sooner.

c. The workforce for the central operations area could include persons who already work on the Yucca Mountain Project.

4.3.2.1 Land Use and Ownership

Section 4.1.1 describes potential land use and ownership impacts from the Proposed Action. Under the Proposed Action, DOE would require a four-lane paved access road and two 138-kilovolt transmission lines; infrastructure improvements would require a two-lane access road and one 138-kilovolt transmission line.

The proposed infrastructure improvements would have negligible effects on existing or future land uses. Most of the affected land would be on the Nevada Test Site and the Nevada Test and Training Range. As Chapter 3, Section 3.1.2 describes, the U.S. Air Force has issued a right-of-way reservation that authorizes DOE to use certain land for the Yucca Mountain Project, which would include the crest road. The authorized use of Test Site land is based on a 2002 management agreement between DOE's Nevada Operations Office and Office of Repository Development. Because the improvements would not change the nature of current activities at Yucca Mountain, the actions would not affect operations at either the Test Site or the Range.

The proposed road upgrades could include the development of an aggregate pit at an unspecified location. The *Materials Act of 1947* governs access to and use of common varieties of sand, stone, and gravel on public lands by federal agencies; the Act authorizes the Bureau of Land Management to issue free-use permits for these materials. If the Department required the development of this pit, it would apply to the Bureau for a free-use permit. DOE would not open a new pit if an adequate quantity and quality of aggregate was available from the existing aggregate pits at Yucca Mountain west of H Road along Fran Ridge.

DOE would construct the Sample Management Facility near Gate 510 on Bureau of Land Management land outside the analyzed land withdrawal area, move the contents of the existing Sample Management Facility at the Field Operations Center, and dismantle the existing facility. The facility would require about 0.012 square kilometers (3 acres). Construction of the new facility would not affect the use of public land in the area.

4.3.2.2 Air Quality

Section 4.1.2 describes potential nonradiological air quality impacts from the Proposed Action. The potential environmental impacts from the infrastructure improvements would be smaller than those for the Proposed Action for criteria pollutants.

The potential impacts to air quality from the proposed infrastructure improvements would be small. Sources of air pollutants from the proposed improvements would be (1) dust from surface grading for roads, possible blasting for parts of the new road to the crest of Yucca Mountain, possible relocation or reuse of the existing excavated rock storage pile near the North Portal, vehicle travel on paved and unpaved roads, and wind erosion, and (2) combustion of fossil fuel by diesel- and gasoline-powered construction equipment.

Potential air quality impacts would result primarily from the disturbance of approximately 1 square kilometer (250 acres) of land (Table 4-38). Based on the results of dispersion modeling for this Repository SEIS, gaseous pollutants from fuel-burning equipment would be well below regulatory standards. Therefore, the primary criteria pollutant of concern would be PM_{10}. Emissions for the Proposed Action during the construction analytical period would result in concentrations of PM_{10} that would be no more than 40 percent of the standards. Therefore, the air quality impacts from infrastructure improvements would also be well within the PM_{10} standard.

Certain forms of hazardous silica dust could disperse into the atmosphere if DOE used the excavated rock storage pile near the North Portal for road or storage pad construction. Cristobalite is one of several forms of crystalline silica that occur in Yucca Mountain tuffs. Cristobalite is principally a concern for involved workers who could inhale the particles while performing their tasks. The Department would monitor the environment at and near the storage pile to ensure that workers were not exposed to harmful concentrations of this dust. If engineering controls were unable to maintain safe dust concentrations, DOE would use administrative controls such as access restrictions or respiratory protection (dust suppression, air filters, and personal protective gear) until engineering controls could reestablish safe conditions. DOE would apply the same monitoring and engineering controls to the storage piles as it would to construction sites where the silica could be present. Section 4.1.2.1 discusses the potential impacts related to cristobalite.

4.3.2.3 Hydrology

Section 4.1.3 describes the potential environmental impacts to hydrological resources at Yucca Mountain from the Proposed Action. This infrastructure improvement analysis evaluated potential impacts to these resources in three areas: surface water, groundwater quality, and water demand.

Water demand for dust suppression would be smaller than that for the construction of the four-lane road to support repository construction and operation and would not be concurrent with water demand for repository construction. Potential contamination of groundwater and the volume of surface runoff would also be smaller than that under the Proposed Action.

4.3.2.3.1 *Surface Water*

Potential impacts to surface water, drainages, and floodplains from the infrastructure improvements would be small. Disturbed and loosened ground would generate less runoff and more infiltration and possibly be more susceptible to erosion during heavy precipitation, but this would occur only during construction. At the completion of construction, DOE would either cover most disturbed areas with impermeable surfaces (structures or asphalt) or compact them, at which time runoff rates could increase. In any case, changes to infiltration and runoff rates would be limited to relatively small areas of disturbed land; DOE would take precautions during construction to minimize erosion. DOE would control the use of petroleum, oil, lubricants, and other hazardous materials during construction; the Department would promptly clean up spills and remediate the soil and alluvium. The designs of road crossings at washes would maintain the flow of water through culverts and prevent erosion up- and downstream of the crossings. The proposed road upgrades would require improvement of the access road that crosses Fortymile Wash and would extend along Drill Hole Wash to near the point it is joined by Midway Valley (Sever) Wash. This construction would affect both Fortymile and Drill Hole washes, including their floodplains, but the impacts would be small. Appendix C contains the floodplain and wetlands assessment for this Repository SEIS. Section C.2.2 discusses proposed infrastructure improvements.

Improvement of the road that crosses Fortymile Wash would require placement of fill in the channels of the wash. Raising the road across Fortymile Wash would require about 0.00081 square kilometer (0.2 acre) of new fill. Replacement of the access road near the joined Drill Hole, Midway Valley, and Fortymile washes could require modification of the flow channel of Drill Hole Wash. Improvement of the access road in this area could have beneficial effects on surface-water flow because the drainage area design; construction would reduce erosion along the existing road and accommodate the combined flow from Drill Hole and Midway Valley washes more appropriately. Culverts (which would generally be designed to accommodate a 100-year flood) would have small impacts on surface water or other resources because DOE would design and construct them to minimize erosion and the associated sediment transport and to accommodate the flow in the washes during storms.

DOE would, if required, obtain a permit from the U.S. Army Corps of Engineers for construction in waters that meet the criteria for jurisdictional waters of the United States. Fortymile Wash, a tributary of the *Amargosa River*, and some of its tributaries in and near the geologic repository operations area might be waters of the United States.

4.3.2.3.2 *Groundwater Quality*

The proposed infrastructure improvements would have small impacts on the quality of groundwater because the water table varies from 270 to 760 meters (900 to 2,500 feet) below the surface. DOE would remediate inadvertent spills of hazardous materials and would not allow such material to reach the water table.

4.3.2.3.3 *Water Demand*

The quantity of groundwater necessary for the proposed infrastructure improvements would be 315,000 cubic meters (255 acre-feet) over a 2-year period. DOE would pump the water from wells at Yucca Mountain in the western two-thirds of the Jackass Flats basin. Of the water demand over the 2-year period, an average of about 80 percent would be for access road construction, including water for compaction of material and dust suppression. Less than 1 percent of the total water demand at the site would be for construction worker consumption. Construction workers would generally not shower on the site .

The lowest estimate of perennial yield for this part of the Jackass Flats basin is 720,000 cubic meters (584 acre-feet). The impacts to regional water availability would be less than the estimated minimum perennial yield for the Jackass Flats basin. The water demand estimates in Section 4.1.3 include the estimates for construction of a four-lane access road and other site improvements.

4.3.2.4 Biological Resources and Soils

Section 4.1.4 describes potential environmental impacts from the Proposed Action on biological resources and soils. Potential impacts to biological resources from the proposed infrastructure improvements involve four areas: (1) vegetation, (2) wildlife, (3) special-status species, and (4) soils. Impacts to plants, animals, and special-status species would be the same or smaller than those under the Proposed Action in that there would be less land disturbance and habitat loss and construction analytical periods would be shorter.

4.3.2.4.1 *Vegetation*

Potential impacts to vegetation from the infrastructure improvements would be small. Construction of the access road and transmission line would remove vegetation on about 1 square kilometer (250 acres), (Table 4-38). Soil compaction would change the physical structure of the soil and would probably reduce the reestablishment of native species. Dust from construction would stress downwind plant communities by covering leaves and reducing photosynthetic capacity. This impact would be temporary and would end when sufficient rain and wind removed the dust from the leaves.

Clearing native vegetation and disturbing the soil would create habitat for nonnative invasive plant species. These plants often out-compete native species and generally have little or no value for native wildlife. The seeds of *nonnative species* can spread into surrounding undisturbed areas by wind and wildlife, as well as by workers and construction equipment. Because many nonnative plant species are annuals or grasses that generate large amounts of litter, the potential for fires is generally higher than in nearby areas of native vegetation. After construction was complete, DOE would revegetate unneeded disturbed areas (Section 4.1.4) and would control invasive species on those sites.

4.3.2.4.2 *Wildlife*

Potential impacts to wildlife from the proposed infrastructure improvements would be small. The proposed road and transmission line construction would disturb about 1 square kilometer (250 acres) much of which earlier activities had disturbed (Table 4-38). These are very small areas in comparison to the large amount of surrounding undisturbed, similar habitat.

Loss of habitat would adversely affect some large and small animals (for example, burros, mule deer, birds, and reptiles). Construction noise could startle birds and other animals, including game species, and they would tend to avoid contact with humans by moving to other areas. Construction equipment could crush or smother animals that use underground habitats, such as rodents, snakes, desert tortoises, kit foxes, and burrowing owls. Wildlife deaths could also occur from collisions with vehicles traveling to and from Yucca Mountain. New manmade structures would provide additional perches for raptors, which could result in an increase in predation of lizards, snakes, rodents, and tortoises.

If construction occurred during the migratory bird nesting season (generally May 1 to July 15 at Yucca Mountain), DOE would have a qualified biologist survey areas before it began activities in those areas. If the survey found active nests, DOE would delineate a buffer zone around the nests in which it would avoid disturbance until the young birds fledged. Therefore, the proposed activities would be unlikely to result in deaths or otherwise to disturb nesting migratory birds.

4.3.2.4.3 *Special-Status Species*

Potential impacts to special-status species from the proposed infrastructure improvements would be small. The desert tortoise is the only species (animal or plant) in the affected area that the U.S. Fish and Wildlife Service lists as threatened under the *Endangered Species Act*. There are no listed *endangered species*. The Fish and Wildlife Service concluded in a Biological Opinion issued in 2001 that construction activities at Yucca Mountain would be unlikely to jeopardize the Mojave population of the desert tortoise. DOE included that opinion in the Yucca Mountain FEIS (DIRS 155970-DOE 2002, Appendix O). However, construction activities could kill or injure some tortoises, and there could be an increase in the number of ravens or other predators of tortoises due to additional perching sites on manmade structures. DOE would implement the terms and conditions in the Fish and Wildlife Service biological opinion to protect the desert tortoise.

Chapter 3, Table 3-7 lists other special-status animal species that do or might occur at Yucca Mountain. The proposed infrastructure improvements would result in the loss of habitat for a small number of chuckwallas, loggerhead shrikes, burrowing owls, and some other migratory birds. These species occur widely in neighboring undisturbed areas, so the overall impacts to these species would be small. The described actions to protect migratory birds would also protect these species from direct mortality or destruction of active nests.

4.3.2.4.4 *Soils*

Construction and operation of the infrastructure improvements would result in disturbed land and expose soil materials to potential loss by wind and water erosion. DOE would stockpile topsoil to reclaim disturbed areas. To further minimize soil loss, the Department would control fugitive dust by water spraying, chemical treatment, and wind fences. Control of stormwater runoff would minimize soil erosion. Because the areas of disturbance would be smaller for the infrastructure improvements than for the Proposed Action, the potential for soil loss would be smaller.

4.3.2.5 Cultural Resources

Land disturbances for proposed infrastructure improvements could have impacts to cultural resources. DOE surveyed the *alignment* of the proposed new access road during 2005 and 2006 to determine the nature and extent of cultural resources. Because of these surveys, DOE moved the corridor for the access road east to avoid cultural sites near Fortymile Wash.

As Section 4.1.5 of this Repository SEIS states, the Yucca Mountain FEIS concluded that 51 archaeological sites were recommended as eligible for inclusion in the *National Register of Historic Places* by DOE. DOE has revised this number to 232 archaeological sites. The revised number reflects recent investigations for the U.S. Highway 95 access road and a reevaluation of the importance of obsidian artifacts. Recent studies suggest that obsidian artifacts can provide important information on prehistoric American Indian settlement systems. The large increase in the number of eligible archaeological sites since completion of the FEIS reflects this finding and includes extractive localities, processing localities, or manufacture stations where American Indians used obsidian as a stone tool material.

Before beginning other land disturbances (for example, expansions at existing sites and alignments), DOE would conduct preconstruction surveys to identify cultural sites in the affected areas. The Department would then evaluate identified sites for their importance and eligibility for inclusion in the *National Register of Historic Places*. DOE would include American Indian monitors in all surveys to identify cultural sites in the affected areas. In addition, the Department has implemented a worker education program on the protection of archaeological sites and artifacts to limit direct and indirect impacts to them. DOE would work collaboratively with the Consolidated Group of Tribes and Organizations to involve tribal representatives in the worker education program.

4.3.2.6 Socioeconomics

Section 4.1.6 describes the potential socioeconomic impacts of the Proposed Action. The socioeconomic impacts of the infrastructure improvements would be smaller than those under the Proposed Action because the associated construction workforce would be smaller and the construction analytical period would be shorter.

The proposed infrastructure improvements would have small socioeconomic impacts. Construction would require a maximum of 196 workers for 2 years (Table 4-38). Most of these workers would probably come from the metropolitan Las Vegas area. In comparison, construction employment at a repository at Yucca Mountain would peak at 2,590 jobs, of which 1,090 would be newly created. That level of employment would be less than a 0.2-percent increase in total regional employment and, therefore, would have even smaller socioeconomic impacts.

Although Yucca Mountain site employment numbers have dropped significantly since late 1995, the estimated workers necessary for the infrastructure improvements could come from the existing workforce and would have little impact on the regional economy or on employment, economics, population, housing, and public services.

4.3.2.7 Occupational and Public Health and Safety

Section 4.1.7 describes the potential health and safety impacts to workers (occupational impacts) and to members of the public (public impacts) from the Proposed Action. It also reports the most recent accident rates from the CAIRS database. Infrastructure improvements would employ fewer people and have a shorter construction analytical period; therefore, the potential impacts would be smaller than those of the Proposed Action. There would be no radiological issues in relation to the improvements. In addition, the purpose of the infrastructure improvements would be to enhance and ensure that continued scientific testing, exploration work, and maintenance could occur safely.

From an occupational health and safety standpoint, the types of potential health and safety impacts workers encountered would include industrial hazards common to construction work sites and potential exposure to naturally occurring cristobalite.

The possibility that DOE would use material from the excavated rock storage pile near the North Portal for road construction and leveling of the site for the central operations area could result in exposure to cristobalite. Based on the content of cristobalite in the rock, the storage pile could have a cristobalite content between 18 and 28 percent. DOE would implement engineering controls to limit dust emissions, continually monitor concentrations and, if monitoring showed concentrations were too high or above the threshold limits, limit operations. If engineering controls were unable to maintain dust concentrations below the limits, DOE would use administrative controls such as access restrictions, employee rotations, and respiratory protection until engineering controls could reestablish safe conditions. DOE would apply the same engineering and administrative controls to construction sites where silica could be present as it would for the storage pile. Section 4.1.2.1 discusses potential impacts in relation to cristobalite.

Potential health impacts to members of the public would occur from emissions from fossil fuels and PM_{10}. In both cases the potential impacts would be small (Section 4.3.2.2).

4.3.2.8 Accident Scenarios

There would be no radiological impacts from any accident that involved the infrastructure improvements. The occupational health and safety impact discussions in Sections 4.3.2.7 and 4.1.7.1 include impacts from industrial accidents.

4.3.2.9 Noise

Section 4.1.9 describes potential noise impacts to workers and the public from the Proposed Action. Noise impacts from the infrastructure improvements would be similar to those estimated for the Proposed Action; however, these impacts would be temporary. Noise from construction activities for a two-lane road would not be notably less than that for a four-lane road. The construction of the offsite facilities would also be similar to that of the Proposed Action.

Sources of noise would include construction of the access road from U.S. Highway 95 to Gate 510, an electrical transmission line, and the Sample Management Facility. Activities would involve typical construction equipment (such as bulldozers, graders, loaders, and pavers). This type of equipment generates noise at 85 dBA at 15 meters (50 feet). Noise and sound levels would be typical of new construction activities and would be intermittent. The distance from Gate 510 to the intersection of Nevada State Route 373 and U.S. Highway 95 is approximately 3.2 kilometers (2 miles). The nearest permanent residents would be in the town of Amargosa Valley, which is southwest of the intersection of U.S. Highway 95 and State Route 373. The analysis assumed the maximally exposed member of the public would be 100 meters (300 feet) from offsite construction activities. Section 4.1.2.1 discusses this individual. Because of the distance between construction activities and receptors, DOE does not expect noise impacts to the public from the construction of infrastructure improvements.

Traffic noise on the access road would not exceed or significantly add to the existing traffic noise on U.S. Highway 95. Noise from operations after construction would be typical of commercial environments and would have no impacts.

4.3.2.10 Aesthetics

Section 4.1.10 describes the potential aesthetics impacts of the Proposed Action. Aesthetics impacts from the infrastructure improvements would be similar to those DOE estimated for the Proposed Action because the landscape intrusions would be of the same type but could have a smaller scope. The transmission line would be a noticeable linear feature, but most of it would traverse remote areas.

Construction equipment, facilities, and activities would be potential sources of impacts to visual resources during construction of roads, a transmission line, and the Sample Management Facility. Casual observers might see or be attracted to the presence of workers, vehicles, and the generation of dust and vehicle exhaust. As Section 4.1.10 notes, the crest road would not be visible from offsite locations.

DOE would reclaim disturbed areas once construction was complete. Considering the effect of best management practices for construction projects, construction activities would be noticeable but would not dominate the attention of the viewer. Therefore, there would be small project-related visual impacts during construction.

4.3.2.11 Utilities, Energy, Materials, and Site Services

Section 4.1.11 discusses impacts to residential water, energy, materials, and site services from the Proposed Action. In all aspects, the impacts from the infrastructure improvements would be smaller than those from the Proposed Action because the scope of the activities would be smaller.

Section 4.3.2.3.3 discusses water demand for the proposed infrastructure improvements. The electricity demand for construction would be well within the supply capacity in the southern Nevada region (Chapter 3, Section 3.11.1). Nevada Power Company, which supplies electricity to southern Nevada, sold 21 million megawatt-hours in 2005. Construction would consume a variety of fossil fuels that included gasoline, heating oil, diesel fuel, propane, and kerosene. Overall, impacts on the regional supply of fossil fuels would be small. The fossil-fuel system in the State of Nevada has sufficient capacity to meet normal Nevada demands.

Impacts to existing emergency services, law enforcement, fire protection, and medical services at Yucca Mountain would be negligible because construction would not involve a substantial increase in the number of workers.

4.3.2.12 Management of Repository-Generated Waste and Hazardous Materials

Section 4.1.12 describes quantities of waste the Proposed Action would generate. Wastes from construction of a four-lane access road and two transmission lines would be greater than the wastes for a two-lane access road and one transmission line. Estimates of generated waste for the Proposed Action include the debris from dismantlement of the temporary structures at the North Portal and the existing Sample Management Facility at the Field Operations Center.

The proposed infrastructure improvements would generate increased volumes of nonhazardous solid waste, construction debris, hazardous waste, recyclables, sanitary sewage, and wastewater, but the additions would be small in comparison with waste generation for the Proposed Action. Chapter 3, Section 3.1.12.1 provides landfill capacities within Nevada.

4.3.2.13 Environmental Justice

Section 4.1.13 describes the analysis of environmental justice in terms of the potential for disproportionately high and adverse impacts to minority or low-income populations. DOE has not identified any high and adverse potential impacts to members of the public. Further, DOE has not identified subsections of the population, including minority or low-income populations, that would receive disproportionate impacts, and it has identified no unique exposure pathways, sensitivities, or cultural practices that would expose minority or low-income populations to disproportionately high and adverse impacts. Therefore, this SEIS concludes that no disproportionately high and adverse impacts would result from these improvements.

4.3.3 BEST MANAGEMENT PRACTICES AND MITIGATION MEASURES

DOE would implement a variety of environmental protection measures and best management practices for the infrastructure improvements to avoid or mitigate potential adverse effects. Table 4-39 summarizes these measures and practices for each resource area.

4.3.3.1 Unavoidable Adverse Impacts

With the successful implementation of the best management practices and mitigation measures, unavoidable adverse impacts would be small. The small impacts would occur to fossil fuels, building materials, and land disturbance.

Table 4-39. Best management practices and mitigation measures.

Resource	Practices and measures
Land use	DOE would consult with and obtain right-of-way from the Bureau of Land Management for activities on public land. It would follow the mitigation measures and stipulations.
	DOE would coordinate with Nye County in relation to the construction schedule and possible conflicts with any off-road vehicle events on public lands in the affected area.
Air quality	DOE would consult with the Nevada Bureau of Air Pollution Control about the possible need to modify the current air quality operating permit for operations. Stipulations in the permit would minimize impacts to air quality.
Hydrology	DOE would obtain a Construction Storm Water Permit from the Nevada Division of Environmental Protection that would include preparation of a Storm Water Pollution Prevention Plan. This plan would include established best management practices for the control of erosion and pollution while constructing crossings and working in dry washes.
	DOE would, as necessary, obtain a Section 404 permit from the U.S. Army Corps of Engineers for construction in washes that meet the Corps' criteria as jurisdictional waters of the United States and would implement mitigation measures and best management practices in the permit.
Biological resources	
Wildlife	If construction occurred during migratory bird-nesting season, a qualified biologist would survey areas before the start of construction. If the survey found active nests, DOE would delineate a buffer zone around nests, within which disturbance would not occur until the young birds fledged. The size of the protective buffer would depend on species-specific requirements.
Vegetation	Where appropriate, DOE would restore areas affected by grading, plowing, or trenching to their approximate original contours in accordance with the *Reclamation Implementation Plan* for Yucca Mountain (DIRS 154386-YMP 2001, all).
Special-status species	DOE would follow the mitigation measures for the protection of desert tortoises required by the U.S. Fish and Wildlife Service's 2001 Biological Opinion on Yucca Mountain (DIRS 155970-DOE 2002, Appendix O).
	DOE would clearly mark populations of special-status plant or animal species discovered during preconstruction surveys with flagging or caution tape and would require construction contractors to inform crews about the importance of avoiding flagged areas.
Cultural resources	DOE would conduct preconstruction surveys to identify cultural sites in the potentially affected areas. It would evaluate each site for eligibility for inclusion in the *National Register of Historic Places*. Where practicable, DOE would avoid sites or, if not practicable, would collect artifacts at eligible sites in accordance with Section 106 of the *National Historic Preservation Act* and document the findings. DOE would include American Indian monitors in all surveys to identify cultural sites in the affected area. In addition, DOE has implemented a worker education program on the protection of archaeological sites and artifacts to limit direct and indirect impacts to them. DOE would work collaboratively with the Consolidated Group of Tribes and Organizations to involve tribal representatives in the worker education program.
Occupational and public health and safety	If engineering controls were unable to maintain safe concentrations of silica dust during possible use of the excavated rock storage pile near the North Portal for road construction and surface leveling, DOE would use respiratory protection (air filters, or personal protective gear) until engineering controls could reestablish safe conditions.
Noise	DOE would conduct construction activities only during daylight hours.
Aesthetics	DOE would use shielded or down-directed and dark-sky-friendly lighting at the central operations area and at other new facilities at Yucca Mountain to minimize the amount of night lighting visible from offsite locations.

Table 4-39. Best management practices and mitigation measures (continued).

Resource	Practices and measures
Environmental justice	Through the ongoing Native American Interaction Program, DOE would continue to solicit input from the 17 tribes and organizations that have cultural and historic ties to the Yucca Mountain area. Through this program, the tribes and organizations can express their views and concerns about the management of cultural resources and related issues. DOE would include American Indian monitors in all surveys to identify cultural sites in the affected area. In addition, DOE has implemented a worker education program on the protection of archaeological sites and artifacts to limit direct and indirect impacts to them. DOE would work collaboratively with the Consolidated Group of Tribes and Organizations to involve tribal representatives in the worker education program.

4.3.4 CUMULATIVE IMPACTS

A cumulative impact is an impact on the environment that results from the incremental impact of the action when it is added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions. Chapter 8 provides more detail on cumulative impacts for the actions in the following sections.

4.3.4.1 Land Withdrawal To Study a Corridor for a Proposed Rail Line to Yucca Mountain

On December 28, 2005, acting on an application from DOE, the Secretary of the Interior published Public Land Order No. 7653 that withdrew for 10 years about 1,250 square kilometers (310,000 acres) of public land around the potential rail lines under study from the staking of new mining claims (70 FR 76854).

The withdrawal does not result in any surface disturbances, and it does not affect the development of existing valid mining claims. It does, however, preclude the staking of new claims on these public lands, which include lands in the vicinity of Yucca Mountain. Those lands are west of the area that infrastructure improvements would affect and are a subset of the broader analyzed land withdrawal area for the repository. This action would not result in cumulative impacts.

4.3.4.2 Activities on the Nevada Test and Training Range

The U.S. Air Force operates the Nevada Test and Training Range. The *Renewal of the Nellis Air Force Range Land Withdrawal: Legislative Environmental Impact Statement* (DIRS 103472-USAF 1999, all) addressed potential environmental impacts of extending the land withdrawal for military activities by the Air Force. The land withdrawal renewal for the Range was approved, and activities on the Range have continued to evolve with changing military needs. In general, however, current and future developments at the Range would have small cumulative impacts with the proposed infrastructure improvements because the impacts would not occur on those Air Force lands that DOE uses for operations at Yucca Mountain.

On January 10, 2007, the Bureau of Land Management announced that DOE had filed an application to request a second land withdrawal (72 FR 1235). The application is for an additional 842 square kilometers (208,000 acres) from surface entry and mining to December 27, 2015.

4.3.4.3 Nevada Test Site Activities

The Nevada Test Site has been the nation's proving ground for the development and testing of nuclear weapons. From 1951 to 1992, DOE and its predecessor agencies conducted more than 900 tests at the site. Current activities at the Test Site include the management of radioactive and hazardous wastes; weapons stockpile, stewardship, and management; materials disposition; nuclear emergency response; and nondefense research and development. Past and present activities, specifically in Area 25 where many of the facilities for the Yucca Mountain Project are, would be part of the affected environment. Current and future Test Site activities in Area 25 that could have cumulative impacts with the infrastructure improvements include the continued withdrawal of groundwater for Test Site operations.

The small incremental cumulative impacts would include land disturbance, water use, waste generation, noise, and emissions from construction equipment and fugitive dust. The impacts would be temporary.

4.3.4.4 Yucca Mountain Project Gateway Area Concept Plan

Nye County has prepared a Yucca Mountain Gateway Area Concept Plan with proposed land use designations for the area around the proposed Yucca Mountain Repository entrance. Chapter 8 of this Repository SEIS contains Nye County's perspective on cumulative impacts and discusses the role of the land use concept plan as guidance for the management of development near the entrance area. Nye County proposed this plan to ensure land development would occur in an orderly manner while increasing the opportunities for industrial and commercial development. Nye County views this plan as a starting point for development of the infrastructure, institutional capacity, and facilities that would be consistent with the proposed repository land use.

There are no specific proposals for development, but incremental cumulative impacts could include additional disturbed land, water use, emissions from construction equipment, fugitive dust, waste generation, and noise.

4.3.4.5 Desert Space and Science Museum

Nye County proposes to construct a Desert Space and Science Museum and commercial facilities in the area of the Gateway Area Concept Plan. Under the proposal, the Bureau of Land Management would transfer 3.3 square kilometers (820 acres) to Nye County, of which 0.4 square kilometer (100 acres) would have permanent developed facilities. Nye County would manage the remaining 2.9 square kilometers (720 acres) for natural resource and habitat values.

The museum would result in some additional water use and employment that could affect the regional economy. Other incremental cumulative impacts would occur only during infrastructure construction and would include emissions from construction equipment, fugitive dust, and noise.

REFERENCES

102043	AIWS 1998	AIWS (American Indian Writers Subgroup) 1998. *American Indian Perspectives on the Yucca Mountain Site Characterization Project and the Repository Environmental Impact Statement.* Las Vegas, Nevada: Consolidated Group of Tribes and Organizations. ACC: MOL.19980420.0041.
152803	Bland 1998	Bland, J. 1998. "Cask Manufacturing Multipliers." E-mail from J. Bland (CRWMS M&O) to K. House, August 5, 1998 with attachments. Las Vegas, Nevada. ACC: MOL.2001101.0238.
178610	Bland 2007	Bland, J. 2007. "Baseline: REMI Policy Insight, Version 9, Last History Year 2004." E-mail from J. Bland to E. Gorsem, January 10, 2007, with attachment. ACC: MOL.20070119.0084.
182205	Bland 2007	Bland, J. 2007. "Staffing for the Repository: SEIS." E-mail from J. Bland to S. Walker, April 12, 2007, with attachment. ACC: MOL.20070806.0013; MOL.20070806.0014.
182642	Bland 2007	Bland, J.B. 2007. *SEIS Socioeconomic Inputs-Outputs: Residential Patterns of Changing Employment, Assume 20% of Site Workers Live in Nye County - Scenario One.* Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20070822.0018.
101505	BLM 1986	BLM (Bureau of Land Management) 1986. *Visual Resource Inventory.* BLM Manual Handbook 8410-1. Washington, D.C.: U.S. Bureau of Land Management. ACC: MOL.20010730.0378.
173053	BLM 1986	BLM (Bureau of Land Management) 1986. *Visual Resource Contrast Rating, BLM Manual Handbook 8431-1.* Washington, D.C.: Bureau of Land Management. ACC: MOL.20050406.0040.
103079	BLM 1998	BLM (Bureau of Land Management) 1998. *Proposed Las Vegas Resource Management Plan and Final Environmental Impact Statement.* Three volumes. Las Vegas, Nevada: Bureau of Land Management. ACC: MOL.20010724.0319.
176043	BLM 1998	BLM (Bureau of Land Management) 1998. *Record of Decision for the Approved Las Vegas Resource Management Plan and Final Environmental Impact Statement.* Las Vegas, Nevada: Bureau of Land Management, Las Vegas Field Office. ACC: MOL.20060313.0209.

181921	BLS n.d.	BLS (Bureau of Labor Statistics) n.d. *Table A-1. Fatal Occupational Injuries by Industry and Event or Exposure, All United States, 2003.* Washington, D.C.: U.S. Department of Labor, Bureau of Labor Statistics. ACC: MOL.20070724.0356.
181922	BLS n.d.	BLS (Bureau of Labor Statistics) n.d. *Table A-1. Fatal Occupational Injuries by Industry and Event or Exposure, All United States, 2004.* Washington, D.C.: U.S. Department of Labor, Bureau of Labor Statistics. ACC: MOL.20070724.0357.
181924	BLS n.d.	BLS (Bureau of Labor Statistics) n.d. *Table A-1. Fatal Occupational Injuries by Industry and Event or Exposure, All United States, 2005.* Washington, D.C.: U.S. Department of Labor, Bureau of Labor Statistics. ACC: MOL.20070724.0358.
181925	BLS n.d.	BLS (Bureau of Labor Statistics) n.d. *"Table 1. Incidence Rates of Nonfatal Occupational Injuries and Illnesses by Industry and Selected Case Types, 2001.* Washington, D.C.: U.S. Department of Labor, Bureau of Labor Statistics. ACC: MOL.20070724.0351.
181926	BLS 2003	BLS (Bureau of Labor Statistics) 2003. *Table 1. Incidence Rates of Nonfatal Occupational Injuries and Illnesses by Industry and Case Types, 2002.* Washington, D.C.: U.S. Department of Labor, Bureau of Labor Statistics. ACC: MOL.20070724.0352.
181927	BLS 2005	BLS (Bureau of Labor Statistics) 2005. *Table 1. Incidence Rates of Nonfatal Occupational Injuries and Illnesses by Industry and Case Types, 2003.* Washington, D.C.: U.S. Department of Labor, Bureau of Labor Statistics. ACC: MOL.20070724.0353.
181928	BLS 2005	BLS (Bureau of Labor Statistics) 2005. *Table 1. Incidence Rates of Nonfatal Occupational Injuries and Illnesses by Industry and Case Types, 2004.* Washington, D.C.: U.S. Department of Labor, Bureau of Labor Statistics. ACC: MOL.20070724.0354.
181929	BLS 2006	BLS (Bureau of Labor Statistics) 2006. *Table 1. Incidence Rates of Nonfatal Occupational Injuries and Illnesses by Industry and Case Types, 2005.* Washington, D.C.: U.S. Department of Labor, Bureau of Labor Statistics. ACC: MOL.20070724.0355.

185184	BLS 2008	BLS (Bureau of Labor Statistics) 2008. "Table A-1. Fatal Occupational Injuries by Industry and Event or Exposure, All United States, 2006." *Census of Fatal Occupational Injuries (CFOI) - Current and Revised Data*. Washington, D.C.: U.S. Department of Labor, Bureau of Labor Statistics. Accessed March, 4, 2008. ACC: MOL.20080306.0050. URL: http://www.bls.gov/iif/oshwc/cfoi/cftb0214.pdf
185185	BLS 2008	BLS (Bureau of Labor Statistics) 2007. "Table 1. Incidence Rates of Nonfatal Occupational Injuries and Illnesses by Industry and Case Types, 2006." *Industry Injury and Illness Data.* Washington, D.C.: U.S. Department of Labor, Bureau of Labor Statistics. Accessed March 4, 2008. ACC: MOL.20080306.0051. URL: http://www.bls.gov/iif/oshwc/osh/os/ostb1765.pdf
169734	BSC 2004	BSC (Bechtel SAIC Company) 2004. *Yucca Mountain Site Description*. TDR-CRW-GS-000001 Rev02 ICN 01, April 2004. Las Vegas, Nevada. ACC: DOC.20040504.0008.
179303	BSC 2006	BSC (Bechtel SAIC Company) 2006. *Low-Level Waste Management Plan.* 000-30R-MW00-00100-000 Rev 000. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20061218.0016.
177510	BSC 2007	BSC (Bechtel SAIC Company) 2007. *General Public Atmospheric Dispersion Factors.* 000-00C-MGR0-02800-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070329.0001.
180185	BSC 2007	BSC (Bechtel SAIC Company) 2007. *Characteristics for the Representative Commercial Spent Fuel Assembly for Preclosure Normal Operations.* 000-PSA-MGR0-00700-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070521.0008.
183261	BSC 2007	BSC (Bechtel SAIC Company) 2007. *Yucca Mountain Project Drainage Report and Analysis.* 000-CDC-MGR0-00100-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070924.0043.
182322	BSC 2007	BSC (Bechtel SAIC Company) 2007. *Concepts for Waste Retrieval and Alternate Storage of Radioactive Waste.* 800-30R-HER0-00100-000 Rev 004. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070604.0013.
183160	BSC 2007	BSC (Bechtel SAIC Company) 2007. *General Public Atmospheric Dispersion Factors.* 000-00C-MGR0-02800-000-00B. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070813.0003.

173226	Buqo 2004	Buqo, T.S. 2004. *Nye County Water Resources Plan*. Pahrump, Nevada: Nye County, Department of Natural Resources and Federal Facilities. ACC: MOL.20050418.0041.
181932	Bureau of the Census n.d.	Bureau of the Census n.d. "Metropolitan Areas - Personal Income and Earnings by Industry." Table B-8 of *State and Metropolitan Area Data Book: 2006.* Pages 162-167. Washington, D.C.: U.S. Census Bureau. ACC: MOL.20070724.0366.
182017	Bureau of the Census 2005	Bureau of the Census 2005. "2002 Economic Census, Summary Statistics by 2002 NAICS Worcester, MA Metropolitan Statistical Area." *2002 Economic Census*, *Geographic Area Series.* Washington, D.C.: U.S. Census Bureau. Accessed July 18, 2007. ACC: MOL.20070724.0371. URL: http://www.census.gov/econ/census02/data/metro4/M49340.htm
182018	Bureau of the Census 2005	Bureau of the Census 2005. "2002 Economic Census, Nonemployer Statistics Worcester, MA Metropolitan Statistical Area." *2002 Economic Census, Nonemployer Statistics.* Washington, D.C.: U.S. Census Bureau. Accessed July 18, 2007. ACC: MOL.20070724.0372. URL: http://www.census.gov/epcd/nonemployer/2002/M14849340.htm
182020	Bureau of the Census 2005	Bureau of the Census 2005. "2002 Economic Census, Summary Statistics by 2002 NAICS Greensboro-High Point, NC Metropolitan Statistical Area." *2002 Economic Census, Geographic Area Series.* Washington, D.C.: U.S. Census Bureau. Accessed July 18, 2007. ACC: MOL.20070724.0373. URL: http://www.census.gov/econ/census02/data/metro2/M24660.htm
181933	Bureau of the Census n.d.	Bureau of the Census n.d. "Metropolitan Areas - Labor Force and Private Business Establishments and Employment." Table B-9 of *State and Metropolitan Area Data Book: 2006.* Pages 168-173. Washington, D.C.: U.S. Census Bureau. ACC: MOL.20070724.0365.
181937	Bureau of the Census n.d.	Bureau of the Census n.d. "Metropolitan Areas - Population by Age, Race, and Sex." Table B-3 of *State and Metropolitan Area Data Book: 2006.* Pages 132-137. Washington, D.C.: U.S. Census Bureau. ACC: MOL.20070724.0364.
181938	Bureau of the Census n.d.	Bureau of the Census n.d. "Resident Population by Race, Hispanic or Latino Origin, and State: 2005." Table 23 of *Statistical Abstract of the United States: 2007.* Page 26. Washington, D.C.: U.S. Census Bureau. ACC: MOL.20070724.0363.

181940	Bureau of the Census n.d.	Bureau of the Census n.d. "Individuals and Families Below Poverty Level-Number and Rate by State: 2000 and 2004." Table 690 of *Statistical Abstract of the United States: 2007.* Page 457. Washington, D.C.: U.S. Census Bureau. ACC: MOL.20070724.0361.
182021	Bureau of the Census 2005	Bureau of the Census 2005. "2002 Economic Census, Nonemployer Statistics Greensboro-High Point, NC Metropolitan Statistical Area." *2002 Economic Census, Nonemployer Statistics.* Washington, D.C.: U.S. Census Bureau. Accessed July 18, 2007. ACC: MOL.20070724.0374. URL: http://www.census.gov/epcd/nonemployer/2002/M26824660.htm
182022	Bureau of the Census 2005	Bureau of the Census 2005. "2002 Economic Census, Summary Statistics by 2002 NAICS Akron, OH Metropolital Statistical Area." *2002 Economic Census, Geographic Area Series.* Washington, D.C.: U.S. Census Bureau. Accessed July 18, 2007. ACC: MOL.20070724.0375. URL: http://www.census.gov/econ/census02/data/metro1/M10420.htm
182023	Bureau of the Census 2005	Bureau of the Census 2005. "2002 Economic Census, Nonemployer Statistics Akron, OH Metropolitan Statistical Area." *2002 Economic Census, Nonemployer Statistics.* Washington, D.C.: U.S. Census Bureau. Accessed July 18, 2007. ACC: MOL.20070724.0376. URL: http://www.census.gov/epcd/nonemployer/2002/M18410420.htm
182024	Bureau of the Census 2005	Bureau of the Census 2005. "2002 Economic Census, Summary Statistics by 2002 NAICS York-Hanover, PA Metropolitan Statistical Area." *2002 Economic Census, Geographic Area Series.* Washington, D.C.: U.S. Census Bureau. Accessed July 18, 2007. ACC: MOL.20070724.0377. URL: http://www.census.gov/econ/census02/data/metro4/M49620.htm
182026	Bureau of the Census 2005	Bureau of the Census 2005. "2002 Economic Census, Nonemployer Statistics York-Hanover, PA Metropolitan Statistical Area." *2002 Economic Census, Nonemployer Statistics.* Washington, D.C.: U.S. Census Bureau. Accessed July 18, 2007. ACC: MOL.20070724.0378. URL: http://www.census.gov/epcd/nonemployer/2002/M56449620.htm

182027	Bureau of the Census 2005	Bureau of the Census 2005. "2002 Economic Census, Summary Statistics by 2002 NAICS Chattanooga, TN-GA Metropolitan Statistical Area." *2002 Economic Census, Geographic Area Series.* Washington, D.C.: U.S Census Bureau. Accessed July 18, 2007. ACC: MOL.20070724.0379. URL: http://www.census.gov/econ/census02/data/metro1/M16860.htm
182028	Bureau of the Census 2005	Bureau of the Census 2005. "2002 Economic Census, Nonemployer Statistics Chattanooga, TN-GA Metropolitan Statistical Area." *2002 Economic Census, Nonemployer Statistics.* Washington, D.C.: U.S. Census Bureau. Accessed July 2, 2007. ACC: MOL.20070724.0380. URL: http://www.census.gov/epcd/nonemployer/2002/M17416860.htm
181931	Bureau of the Census 2006	Bureau of the Census 2006. "Metropolitan Areas - Area and Population." Table B-1 of *State and Metropolitan Area Data Book: 2006.* Washington, D.C.: Bureau of the Census. ACC: MOL.20070724.0367.
181939	Bureau of the Census 2006	Bureau of the Census 2006. "Metropolitan Areas with Component Counties - Population Characteristics and Housing Units." Table C-2 of *State and Metropolitan Area Data Book: 2006.* Pages 208-227. Washington, D.C.: U.S. Census Bureau. ACC: MOL.20070724.0362.
177702	CEQ 1997	CEQ (Council on Environmental Quality) 1997. *Environmental Justice Guidance Under the National Environmental Policy Act.* Washington, D.C.: Council on Environmental Quality. ACC: MOL.19881123.0604
182821	Converse Consultants 2005	Converse Consultants 2005. *Water Resources Assessment Report, Task 3.4, Rev. 0.* Converse Project No. 04-33110-01. Las Vegas, Nevada: Converse Consultants. ACC: ENG.20070614.0005.
104523	CRWMS M&O 1999	CRWMS M&O (Civilian Radioactive Waste Management System Management and Operating Contractor) 1999. *Engineering File - Subsurface Repository.* BCA000000-01717-5705-00005 Rev 02, DCN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990621.0157; MOL.19990615.0230.
150174	CRWMS M&O 1999	CRWMS M&O (Civilian Radioactive Waste Management System Management and Operating Contractor) 1999. *Effects of Topsoil Stockpiling on Soil Viability at Yucca Mountain, Nevada.* B00000000-01717-5705-00054 Rev00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000329.0681.

145966	CRWMS M&O 2000	CRWMS M&O (Civilian Radioactive Waste Management System Management & Operating Contractor) 2000. *Numerical Modeling of Groundwater Flow in the Death Valley Hydrographic Region: Basins 225-230*. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000228.0518.
101811	DOE 1996	DOE (U.S. Department of Energy) 1996. *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada.* DOE/EIS-0243. Las Vegas, Nevada: U.S. Department of Energy, Nevada Operations Office. ACC: MOL.20010727.0190; MOL.20010727.0191.
155970	DOE 2002	DOE (U.S. Department of Energy) 2002. *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*. DOE/EIS-0250F. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20020524.0314; MOL.20020524.0315; MOL.20020524.0316; MOL.20020524.0317; MOL.20020524.0318; MOL.20020524.0319; MOL.20020524.0320.
162638	DOE 2002	DOE (U.S. Department of Energy) 2002. *Supplement Analysis for the Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada*. DOE/EIS-0243-SA-01, July 2002. Las Vegas, Nevada: U.S. Department of Energy, National Nuclear Security Administration, Nevada Operations Office. ACC: MOL.20030409.0001.
172055	DOE 2004	DOE (U.S. Department of Energy) 2004. *Spill Prevention, Control, and Countermeasures Plan for Site Activities.* BAB000000-01717-4600-00009 Rev 02. Las Vegas, Nevada: U.S. Department of Energy, Office or Repository Development. ACC: DOC.20040329.0003.
178579	DOE 2004	DOE (U.S. Department of Energy) 2004. *Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements*. Second Edition. Washington, D.C.: U.S. Department of Energy, Office of NEPA Policy and Compliance. ACC: MOL.20070111.0019.

182204	DOE 2004	DOE (U.S. Department of Energy) 2004. *"Quick Source Guide, Revised Occupational Injury and Illness Case Classification Terminology, Office of Corporate Performance Assessment, September 2004 Quick Source Guides."* Washington, D.C.: U.S. Department of Energy, Office of Health, Safety and Security. Accessed July 30, 2007. ACC: MOL.20070806.0007. URL: http://www.hss.energy.gov/CSA/Analysis/cairs/quicksource.html
178817	DOE 2006	DOE (U.S. Department of Energy) 2006. *Draft Environmental Assessment for the Proposed Infrastructure Improvements for the Yucca Mountain Project, Nevada*. DOE/EA-1566. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: HQO.20060911.0011.
182198	DOE 2007	DOE (U.S. Department of Energy) 2007. "DOE and Contractor Injury and Illness Experience by Operation Type by Year and Quarter, 2001 through 2006, 4th Quarter." *DOE and Contractor Injury and Illness Experience by Year and Quarter, 2002 through 2007, 1st Qtr*. Washington, D.C.: U.S. Department of Energy. Accessed August 8, 2007. ACC: MOL.20070806.0010; MOL.20070810.0042. URL: https://cairs.hss.doe.gov/cairs/help/reports/dataqtr/menu.html
182199	DOE 2007	DOE (U.S. Department of Energy) 2007. "DOE and Contractor Injury and Illness Experience by Field Organization by Year by Quarter, 2001 through 2006, 4th Quarter." *DOE and Contractor Injury and Illness Experience by Year and Quarter, 2002 through 2007, 1st Qtr*. Washington, D.C.: U.S. Department of Energy. Accessed August 8, 2007. ACC: MOL.20070806.0011; MOL.20070810.0042.
185304	DOE 2008	DOE (U.S. Department of Energy) 2008. *Transportation, Aging and Disposal Canister System Performance Specification.* WMO-TADCS-000001, Rev. 1 ICN 1. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: DOC.20080331.0001.
185316	EIA n.d.	EIA (Energy Information Administration) n.d. "Table 3. State Emissions by Year (Million Metric Tons of Carbon Dioxide)." *Energy Emissions Data & Environmental Analysis of Energy Data.* Washington, D.C.: U.S. Department of Energy, Energy Information Administration. Accessed March 27, 2008. ACC: MOL.20080414.0050. URL: http://www.eia.doe.gov/environmental.html

176397	EIA 2005	EIA (Energy Information Administration) 2005. *Fuel Oil and Kerosene Sales 2004*. DOE/EIA-0535(04). Washington, D.C.: U.S. Department of Energy, Energy Information Administration. ACC: MOL.20060216.0167.
182203	EIA 2006	EIA (Energy Information Administration) 2006. "Table F1: Motor Gasoline Consumption, Price, and Expenditure Estimates by Sector, 2004." *State Energy Consumption, Price, and Expenditure Estimates (SEDS)*. Washington, D.C.: U.S. Department of Energy, Energy Information Administration. Accessed May 24, 2007. ACC: MOL.20070806.0008. URL: http://www.eia.doe.gov/emeu/states/_seds_updates.html
103243	EPA 1996	EPA (U.S. Environmental Protection Agency) 1996. *Ambient Levels and Noncancer Health Effects of Inhaled Crystalline and Amorphous Silica: Health Issue Assessment.* EPA/600/R-95/115. Research Triangle Park, North Carolina: U.S. Environmental Protection Agency. ACC: MOL.20010727.0172.
103245	EPA 1996	EPA (U.S. Environmental Protection Agency) 1996. *National Capacity Assessment Report: Capacity Planning Pursuant to CERCLA Section 104(c)(9).* EPA530-R-95-016. Washington, D.C.: U.S. Environmental Protection Agency. ACC: MOL.20010727.0171.
175452	EPA 1999	EPA (U.S. Environmental Protection Agency) 1999. *Cancer Risk Coefficients for Environmental Exposure to Radionuclides*. EPA 402-R-99-001. Federal Guidance Report No. 13. CD Supplement. Washington, D.C.: U.S. Environmental Protection Agency, Office of Radiation and Indoor Air. ACC: MOL.20020312.0287.
181916	EPA 1999	EPA (U.S. Environmental Protection Agency) 1999. "Facility SIC Report - Criteria Air Pollutants, Geographic Area: Worcester Co, MA." *AirData.* Washington, D.C.: U.S. Environmental Protection Agency. Accessed July 13, 2007. ACC: MOL.20070724.0337. URL: http://iaspub.epa.gov/airsdata/adnet.sic?geotype=co&geocode=25027&geoinfo=co%7E25027%7EWorcester+Co%2C+Massachusetts&pol=NOX+VOC+PM25&year=1999&fld=cnt&fld=count_pct&fld=emis&fld=emission_pct&rpp=25

181917	EPA 1999	EPA (U.S. Environmental Protection Agency) 1999. "Facility SIC Report - Criteria Air Pollutants, Geographic Area: Guilford Co, NC." *AirData.* Washington, D.C.: U.S. Environmental Protection Agency. Accessed July 13, 2007. ACC: MOL.20070724.0338. URL: http://iaspub.epa.gov/airsdata/adnet.sic?geotype=co&geocode=37081&geoinfo=co%7E37081%7EGuilford+Co%2C+North+Carolina&pol=NOX+VOC+PM25&year=1999&fld=cnt&fld=count_pct&fld=emis&fld=emission_pct&rpp=25
181918	EPA 1999	EPA (U.S. Environmental Protection Agency) 1999. "Facility SIC Report - Criteria Air Pollutants, Geographic Area: Hamilton Co, TN." *AirData.* Washington, D.C.: U.S. Environmental Protection Agency. Accessed July 13, 2007. ACC: MOL.20070724.0339. URL: http://iaspub.epa.gov/airsdata/adnet.sic?geotype=co&geocode=47065&geoinfo=co%7E47065%7EHamilton+Co%2C+Tennessee&pol=NOX+VOC+PM25&year=1999&fld=cnt&fld=count_pct&fld=emis&fld=emission_pct&rpp=25
181919	EPA 1999	EPA (U.S. Environmental Protection Agency) 1999. "Facility SIC Report - Criteria Air Pollutants, Geographic Area: Summit Co, OH." *AirData.* Washington, D.C.: U.S. Environmental Protection Agency. Accessed July 13, 2007. ACC: MOL.20070724.0340. URL: http://iaspub.epa.gov/airsdata/adnet.sic?geotype=co&geocode=39153&geoinfo=co%7E39153%7ESummit+Co%2C+Ohio&pol=NOX+VOC+PM25&year=1999&fld=cnt&fld=count_pct&fld=emis&fld=emission_pct&rpp=25
181920	EPA 1999	EPA (U.S. Environmental Protection Agency) 1999. "Facility SIC Report - Criteria Air Pollutants, Geographic Area: York Co, PA." *AirData.* Washington, D.C.: U.S. Environmental Protection Agency. Accessed July 13, 2007. ACC: MOL.20070724.0341. URL: http://iaspub.epa.gov/airsdata/adnet.sic?geotype=co&geocode=42133&geoinfo=co%7E42133%7EYork+Co%2C+Pennsylvania&pol=NOX+VOC+PM25&year=1999&fld=cnt&fld=count_pct&fld=emis&fld=emission_pct&rpp=25
177709	EPA 2006	EPA (U.S. Environmental Protection Agency) 2002. *National Emissions Inventory: All-Sector Summary Data for Criteria Air Pollutants*. MO0607NEI2002D.000. Las Vegas, Nevada: U.S. Environmental Protection Agency. ACC: MOL. 20060807.0042.

181914	EPA 2007	EPA (U.S. Environmental Protection Agency) 2007. "8-Hour Ozone Nonattainment State/Area/County Report." *Green Book.* Washington, D.C.: U.S. Environmental Protection Agency. Accessed September 11, 2007. ACC: MOL.20071003.0194. URL: http://www.epa.gov/air/oaqps/greenbk/gncs.html
185248	EPA 2007	EPA (U.S. Environmental Protection Agency) 2007. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005.* Washington, D.C.: U.S. Environmental Protection Agency, Office of Atmospheric Programs. ACC: MOL.20080331.0109.
181232	Fitzpatrick-Maul 2007	Fitzpatrick-Maul, D. 2007. "SEIS Water Balance Revision 4." Electronic mail from D. Fitzpatrick-Maul to K. Davis, SEIS Team, dated April 16, 2007, with attachment. ACC: MOL.20070816.0027; MOL.20070808.0055.
185100	Gecol 2007	Gecol, H. 2007. *Status of Energy in Nevada, Report to Governor Gibbons and Legislature.* Carson City, Nevada: State of Nevada, Nevada State Office of Energy. ACC: MOL.20080304.0035.
177297	Hanson et al. 2006	Hanson, C.E.; Towers, D.A.; and Meister, L.D. 2006. *Transit Noise and Vibration Impact Assessment*. FTA-VA-90-1003-06. Washington, D.C.: U.S. Department of Transportation, Federal Transit Administration. ACC: MOL.20060814.0190.
103277	IAEA 1992	IAEA (International Atomic Energy Agency) 1992. *Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards.* Technical Reports Series No. 332. Vienna, Austria: International Atomic Energy Agency. TIC: 243768.
172935	ICRP 2001	ICRP (International Commission on Radiological Protection) 2001. *The ICRP Database of Dose Coefficients: Workers and Members of the Public.* ICRP Publication 72. New York, New York: Elsevier. TIC: 255638.
185132	Parry et al. 2007	Parry, M.; Canziani, O.; Palutikof, J.; van der Linden, P.; and Hanson, C., eds. 2007. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. New York, New York: Cambridge University Press. TIC: 260104.

174559	Lawrence 2002	Lawrence, A. 2002. "Radiation Risk Estimation from Total Effective Dose Equivalents (TEDEs)." Memorandum from A. Lawrence (DOE) to distribution, August 9, 2002, with attachments. ACC: MOL.20050815.0190.
182804	Maher 2006	Maher, M. 2006. "Nye County, Nevada Request to Initiate Transaction for Acquisition of 292.46 Acres of Land for Commercial Purposes Pursuant to Public Law #106-113." Letter from M. Maher (Nye County) to J. Palma (BLM), March 21, 2006, with enclosure. ACC: MOL.20070913.0510.
182197	Morton 2007	Morton, L. 2007. "Status of June 15 Data Call re: Utilities/electrical power." E-mail from L. Morton to J. Rivers, S. Walker, E. Harr, and L. Shaser, June 18, 2007. ACC: MOL.20070806.0019.
182210	Morton 2007	Morton, L. 2007. "Addt'l Input for 4/30/07 SEIS Air Quality." E-mail from L. Morton to J. Summerson, J. Rivers, and S. Walker, May 1, 2007, with attachment. ACC: MOL.20070910.0118; MOL.20070806.0016.
182211	Morton 2007	Morton, L. 2007. "SEIS Input for April 30, 2007." E-mail from L. Morton to J. Summerson, April 30, 2007, with attachment. ACC: MOL.20070910.0117; MOL.20070806.0018.
182319	Morton 2007	Morton, L. 2007. "Fw: BSC Technical Input Due 6/15/2007." E-mail from L. Morton to J. Summerson and J. Rivers, June 18, 2007, with attachment. ACC: MOL.20070809.0004; MOL.20070809.0005.
182713	Morton 2007	Morton, L. 2007. "SEIS Question RE: Concrete Usage." E-mail from L. Morton to (leroys@ageiss.com), July 16, 2007, with attachment. ACC: MOL.20070913.0504.
184918	Morton 2007	Morton, L. 2007. "Manufacturing Repository Components, Items 1-2." E-mail from L. Morton (BSC) to J. Summerson (DOE), dated April 30, 2007, with attachments. Las Vegas, Nevada. ACC: MOL.20070724.0360; MOL.20070816.0029.
185329	Morton 2007	Morton, L. 2007. "SEIS Deliverable Due 6/15/07 - Aesthetics." Email from L. Morton to J. Summerson and J. Rivers, June 14, 2007, with attachments. ACC: MOL.20080509.0016.
153066	Murphy 2000	Murphy, S.L. 2000. "Deaths: Final Data for 1998." *National Vital Statistics Reports*. Vol. 48, No. 11. Hyattsville, Maryland: National Center for Health Statistics. TIC: 249111.

100953	Napier et al. 1988	Napier, B.A.; Peloquin, R.A.; Strenge, D.L.; and Ramsdell, J.V. 1988. *GENII - The Hanford Environmental Radiation Dosimetry Software System.* Three volumes. PNL-6584. Richland, Washington: Pacific Northwest Laboratory. ACC: NNA.19920626.0034; NNA.19920626.0036; NNA.19920626.0041
179907	Napier 2007	Napier, B.A. 2007. *GENII Version 2 Users' Guide.* PNNL-14583, Rev. 2. Richland, Washington: Pacific Northwest National Laboratory. ACC: MOL.20070314.0029.
174324	NatureServe 2004	NatureServe 2004. *Landcover Descriptions for The Southwest Regional Gap Analysis Project.* Arlington, Virginia: NatureServe. TIC: 257833.
184969	NDEP 2007	NDEP (Nevada Division of Environmental Protection) 2007. *State of Nevada Solid Waste Management Plan 2007.* Carson City, Nevada: State of Nevada, Nevada Division of Environmental Protection. ACC: MOL.20080514.0134.
182320	NRC 2007	NRC (U.S. Nuclear Regulatory Commission) 2007. "Low-Level Waste Disposal Statistics." Washington, D.C.: U.S. Nuclear Regulatory Commission. Accessed August 7, 2007. ACC: MOL.20070809.0006. URL: http://www.nrc.gov/waste/llw-disposal/statistics.html
173400	NRMCA 2004	NRMCA (National Ready Mix Concrete Association) 2004. *Industry Fact Sheet, U.S. Ready Mixed Concrete Production*. Silver Spring, Maryland: National Ready Mix Concrete Association. TIC: 257545.
182710	NWRPO 2007	NWRPO (Nuclear Waste Repository Project Office) 2007. *Nye County Public Safety Report.* NWRPO-2007-06. Las Vegas, Nevada: Nye County Nuclear Waste Repository Project Office. ACC: MOL.20070913.0315.
182189	Rhode 2007	Rhode, D. 2007. *Information About Cultural Resources that DRI Has Recorded Within the Potential Yucca Mountain Withdrawal Area.* Letter from D. Rhode (DRI) to H. Roberts (HRA), July 17, 2007, with enclosure. ACC: MOL.20070806.0009.
179923	Shroff 2006	Shroff, B. 2006. *CAP88-PC Version 3.0 User Guide*. Washington, D.C.: U.S. Environmental Protection Agency, Office of Radiation and Indoor Air. ACC: MOL.20070613.0036.

177399	SNL 2007	SNL (Sandia National Laboratories) 2007. *Biosphere Model Report.* MDL-MGR-MD-000001 Rev 02. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20070830.0007.
182586	Spence 2007	Spence, R.E. 2007. "2006 Annual Report of Compliance Activities Conducted for the Biological Opinions for the Yucca Mountain Project (File Numbers 1-5-96-F-307R and 1-5-00-F-518)." Letter from R. Spence (DOE) to A. Lavoie (Fish and Wildlife Service) dated February 6, 2007. ACC: CCU.20070206.0005.
145962	Tucci and Faunt 1999	Tucci, P. and Faunt, C.C. 1999. *Simulated Effects of Potential Withdrawals from Wells Near Yucca Mountain, Nevada*. Water-Resources Investigations Report 99-4166. Denver, Colorado: U.S. Geological Survey. ACC: MOL.19991112.0127.
105034	Turnipseed 1992	Turnipseed, R.M. 1992. *Ruling #3870: In the Matter of Application 52338 Filed to Appropriate the Waters from an Underground Source Within the Forty Mile Canyon-Jackass Flats Groundwater Basin, Nye County, Nevada*. Carson City, Nevada: State of Nevada, Office of the State Engineer. ACC: HQX.19930511.0006.
103472	USAF 1999	USAF (U.S. Air Force) 1999. *Renewal of the Nellis Air Force Range Land Withdrawal: Legislative Environmental Impact Statement.* Washington, D.C.: U.S. Department of the Air Force. ACC: MOL.20010726.0068.
185186	USGS 2008	USGS (U.S. Geological Survey) 2008. *Mineral Commodity Summaries 2008*. Washington D.C.: U.S. Government Printing Office. ACC: MOL.20080306.0052.
179926	USGS National Gap Analysis Program n.d.	SWReGAP (Southwest Regional Gap Analysis Project) n.d. "Landcover Data for Nevada." *SWReGAP Landcover Data - Nevada.* Denver, Colorado: U.S. Geological Survey. Accessed March 26, 2007. ACC: MOL.20070613.0011. URL: http://earth.gis.usu.edu/swgap/landcover_nv.php
101941	USN 1996	USN (U.S. Department of the Navy) 1996. *Department of the Navy Final Environmental Impact Statement for a Container System for the Management of Naval Spent Nuclear Fuel.* DOE/EIS-0251. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20010724.0299.
154386	YMP 2001	YMP (Yucca Mountain Site Characterization Project) 2001. *Reclamation Implementation Plan.* YMP/91-14, Rev. 2. Las Vegas, Nevada: Yucca Mountain Site Characterization Office. ACC: MOL.20010301.0238.

5

Estimated Environmental Impacts of Postclosure Repository Performance

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

5. ENVIRONMENTAL IMPACTS OF POSTCLOSURE REPOSITORY PERFORMANCE

This chapter presents the approach and analyses of potential human health *impacts* from releases of *radioactive* and nonradioactive materials to the environment after *closure* of the proposed *repository* at Yucca Mountain. In addition, it discusses estimates of potential biological and environmental impacts from radiological and chemical groundwater *contamination*, and potential biological impacts from the *postclosure* production of heat due to *decay* of the radioactive materials that the U.S. Department of Energy (DOE or the Department) would dispose of in the repository. This chapter of the *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F-S1) (Repository SEIS) summarizes, incorporates by reference, and updates the information in Chapter 5 of the *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F; DIRS 155970-DOE 2002, pp. 5-1 to 5-50) (Yucca Mountain FEIS).

Waste packages would be disposed of in dedicated emplacement *drifts*, supported on *emplacement* pallets, and aligned end-to-end on the drift floor (Chapter 2, Section 2.1.2.2.2, Figure 2-8).

Closure of a repository would include the following activities (Chapter 2, Section 2.1.6):

- Emplacement of the *drip shields* over the waste packages;
- Backfilling of *subsurface* ramps and subsurface-to-surface openings;
- Removal of surface facilities; and
- Creation of *institutional controls*, which would include land records and surface monuments, to identify the location of the repository and discourage *human intrusion*.

> **WASTE PACKAGE**
>
> A waste package would consist of the corrosion-resistant outer container, the waste form and any internal containers (such as the transportation, aging, and disposal canister), spacing structure or baskets, and shielding integral to the container. The waste package would be ready for emplacement in the repository when the outer lid welds were complete and accepted.

After *repository-closure*, few workers would be employed. There would be minimal use of water, utilities, energy, or services and minimal generation of waste. There would be no change in water quality other than those from the transport of *radionuclides* and chemical contaminants. Impacts to land use, noise, socioeconomics, cultural resources, aesthetics, utilities, or services after closure as a result of the *disposal* of radioactive materials in the repository or as a result of any currently envisioned postclosure monitoring program that could be approved by the U.S. Nuclear Regulatory Commission (NRC) would be small. At such time as the postclosure monitoring program is further detailed, the estimates of impacts would be updated. Chapter 4 discusses impacts from *construction*, *operations*, *monitoring*, and closure.

DOE assessed the processes by which radionuclides could be released from a repository at Yucca Mountain and transported to the environment. The analysis used computer programs to assess the release and movement of radionuclides and hazardous materials in the environment. Some of the programs analyzed the behavior of engineered components such as the waste package, while others analyzed natural *processes* such as the movement of *groundwater*. DOE based the programs on the best available *geologic*, geochemical, and hydrologic data and current knowledge of the behavior of the materials DOE proposes for the system. The analysis used data from Yucca Mountain *site characterization* activities, material tests, and expert judgment as input parameters to estimate human health impacts. Many parameters that DOE used in the analysis cannot be exactly measured or known; therefore, DOE used a range of values. The analysis accounted for this type of uncertainty; the results are ranges of potential health impacts.

The analysis considered human health impacts during the first 10,000 years after repository closure and the radiation *dose* during the period from 10,000 years after closure to 1 million years after closure (the post-10,000-year period). Estimates of potential human health impacts included the effects on repository performance of such expected processes as *corrosion* of waste packages, degradation and dissolution of waste forms, flow through the saturated and *unsaturated zones*, and changing climate, in addition to early waste package and drip shield failure (a failure that could occur soon after closure due to defects in a waste package or drip shield) mechanisms and igneous and *seismic* events. Additional analyses examined the effects of such disturbances as inadvertent drilling and potential for criticality.

WHY 10,000 YEARS AND 1 MILLION YEARS?

The Total System Performance Assessment-License Application (TSPA-LA) model provides estimates of potential radiological impacts (doses) for two periods: the estimated dose at times for the first 10,000 years after closure and a dose at times after the first 10,000 years up to 1 million years after closure. The TSPA-LA model assessed annual individual doses in each of these periods.

DOE could have performed the analyses for this Repository SEIS for any number of periods. So why these two? The main reason is that the U.S. Environmental Protection Agency and the U.S. Nuclear Regulatory Commission have proposed dose limits for a maximum annual individual dose in each period. DOE has compared the results of the postclosure performance assessments with the proposed limits to provide a context in which to consider the potential environmental impacts of the Proposed Action.

The analysis of postclosure repository performance and environmental impacts considered all potential *pathways*, including airborne releases, through which radionuclides from *spent nuclear fuel* or *high-level radioactive waste*, and hazardous or carcinogenic chemicals could reach human populations and result in impacts to public health. U.S. Environmental Protection Agency (EPA) and NRC proposed regulations require evaluation of all potential paths. The principal *exposure pathway* would be groundwater. Rainwater could migrate down through the unsaturated zone into the repository, could dissolve or mobilize some of the material in the repository, and could carry *contaminants* from the dissolved material down through the unsaturated and saturated groundwater zones to locations where human *exposure* could occur. An atmospheric pathway could result from a volcanic conduit that intersected the repository, destroyed waste packages, and erupted at the surface. Depending on atmospheric conditions, the volcanic eruption at the ground surface could disperse volcanic tephra (solid material of all sizes explosively ejected from a volcano into the atmosphere) and entrained radionuclides (radionuclides that were bound to or captured by the volcanic tephra). The calculation of annual *radiation* dose included human health impacts from this latter pathway (Section 5.5).

Another atmospheric pathway could result from the escape of gaseous radionuclides, such as carbon-14, from the repository to the surface and their downwind transport. DOE analyzed these possible airborne releases in the Yucca Mountain FEIS. Section 5.6 provides a summary of this analysis. Because DOE is not aware of significant new information or circumstances that bear on this analysis, DOE would not expect any change in the estimated impacts from the escape of gaseous radionuclides; therefore, DOE did not conduct a new analysis for this Repository SEIS.

10 CFR PART 63 AND 40 CFR PART 197

In 2001, both the U.S. Environmental Protection Agency (EPA) and the U.S. Nuclear Regulatory Commission (NRC) adopted public health and safety standards for any radioactive material to be disposed of in a Yucca Mountain Repository. In 2004, in response to legal challenges, the U.S. Court of Appeals for the District of Columbia Circuit struck down the portions of those standards that addressed the period for which compliance must be demonstrated and remanded the provisions to the federal agencies for revision.

In 2005, EPA proposed new standards to address the Court's decision. The proposed standards incorporate multiple compliance criteria applicable at different times for protection of individuals, the environment, and in circumstances involving human intrusion into the repository. The proposals also identify certain specific processes that must be considered in projecting repository performance. When finalized, these standards will be codified in 40 CFR Part 197, Subpart B.

Because Section 801 of the *Energy Policy Act of 1992* requires NRC to modify its technical requirements for licensing of a Yucca Mountain Repository to be consistent with the standards promulgated by EPA, NRC also proposed new standards in 2005 to implement the proposed EPA standards for doses that could occur after 10,000 years but within the period of geologic stability. The proposed NRC standards also specify a value to be used to represent climate change after 10,000 years, as required by EPA. When finalized, these standards will be codified in 10 CFR Part 63.

In developing the TSPA-LA model for the analysis in this Repository SEIS, DOE took into consideration the regulatory requirements in the proposed EPA and NRC standards to provide a perspective on potential radiological impacts during the postclosure period. For this SEIS, DOE based the analyses on the TSPA-LA model that serves as the basis for the compliance assessment included in DOE's application to the NRC for construction authorization and a license to receive and possess radioactive materials at the repository.

The analysis for this Repository SEIS estimated potential human health impacts from the groundwater and atmospheric transport pathways at the location of the *reasonably maximally exposed individual* (RMEI; 40 CFR 197.21), which is approximately 18 kilometers (11 miles) downgradient from the proposed repository. A hypothetical *reasonably maximally exposed individual* is defined with parameters that significantly affect exposure estimates set at high values so that the hypothetical individual is "reasonably maximally exposed" for the purpose of assessing potential doses that could result from releases of *radioactivity* from a repository. These impacts include both radiological doses and probabilities of resultant *latent cancer fatalities*. A latent cancer fatality is a death that results from *cancer* from exposure to *ionizing radiation* or other *carcinogens*.

DOE has made modifications to the repository design and operational plans since the completion of the Yucca Mountain FEIS. DOE has modified the *Total System Performance Assessment* (TSPA) model to account for these changes, as well as for additional data it has collected since the completion of the FEIS. Section 5.1 summarizes modifications that this Repository SEIS addresses in the TSPA model. For this Final Repository SEIS, DOE based the analyses on the TSPA-LA model that serves as the basis for the

WHO AND WHERE IS THE "RMEI"?

A hypothetical "reasonably maximally exposed individual (RMEI)" is defined for the purpose of assessing potential doses that could result from releases of radioactivity from a repository.

Under applicable regulations, the RMEI is located 18 kilometers (11 miles) from the repository.

compliance assessment it has included in its application to the NRC for construction authorization. The references in Appendix F, Section F.2 of this Repository SEIS provide further details.

Section 5.1a describes the differences between the TSPA-SEIS model for the Draft Repository SEIS and the TSPA-LA model for this Final Repository SEIS. Section 5.2 describes the inventory of materials that the postclosure performance assessment analyzed for potential releases from the repository; Section 5.3 provides an overview of the repository system; Section 5.4 discusses the locations for impact estimates; Section 5.5 provides the analysis of the postclosure performance for radiological impacts; Section 5.6 provides the analysis of atmospheric radiological materials in the repository; Section 5.7 describes impacts from chemically toxic materials; Section 5.8 describes the human intrusion calculations; Section 5.9 describes the evaluation of the potential for nuclear criticality in the repository and surrounding rock; Section 5.10 presents the impacts to biological resources and soils; and Section 5.11 summarizes the postclosure analyses.

5.1 Differences Between FEIS and SEIS Assessments of Postclosure Repository Performance

There are several differences between the assessments of postclosure repository performance for this Repository SEIS and those in the Yucca Mountain FEIS that accompanied the Secretary of Energy's recommendation to approve the *Yucca Mountain site* in 2002. Figure 5-1 shows the relationships between TSPA models and the FEIS and this SEIS. The major differences are summarized in this section.

5.1.1 RADIOLOGICAL IMPACTS

The results of assessments of postclosure repository performance for this Repository SEIS and those of the Yucca Mountain FEIS are different. The differences are largely due to the standards EPA has proposed, which specify how to calculate post-10,000-year repository performance. Specific requirements about how to make such a calculation did not previously exist. Furthermore, the calculation incorporates additional data and enhancements in the description of engineered and natural components. The Yucca Mountain FEIS results included contributions from the Nominal Scenario Class, limited contributions from the Seismic Scenario Class, and contributions from Waste Package Early Failure. Igneous Scenario Class impacts were not included in the calculation of total impacts. The projections of radiological impacts in the TSPA-LA include contributions from a Seismic Scenario Class, Igneous Scenario Class, Drip Shield Early Failure, Waste Package Early Failure, and the Nominal Scenario Class. As a result of these changes, several *qualitative* observations can be made about the FEIS results.

- The FEIS described future climates in terms of discrete alternating climate states with a precise timing of climate change. The spikes in the dose curves in the FEIS (for example, DIRS 155970-DOE 2002, Figure 5-4, p. 5-26) result from imposed climate changes at fixed times and assumed percolation fluxes. These spikes are responsible for the maximum levels of the individual dose. The

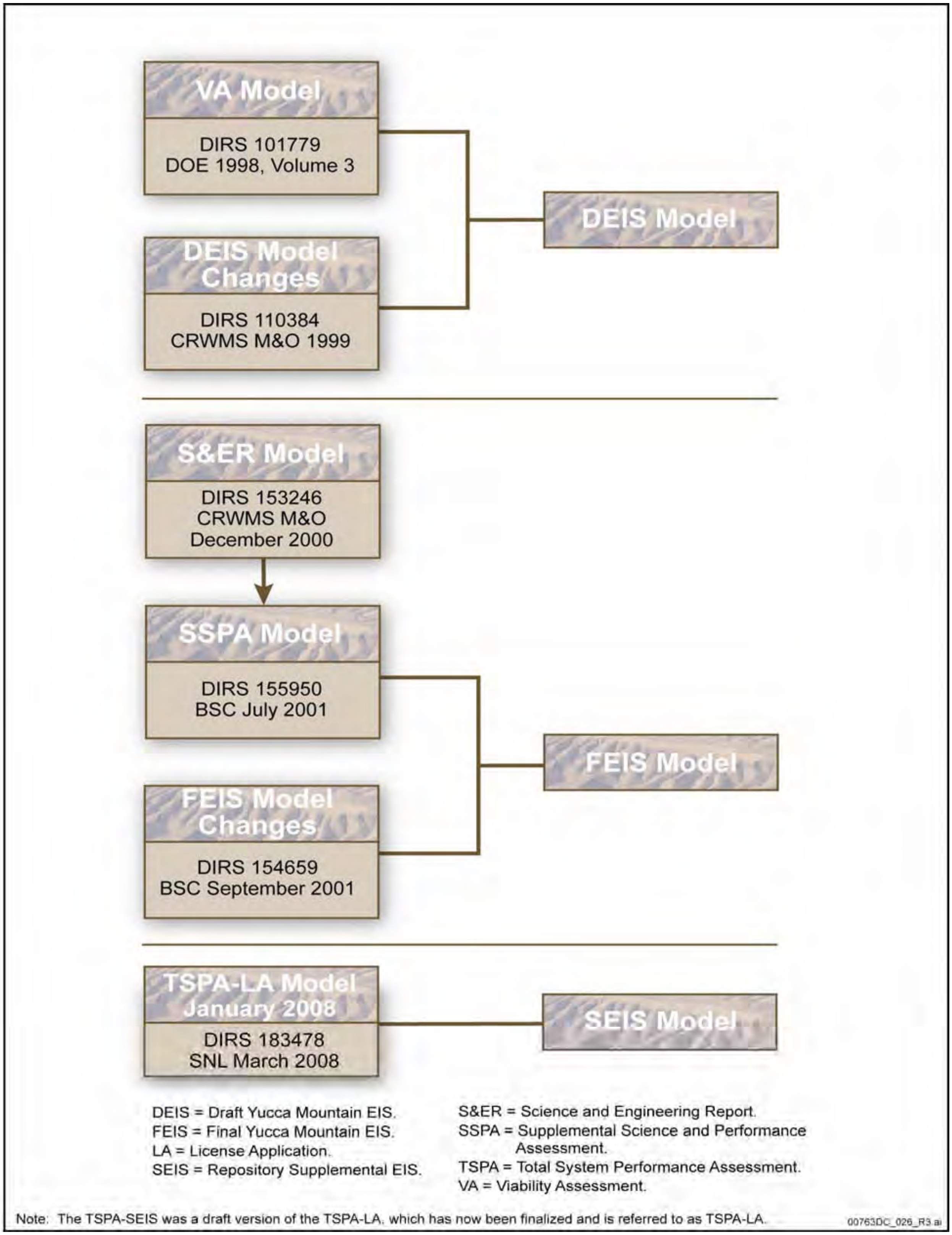


Figure 5-1. Relationship between the published TSPA models and models used for the Draft Yucca Mountain EIS, Yucca Mountain FEIS, and this Repository SEIS.

proposed EPA standards require DOE to assess the effects of long-term climate changes. This requirement allows the use of probabilistic *distribution* for a constant-in-time but uncertain long-term average climate for Yucca Mountain as specified by the NRC. Inclusion of these changes in the FEIS would have resulted in a significant lowering of the projected dose values.

- The proposed EPA standards require DOE to use revised International Commission on Radiological Protection weighting factors for calculation of individual doses. In general, using the revised weighting factors results in *biosphere* dose conversion factors for *actinides* that are lower, whereas biosphere dose conversion factors for *fission* products are higher. Actinides were the dominant contributors to dose in the FEIS. Notably, the biosphere dose conversion factors for neptunium, which was the dominant *nuclide* contributing to doses in the FEIS, decreased by approximately 80 percent from the FEIS to the SEIS with the Commission's revisions. Sensitivity studies that were referenced in the FEIS (DIRS 155970-DOE 2002, p. 5-31) indicate that dose estimates would be significantly lower if the revised methods were applied.

- Waste package and drip shield lifetimes are longer in the SEIS. The increase in waste package lifetimes is due in part to the increase in thickness of the *Alloy 22* outer *barrier* to accommodate the *transportation, aging, and disposal (TAD) canister*. Inclusion of temperature dependence of Alloy 22 corrosion rates in the SEIS resulted in substantially longer waste package lifetimes in the Nominal Scenario Class. Inclusion of new titanium corrosion data in the SEIS resulted in lower corrosion rates, reduced uncertainty, and longer drip shield lifetimes. Inclusion of these enhanced models in the FEIS would have resulted in a significant lowering of the projected dose values.

- For the Yucca Mountain FEIS, there was no explicit requirement for comparison to a compliance standard; the applicable NRC regulation at that time required DOE to calculate the annual dose to the RMEI if one would occur after 10,000 years after disposal but within the period of geologic stability. No regulatory standard applied to the results of this analysis nor did the regulations specify requirements for the estimate of repository performance. DOE was to include the results and their bases in the FEIS as an indicator of long-term disposal system performance.

- The proposed regulatory standards require that DOE's projection of postclosure radiological impacts to the RMEI include those scenario classes (future states of the repository) that resulted from the screening of features, *events*, and processes (Appendix F, Section F.2.1). Therefore, the TSPA-LA projections of radiological impacts to the RMEI include contributions from a Seismic Scenario Class, Igneous Scenario Class, Early Failure Scenario Class (Drip Shield Early Failure and Waste Package Early Failure), and the Nominal Scenario Class.

The proposed EPA and NRC standards identify specific processes, such as degradation of the Engineered Barrier System due to general corrosion and seismic and igneous events, to be included in the postclosure performance projection and guide the development of the *quantitative* approach that DOE should use in the post-10,000-year projection. As a result, DOE has made several changes to the TSPA model since completion of the Yucca Mountain FEIS. DOE has made other refinements to the TSPA model to improve the treatment of uncertainties, incorporate new data and understanding of processes, and reduce conservatism in the projection of repository performance (Table 5-1 contains further detail). The following factors, in addition to those above, are responsible for the major differences in projected repository performance between the Yucca Mountain FEIS and the Repository SEIS.

Table 5-1. Important changes to the TSPA since completion of the Yucca Mountain FEIS.

Component	Change	Estimated effect
Unsaturated zone flow	• Stronger basis for models – Evaluation of fast flow and transport of chlorine-36 – Justification of parameter sets used to model future climates – Evaluation of flow and transport sensitivity to hydrologic parameters	Neutral
	• Revised infiltration model and broader range of infiltration maps	Neutral
	• Revised calibration method to develop probability weights for infiltration maps	Neutral
	• NRC-specified percolation flux for post-10,000-year period per proposed rule	Moderate decrease in dose after 10,000-years
	• Basis on enhanced treatment of uncertainties in input parameters	Neutral
Engineered Barrier System environment—thermal hydrology and in-drift chemistry	• Thermal hydrology – Improved basis for model validation – In-drift condensation processes included	Neutral
	• Near-field/in-drift chemistry – Reevaluated data to constrain in situ water chemistry • Improved model to represent composition of seepage entering emplacement drifts	Small decrease in dose
Abstraction of waste package and drip shield degradation	• Waste package outer barrier corrosion	
	– Additional data available	Supports model basis
	– Thermal dependency of general corrosion included	Large decrease in dose
	– Localized corrosion due to seepage included	Neutral
	• Waste package outer barrier stress corrosion cracking – Improved stress/stress intensity factor profiles	Neutral
	• Drip shield early failure included	Neutral
	• Additional drip shield general corrosion data available	Decrease in dose
Source term	• No credit taken for the ability of cladding to prevent or reduce degradation of commercial spent nuclear fuel	Increase in dose
	• Broader range of in-package chemistry conditions and resulting impacts on waste form degradation considered	Small decrease in dose
Engineered Barrier System radionuclide transport	• Improved representation of radionuclide transport through the waste package	Small decrease in dose
	• Improved representation of radionuclide mass release to fracture and matrix portions of the host rock under the Engineered Barrier System	Small decrease in dose
	• Representation of kinetic sorption of plutonium and americium on iron oxyhydroxide colloids and stationary corrosion products in the waste package	Small decrease in dose
	• Sorption on TAD canister corrosion products included	Small decrease in dose

Table 5-1. Important changes to the TSPA since completion of the Yucca Mountain FEIS (continued).

Component	Change	Estimated effect
Unsaturated zone radionuclide transport	• Transport model revised to reflect transport in a dual-continuum fracture/matrix system more accurately	Small decrease in dose
	• Updated analyses of sorption and diffusion parameters	Neutral
Saturated zone flow and transport	• Updated hydrogeologic framework model that incorporates new Nye County drilling data and updated USGS regional model	Neutral
	• Updated and recalibrated site-scale saturated zone flow model – Water-level measurements in new Nye County wells – New hydrochemical data in flow model validation analysis	Neutral
	• Updated saturated zone flow and transport abstraction model – Reevaluation of parameter uncertainty distributions in consideration of new information	Small decrease in dose
Biosphere	• Incorporation of additional pathways	Increase in dose
	• Inclusion of dosimetric inputs consistent with ICRP Publication 72[a] and based on the concepts recommended in ICRP Publication 60[b]	Moderate decrease in dose
	• Uncertainty in biosphere dose conversion factors included	Neutral
	• GoldSim-based model (GENII-S used in Yucca Mountain FEIS)	Neutral
Seismic scenario class	• Inclusion of the seismic scenario class	Increase in dose
	• Detailed damage analyses developed for degraded states of the Engineered Barrier System components including the TAD-bearing waste packages	Increase in dose
Igneous scenario class	• Assume all drip shields and waste packages destroyed by magma intrusion	Increase in dose
	• New parameter values based on analogue data – Dike length, width, and orientation and number of dikes – Conduit size and number and locations of conduits	Neutral
	• Fraction of eruptive material in tephra, cone, and lavas	
Treatment of uncertainty and variability	• Improved guidelines and management controls for characterization of uncertainty consistently across component abstractions	Consistent treatment of uncertainty
	• Epistemic and aleatory uncertainty separated in the TSPA analyses	Consistent treatment of uncertainty
Features, events, and processes analysis	• Screening justifications updated and revised based on new technical information available since DOE published the TSPA for the Site Recommendation[c] (e.g., TAD canisters; seismic impacts; localized corrosion)	Improve defensibility of included scenario classes

Table 5-1. Important changes to the TSPA since completion of the Yucca Mountain FEIS (continued).

Component	Change	Estimated effect
TSPA model development and implementation	• Technical basis for TSPA planned for the license application builds on the technical foundation documented for the TSPA for the Site Recommendation and updates[d] for the FEIS	Improve defensibility
	• Additional confidence building (validation)	Improve defensibility
	• Additional rigor added to configuration and control processes	Improve defensibility

a. DIRS 172935-ICRP 2001, all.
b. DIRS 101836-ICRP 1991, all.
c. DIRS 153246-CRWMS M&O 2000, all.
d. DIRS 155950-BSC 2001, all; the Yucca Mountain FEIS referred to this model as the "Supplemental Science and Performance Analyses" model.

DOE = U.S. Department of Energy.
ICRP = International Commission on Radiological Protection.
NRC = U.S. Nuclear Regulatory Commission.
TAD = Transportation, aging, and disposal (canister).
TSPA = Total System Performance Assessment.
USGS = U.S. Geological Survey.

5.1.1.1 Drip Shield and Waste Package Corrosion

For this Repository SEIS, DOE included new Titanium Grade 7 corrosion data that were based on 2.5-year tests, which resulted in reduced uncertainty in corrosion rates, lower corrosion rates, and longer drip shield lifetimes. In the Yucca Mountain FEIS, drips shields did not start failing until approximately 20,000 years after emplacement and most of the drip shields failed by about 40,000 years. In the SEIS, drip shields did not start failing until approximately 260,000 years and most of the drip shields failed by 310,000 years.

DOE included temperature dependence of Alloy 22 corrosion rates for this Repository SEIS, which led to substantially longer waste package lifetimes in the Nominal Scenario Class. The following discussion summarizes waste package performance in the Nominal Scenario Class for the Yucca Mountain FEIS and the Repository SEIS. In the Yucca Mountain FEIS, the mean waste package failure behavior resulted in waste package failure from stress corrosion cracking beginning around 15,000 years, and about 50 percent of the waste packages failed by stress corrosion cracking and general corrosion by 100,000 years. For this Repository SEIS, the waste package failure initiated by stress corrosion cracking is estimated to begin around 100,000 years and about 50 percent of the waste packages are estimated to fail by stress corrosion cracking and general corrosion by 1 million years. General corrosion failures are estimated to start at around 400,000 years, and about 9 percent of the waste packages could experience a general corrosion breach within 1 million years. The increase in waste package lifetimes was also due in part to the increase in thickness of the Alloy 22 outer barrier for the *commercial spent nuclear fuel* waste packages from 20 millimeters (0.79 inch) in the FEIS to 25 millimeters (0.98 inch) in this SEIS to accommodate the *TAD canister*.

5.1.1.2 Seismic Scenario Class

The TSPA-LA implements damage models to simulate the response of drip shields, codisposal waste packages, and TAD canisters with commercial spent nuclear fuel waste packages to vibratory ground motion, drift collapse, and *fault* displacement.

5.1.1.3 Igneous Scenario Class

The TSPA-LA assumes all drip shields and waste packages in the repository would be destroyed if a basaltic dike intersected and magma intruded into one or more emplacement drifts. That is, all drip shields and waste packages in the repository would lose their ability to limit or prevent the flow of water and the movement of radionuclides.

5.1.1.4 Impacts at Different Locations

In the Yucca Mountain FEIS the results for the RMEI, who would be located at 18 kilometers (11 miles), were scaled to two other distances: 30 kilometers (19 miles) and 60 kilometers (37 miles). The scaling used factors DOE developed from separate modeling for transport in the *alluvium* of Amargosa Valley. This separate modeling used a simple, dispersion-only model that did not account for any sorption or other attenuating phenomena other than hydrodynamic dispersion (spreading) of the radionuclide plume. New modeling since the FEIS indicates a considerably smaller plume width. Upon review of the basis for the dose calculations, DOE confirmed that if the plume were diluted into the 3.7 million cubic meters (3,000 acre-feet) of water use at the RMEI location, this large water use would likewise consume the entire plume at all other locations, beyond the specified RMEI location of 18 kilometers (11 miles). This is because the spreading of the plume would be insufficient for any of the radionuclides to escape capture in the water-use volume; however, as the plume moved downgradient from the RMEI location, it would be less likely that groundwater wells would capture all of the released radionuclides. Furthermore, the time delay from further transport in the alluvium would result in insignificant amounts of decay. Therefore, the estimated doses at downgradient locations would be no greater than those of the RMEI Thus, doses at distances other than the RMEI location were not calculated for this Repository SEIS. DOE did not assess population dose in this SEIS. It would be inappropriate to apply the lifestyle of the RMEI to the entire population surrounding the repository because the characteristics of the RMEI (a hypothetical individual) are defined in a manner that results in maximum annual and lifetime doses, which would not be applicable to all other members of the population. Further, in recommendations to the EPA in response to congressional direction, the National Academy of Sciences recommended only the use of a standard that sets a limit on the risk to individuals, concluding that an individual-risk standard would protect public health, and that there is no technical basis for a population risk standard by which to make such a judgment.

5.1.2 IMPACTS FROM TOXIC CHEMICALS

Since the FEIS, there has been a change in how chromium chemistry is treated both in the Engineered Barrier System (emplacement drift) environment and in the in-package environment. In the FEIS it was conservatively assumed that, when placed in solution, chromium would fully oxidize to the +6 valence state, chromium(VI). Additional research and analysis has shown that this is an unrealistic assumption for the chemical environments of the Engineered Barrier System and the internal components of the waste package. There is very strong evidence (Appendix F, Section F.5.1) that most or all of the chromium, dissolved from construction materials such as stainless steel and Alloy 22, would exist in the +3 valence state, chromium(III). An important distinction between these two valence states is that chromium(VI) is highly soluble in water and is considered toxic to humans, while chromium(III) is highly insoluble (on the order of less than 1×10^{-3} milligram per liter) and is considered nontoxic to humans. Based on these new findings, chromium was eliminated from further consideration in this Repository SEIS when evaluating impacts from chemically toxic substances (Appendix F, Section F.5.1).

5.1a Differences Between the Draft Repository SEIS and the Final Repository SEIS Assessments of Postclosure Repository Performance

DOE refined the TSPA model slightly between the time of issuance of the Draft Repository SEIS and this Repository SEIS. Two of the refinements resulted in very small changes to the calculated doses to the RMEI. One of the refinements addressed the way radium is treated in a *saturated zone* model. The TSPA-LA was refined to eliminate a small number of realizations that had produced unrealistic results by setting bounds on the previously unbounded range on longitudinal dispersivity (the way the radionuclides spread out as they migrate). The second refinement addressed the way that the time of first occurrence of stress corrosion cracking in the seismic ground motion case was modeled. The analyses for the Draft Repository SEIS assumed all waste packages of a given type (that is, commercial spent nuclear fuel waste package or codisposal waste package) would have degraded internal structural materials once the first waste package of that type was breached by stress corrosion cracking from nominal processes. Waste packages with degraded internal structural materials have reduced structural strength and less resilience to damage from seismic ground motions. This reduction in strength was included in the waste package damage models and, as a result, there was a tendency to overestimate waste package damage. Waste packages are now modeled as having degraded internal structural materials only when they would have actually been breached. Unbreached waste packages would maintain a higher level of structural strength for a longer period. Breaches could occur due to either stress corrosion cracking from nominal processes or seismic-induced damage. Of the two refinements, the second resulted in a greater change in terms of total dose. There were other minor differences in the TSPA-LA model, but their effects did not result in noticeable changes in total dose.

As a result of the refinements, there was no change in the reported value of the mean annual individual dose for the first 10,000 years or in the associated *probability* of a latent cancer fatality. There was a very small change in the reported value of the median annual individual dose for the post-10,000-year assessment; the projected dose was reduced from 0.98 to 0.96 *millirem*. The associated probability of a latent cancer fatality changed from 5.9×10^{-7} to 5.7×10^{-7}. Section 5.6 provides the results of the refined analyses.

5.2 Inventory for Performance Calculations

The postclosure analysis identified the inventory by the source category of waste material to be disposed of (commercial spent nuclear fuel, *DOE spent nuclear fuel*, surplus weapons-usable plutonium, and high-level radioactive waste). Note that the waste forms to be placed in the proposed repository would not exhibit the characteristic of toxicity, as measured by the Toxicity Characteristic Leaching Procedure (40 CFR 261.24). Therefore, the repository would be in compliance with the *Resource Conservation and Recovery Act* (40 CFR 261). For modeling purposes, the analysis averaged the inventory for each of the categories into an appropriate number of packages, each with identical contents. The modeled inventories consisted of two basic types of waste packages: a commercial spent nuclear fuel waste package and a codisposal waste package that would contain DOE spent nuclear fuel and high-level radioactive waste *canisters*.

5.2.1 INVENTORY OF RADIOACTIVE MATERIALS

There are more than 200 radionuclides in the analyzed waste inventory (DIRS 177424-SNL 2007, all). The analysis for this Repository SEIS used a subset of the 200 radionuclides. The number of radionuclides was determined by a screening analysis, the purpose of which was to eliminate from further consideration (screen out) radionuclides that are unlikely to contribute significantly to radiation dose to the RMEI. It would be impractical for DOE to model all of these radionuclides in a TSPA. The radionuclide screening analysis was recently revised to incorporate updated radionuclide inventory and screening factor data (DIRS 177424-SNL 2007, all). This screening analysis determined that 32 radionuclides have the potential to contribute an important fraction of the dose to the RMEI. This set of radionuclides forms the basis for the analysis this chapter discusses.

The analysis abstracted the total inventory into two types of representative waste packages:

1. A commercial spent nuclear fuel package.
2. A codisposal package with high-level radioactive waste in a glass *matrix* and DOE spent nuclear fuel.

For modeling purposes, DOE treated naval spent nuclear fuel as commercial spent nuclear fuel. This modeling approach was justified based upon the results from a suite of model comparisons as described in *Total System Performance Assessment Model/Analysis for the License Application* (DIRS 183478-SNL 2008, Section 7.5.6).

Appendix F, Table F-3 lists the abstracted inventory for the representative waste packages.

5.2.2 INVENTORY OF CHEMICALLY TOXIC MATERIALS

DOE would use several materials in the construction of the repository that are potentially chemically toxic. The Department performed an analysis of impacts from chemically toxic materials for the 10,000-year postclosure period. During that time, only a few waste packages would be likely to fail (Appendix F, Section F.2.4). Therefore, the analysis did not consider any chemically toxic materials inside waste packages. For the Yucca Mountain FEIS, DOE used a screening analysis to determine which, if any, of these materials would have the potential for transport to the *accessible environment* in quantities sufficient to be toxic to humans (DIRS 155970-DOE 2002, pp. I-52 to I-54). The results of that analysis showed that the remaining chemically toxic materials of concern would be chromium, molybdenum, nickel, and vanadium. DOE performed an additional screening analysis based on recent research (Appendix F, Section F.5.1). The additional analysis eliminated chromium from further concern, leaving molybdenum, nickel, and vanadium requiring further analysis. These elements would dissolve into solution as construction materials for the repository and waste packages corroded. As these elements dissolved, some portion of the material would precipitate as minerals and some would stay in solution. The quantities of these elements that remained in solution would be subject to continuous release from the repository.

Because there would be a large mass of construction materials, it would be unlikely that they would corrode completely during the first 10,000 years after closure. Therefore, DOE conservatively assumed that a constant release of material would occur for the entire period. The release rate would depend on the total surface area that was exposed to water, rather than on the total mass. The important sources of these materials would be the *exposed* surfaces available for corrosion. Appendix F, Section F.5.2.2 contains estimates of the amounts available for transport from these surfaces. Table 5-2 lists the total surface areas of alloys of concern and their elemental compositions.

Table 5-2. Total surface area of construction materials and their compositions.

Alloy	Total surface area (square meters)	Total surface area (square feet)	Composition as weight percent: Molybdenum	Nickel	Vanadium
Stainless steel[a]	2,700,000	29,000,000	2.5	12	0
Alloy 22	640,000	6,900,000	14.5	57.2	0.35

Source: Appendix F, Section F.5.2.2

An important design modification since the completion of the Yucca Mountain FEIS is the addition of extensive stainless-steel ground support hardware (support sheets and rock bolts). This additional stainless steel would account for over 90 percent of the total exposed stainless steel in the proposed repository (Appendix F, Section F.5.2.2).

5.3 System Overview

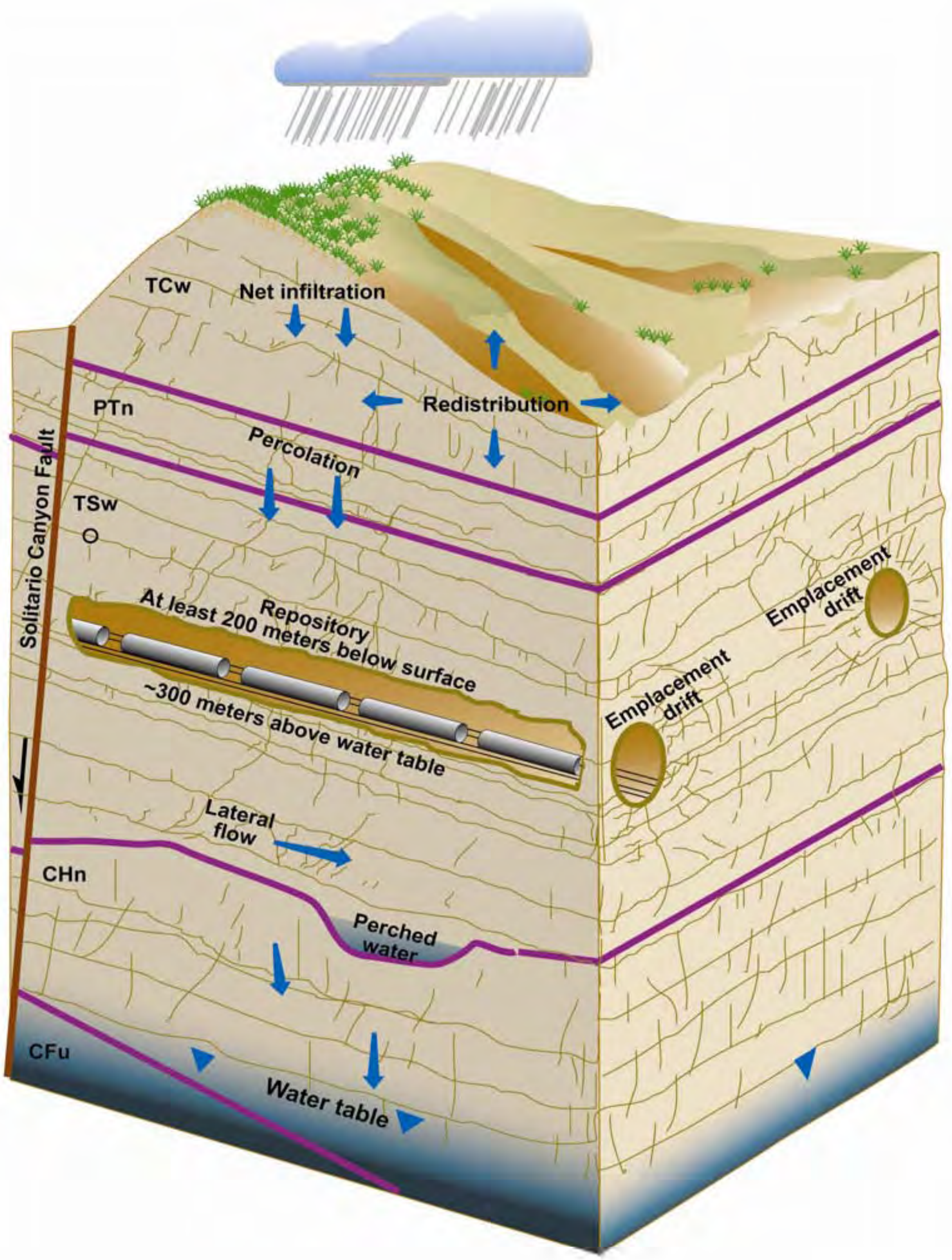
DOE would emplace radioactive materials at least 200 meters (700 feet) beneath the surface in the proposed repository. The emplaced materials would be almost entirely in the form of solids with a very small fraction of the radioactive inventory in the form of trapped gases (Section 5.6). The primary means for the radioactive and chemically toxic materials to contact the biosphere would be along groundwater pathways. The materials could affect human health if the following sequence of events occurred:

- The waste packages and their contents were exposed to water either through nominal or disruptive processes.
- Radionuclides or chemically toxic materials in the package materials or wastes became dissolved or mobilized in the water.
- The radionuclides or chemically toxic materials were transported in water to an *aquifer*, and the water that carried these materials was withdrawn from the aquifer through a well or at a surface-water discharge point and used directly by humans for drinking or in the human food chain (such as through irrigation or watering livestock).

An atmospheric pathway could result from a volcanic conduit that intersected the repository, destroyed waste packages, and erupted at the surface. The eruption at the surface could disperse volcanic tephra and entrained radionuclides under atmospheric conditions. However, the probability of this event would be very low and its impacts would be extremely small (Appendix F, Section F.4.2.1.2). A second atmospheric pathway could result from gaseous radionuclides that leaked from the repository and were transported downwind. This would result in extremely small impacts (Section 5.6). Therefore, the access to and flow of contaminated water are the most important considerations in a determination of potential health effects.

5.3.1 COMPONENTS OF THE NATURAL SYSTEM

Figure 5-2 is a simplified schematic of a repository at Yucca Mountain. It shows the principal features of the natural system that could affect the postclosure performance of the repository. Yucca Mountain is in a



CHn = Calico Hills nonwelded.
CFu = Crater Flat undifferentiated.
PTn = Paintbrush nonwelded.
TCw = Tiva Canyon welded.
TSw = Topopah Spring welded.

Note: To convert meters to feet, multiply by 3.2808.

Source: DIRS 183478-SNL 2008, Figure ES-20
00763DC_033_R3.ai

Figure 5-2. Components of the natural system.

semiarid desert environment where the current average annual precipitation over the unsaturated zone flow and transport model area is 170 millimeters (7 inches), which varies by specific location (DIRS 182145-SNL 2008, all). The *water table* is more than 600 meters (2,000 feet) below the surface of the mountain (DIRS 169855-BSC 2004, Figure 6-2). The proposed repository would be in unsaturated rock approximately midway between the desert environment and the water table (DIRS 179466-SNL 2007, Parameter 01-02).

The water table is the boundary between the unsaturated zone above and the saturated zone below. In the subsurface region above the water table, the rock contains water, but the water does not fill all the open spaces in the rock. Because the open spaces are only partially filled with water, this region is called the unsaturated zone. Water in the unsaturated zone tends to move generally downward in response to capillary action and gravity. In contrast, water fills all the open spaces in the rock below the water table, so this region is called the saturated zone. Water in the saturated zone tends to flow laterally from higher to lower pressures. Both zones contain several different rock types, as Figure 5-2 shows. The layers of major rock types in the unsaturated zone at the Yucca Mountain site are the Tiva Canyon welded, Paintbrush nonwelded, Topopah Spring welded, Calico Hills nonwelded, and Crater Flat undifferentiated *tuffs* (DIRS 169734-BSC 2004, Section 3.3). The figure shows the Solitario Canyon Fault, which forms the western boundary of the repository block (DIRS 169734-BSC 2004, Section 3.2.2). Faults are slip zones where seismic events have displaced rock units vertically, laterally, or diagonally, which results in discontinuous rock layers. These slip zones tend to form a thin plane in which there is more open space that acts as a channel for water. Some faults tend to fill with broken rock that forms as they slip, so they have a very different flow property from that of the surrounding rock. The proposed repository would be in the Topopah Spring *welded tuff* in the unsaturated zone, at least 200 meters (700 feet) below the surface and approximately 300 meters (1,000 feet) above the water table (DIRS 169734-BSC 2004, Section 3.3.5.1; DIRS 179466 SNL-2007, Parameter 01-06).

When rain falls at Yucca Mountain, most of the water runs off, is lost to evaporation, or is taken up by plants growing on the mountain (DIRS 182145-SNL 2008, Table 6.5.7.1-3[a]). A small amount infiltrates the rock on the surface. The small amount of water that infiltrates the rock percolates down through the mountain to the saturated zone. If there was a breach in the package containment, water that flowed through the unsaturated zone into the proposed repository could dissolve some of the waste material and carry it through the groundwater system to the accessible environment where exposure to humans could occur.

5.3.2 COMPONENTS OF THE WASTE PACKAGE AND DRIP SHIELD

The waste packages would consist of two concentric cylindrical containers sealed with an outer welded lid. The inner cylinder, which is the structural support member of the waste package, would be stainless steel. The outer cylinder would be a relatively thin, nickel-based alloy (Alloy 22) that would protect the underlying stainless-steel structural material from corrosion. In addition, spent nuclear fuel and high-level radioactive waste would be in their own sealed containers. Commercial spent nuclear fuel waste packages would contain a stainless-steel TAD canister. DOE codisposal waste packages would contain *disposable canisters*. The current design calls for emplacement of titanium drip shields over the waste packages just before repository closure. With the drip shield in place, the Alloy 22 outer cylinder would be the second corrosion barrier that protected the waste from contact with water. The use of two distinctly different corrosion-resistant materials would reduce the probability that a single environmental condition could cause the failure of both materials. Before the double-walled waste package was sealed, helium would be added as a fill gas. The helium would prevent corrosion of the waste form and help transfer heat from the waste form to the inner wall of the waste package prior to failure of the Alloy 22 outer cylinder. The movement of heat away from the waste form would be an important means to control waste package temperatures.

5.3.3 VISUALIZATION OF THE REPOSITORY SYSTEM FOR ANALYSIS OF POSTCLOSURE IMPACTS

In general, DOE modeled the repository system as a series of processes linked together, one after the other, spatially from top to bottom in the mountain. From a computer modeling standpoint, it is important to break the system into smaller components that relate to the information collection method. An operating repository system would be completely interconnected, and virtually no process would be independent of other processes. However, the complexity of such a system demands some idealization of the system for the performance of an analysis.

The first step in the visualization is the development of a list of all possible features, events, and processes that could apply to the behavior of the system. An example of a feature is the existence of a fault, an example of an event is a seismic event (*earthquake*), and an example of a process is the gradual degradation of the waste package wall by general corrosion. DOE used various types of analyses to screen the list to determine the features, events, and processes it should include in the modeling. The Department assembled the chosen features, events, and processes into scenario classes, which are descriptions of how features, events, and processes link together to result in a certain outcome (Appendix F, Section F.2.1 contains more detail on features, events, and processes).

The elements of the repository system model, referred to in this chapter as the TSPA-LA model, fall into the following categories, which generally relate to parts of the system:

- Unsaturated zone flow,
- Engineered Barrier System environments,
- Waste package and drip shield degradation,
- Waste form degradation,
- Engineered barrier flow and transport,
- Unsaturated zone transport,
- Saturated zone flow and transport, and
- Biosphere.

Appendix F, Sections F.2.2 through F.2.9 discuss the individual models associated with these elements. Sections F.2.10, F.2.11, F.4.1.2, and Sections 5.8 and 5.9 discuss the following scenario classes and assessments, respectively:

- Igneous Scenario Class,
- Seismic Scenario Class,
- Early Waste Package and Drip Shield Failure Scenario Class,
- Human intrusion, and
- Nuclear criticality.

During the development of the TSPA-LA model, DOE had to make assumptions in addition to those mandated by regulation, primarily to account for situations for which there were limited data. If data are limited, the use of appropriate assumptions and associated conservative data values is necessary. The EPA and NRC rulemaking processes acknowledged that uncertainty about physical processes over the large space and time scales of interest will remain, even after many years of site characterization. This postclosure analysis does not seek an exact prediction but rather a cautious but reasonable projection (or estimate) of what could occur, which includes a quantitative evaluation of uncertainty in that projection.

ASSUMPTIONS

The assessment of postclosure impacts sometimes used assumptions in the formulation of models. An assumption is a premise taken as a starting point for some element of the modeling for which there usually is no absolute proof. Assumptions normally account for qualitative uncertainties (where an absolute probability cannot be assigned). There are two types of assumptions: (1) if there is a high certainty (although unquantified) that the premise will hold true and (2) if the assumption is conservative (that is, all alternative assumptions would lead to a smaller impact). A conservative assumption is often used if there is considerable uncertainty about the alternative premise that is more likely. Some assumptions are mandated by regulations that prescribe how the modeling is to occur. A set of assumptions defines the conceptual model used for the analysis. A set of alternative assumptions would represent an alternative model. DOE conducted sensitivity studies to compare alternative models to help define the importance of certain assumptions, especially if there was considerable uncertainty (Section 5.3.4.2.3).

Each assumption has a basis, which can be the reason the assumption represents a condition of high certainty, a statement that it is mandated by regulations, or a statement that it is conservative in relation to the outcome of impact analysis.

5.3.4 UNCERTAINTY

As with any impact estimate, there is a level of uncertainty, especially for estimations of impacts over thousands and hundreds of thousands of years. In this context, uncertainty is the measure of confidence in the calculation in relation to a determination of how a system will operate or respond. The amount of uncertainty in an impact estimate is a reflection of several factors, including the following:

- An understanding of the components of a system (such as human, societal, hydrogeologic, or engineered) and how those components interact.

- The time scale over which estimates are made. Longer time scales for projections produce greater potential for uncertainty. This is particularly true for events that might or might not occur in the future and how a system evolves in response to these future events.

- The available computation and modeling tools. Models are based on a set of working hypotheses, assumptions, and parameters that are inherently uncertain because of the complexity and variability of a natural system.

DOE recognizes that uncertainties exist from the onset of an analysis; however, projections are valuable in the decisionmaking process because they provide insight based on the best information and scientific judgments available. This section discusses uncertainties in the context of possible effects on the impact estimates in this chapter.

5.3.4.1 Uncertainty in Societal Changes and Climate

The analysis this chapter presents is consistent with the regulatory requirements in the proposed EPA and NRC standards. Therefore, this analysis used an approach that involves estimation of radiological exposure to a defined RMEI. EPA and the NRC based the characteristics of the RMEI on societal conditions as they exist today and included consideration of current population distributions, groundwater use, and food consumption patterns. The proposed standards also specify a value to be used to represent climate change after 10,000 years.

DOE based estimates of future climatic conditions on what is known about the past and considered climate impacts due to human activities. Calcite in Devils Hole, a fissure in the ground about 40 kilometers (25 miles) southeast of Yucca Mountain, provides the best record of climate changes over the past 500,000 years. The record shows continual variation, often with rapid jumps, between cold glacial climates (for the *Great Basin* these are called pluvial periods) and warm interglacial climates similar to the present (DIRS 169734-BSC 2004, Sections 6.4 and 6.5). The analysis assumed that the current climate is the driest it will ever be at Yucca Mountain; this is reasonable based on the climatological record that has been projected for the next 10,000 years.

5.3.4.2 Uncertainty in Models and Model Parameters

The postclosure performance model that DOE used to assess the impacts from migration of radionuclides in groundwater includes a number of submodels, each of which must account for features of the system, likely and unlikely events, and processes that would contribute to the release and migration of materials. Because of the long periods to be simulated, the complexity and variability of the natural system, and other factors, the performance modeling must deal with uncertainty. This section discusses the nature of the uncertainties, how DOE accounted for them in this Repository SEIS, and their implications to interpretation of impact results.

5.3.4.2.1 *Relationship Between Variability and Uncertainty*

Uncertainty in model projections of repository performance comes from two major sources: (1) variability in what could happen in the future (*aleatory* uncertainty), and (2) lack of knowledge about quantities that have fixed values in the calculation of either the likelihood of future events at the proposed repository or impacts of these events (*epistemic* uncertainty). Alternative terminology includes the use of stochastic, variable, and irreducible as alternatives to aleatory, and the use of subjective, reducible, or state of knowledge as alternatives to epistemic.

Uncertainty and variability are, in general, related. The exact nature of the variability in a natural system cannot be known because all parts of the system cannot be observed. For example, DOE cannot dig up all the rock in Yucca Mountain and determine that the positioning of the rock layers is exactly as core sample data have suggested. Therefore, there is uncertainty about the properties of the rock at specific locations in the mountain because properties change with distance and it is not known how much they change at any given location. For example, if a function $f(x,y)$ characterizes the two-dimensional variability of some quantity, such as thermal conductivity, there are most likely many possible values for this function of varying levels of credibility. Thus, the function *f(x,y)* characterizes spatial variability, but a lack of knowledge of how to define *f(x,y)* exactly is epistemic uncertainty. If the variability can be appropriately quantified or measured, a model usually can be developed to include this variability in addition to the uncertainty in the representation of variability. However, the ability to model some types of spatial variability can be limited not only by lack of data but also by the capacity of a computer to complete calculations (for example, if one simulation took weeks or months to complete). In these instances, variability must be simplified to be reasonable and appropriate.

The analysis used two basic tools to deal with uncertainty and variability: alternative conceptual models and probability theory. It used alternative conceptual models to examine uncertainty in the understanding of a key physical-chemical process that controls system behavior. For example, different conceptual models of how water in *fractures* interacts with water in the smaller pores or matrix of the rock in the unsaturated zone lead to different flow and transport models. Sometimes conceptual models are not mutually exclusive (for example, both matrix and fracture flow can occur), and sometimes they do not exhaustively cover all possibilities. The analysis used conservatism at the subsystem and total system levels to select the best alternative conceptual model to use rather than to propagate quantitatively multiple conceptual models through the TSPA-LA model.

The analysis used probability theory to understand the impacts of uncertainty in specific model parameters (that is, would results change if the parameter value was different) and to characterize how the repository system might evolve in time due to the occurrence of disruptive events. It used the *Monte Carlo sampling technique* to handle uncertainty in specific model parameters. This technique involves random Latin hypercube sampling of ranges of likely values, or distributions, for all uncertain input parameters. Distributions describe the probability of a particular value falling in a specific range. A common type of distribution is the familiar bell-shaped curve, known as the *normal distribution*. Many different types of distributions describe parameters in the consequence analysis that are appropriate to the understanding of the values and their probabilities. The analysis calculated many realizations of repository system behavior, each based on one set of samples of all the inputs. Each total system realization had an associated probability, so there is some perspective on the likelihood that set of circumstances would occur. The Monte Carlo method yields a range for any chosen performance measure (for example, annual individual dose in a given period at a given location) and a probability for each value in the range. In other words, it gives estimates of repository performance and determines the uncertainties in those estimates. This chapter expresses the impact estimates as the mean, median, and 95th-percentile values (that is, the value for which 95 percent of the results were smaller).

5.3.4.2.2 *Uncertainty in Data*

Some uncertainties for input parameters or models result from a lack of data. Such data gaps can be due to the status of research (perhaps with more data expected later) or conditions that restrict or prevent collection of certain data (for example, data that would require tests over impracticably long periods or the necessity for minimal disturbance of the emplacement site). Uncertainty in data is a subset of parameter and model uncertainty.

The use of parameter distributions and studies of alternative models can help improve the understanding of how data uncertainty can affect the range of the impact results. Further, sensitivity studies can provide insight into the sensitivity of the model to particular parameters. Sensitivity studies identify data that are important to the modeled results, which can help identify those areas for which the study needs additional data. DOE has generated additional data since the completion of the Yucca Mountain FEIS that help improve its ability to characterize the range of impacts in this Repository SEIS. The following are examples of additional data and their uses:

- DOE has measured concentrations of chemical components in the rock, such as chloride, bromide, and sulfate, and the results have helped to identify fast paths for water flow. Ongoing analyses of the isotopic ages of fracture-lining minerals have provided additional information about the history of water movement. These studies have improved the understanding of flow paths and flow rates for water that moves through the unsaturated zone, and have revealed certain characteristics of the water, such as chemical composition and temperature. The analysis has used this new information to model the unsaturated zone more accurately (DIRS 184614-SNL 2007, all).

- DOE has investigated the effects of heat on the seepage of water into emplacement drifts in a drift-scale thermal test and laboratory experiments; these studies have provided additional data for models that predict the effects of coupled processes (DIRS 179590-SNL 2007, all).

- Accelerated corrosion testing of Alloy 22 has enabled more complete estimates of corrosion rates; DOE has used these data to improve the waste package degradation model (DIRS 178519-SNL 2007, all).

5.3.4.2.3 *Consideration of Alternative Conceptual Models*

There were three possible approaches to the incorporation of discrete alternative models in the performance analysis: (1) weighting alternative models into one comprehensive Monte Carlo simulation ("lumping"), (2) performing multiple Monte Carlo simulations for each discrete model, and (3) keeping the discrete models separate and evaluating them individually at the subsystem level to assess uncertainties and conservatisms and, through the use of expert judgment, implementing the reasonable and sometimes conservative models in the Monte Carlo simulation. The analysis used the third alternative to develop the main results in Section 5.5.

5.3.4.2.4 *Uncertainty and Postclosure Analysis*

The TSPA-LA analysis accounted for aleatory and epistemic uncertainties. Both aleatory and epistemic uncertainties were quantified with probability distributions that were propagated through the *probabilistic* Monte Carlo analysis. Using this technique, uncertainties in TSPA-LA projections were quantified via multiple sampling of aleatory and epistemic probability distributions and corresponding model simulations or realizations. The benefits of this probabilistic approach included: (1) obtaining a representative range of possible outcomes to quantify uncertainty of TSPA-LA projections, and (2) analyzing the relationship between the uncertain inputs and uncertain outputs to provide understanding of the effects of uncertainties on TSPA-LA projections.

5.3.4.2.5 *Uncertainty and Sensitivity*

In addition to accounting for the uncertainty, there is a need to understand characteristics of the engineered and natural systems (such as the unsaturated and saturated zones of the groundwater system) that would have the most influence on repository performance. This information helps define uncertainty in the context of what would influence results the most. This concept is called sensitivity analysis, which uses a number of methods to explain the results and quantify sensitivities. The overall postclosure performance of the repository would be a function of sensitivity (if a parameter was varied, how much would the performance measures change) and uncertainty (how much variation of a parameter would be reasonable). For example, the postclosure performance results could be sensitive to a certain parameter, but the value for the parameter is exactly known. The uncertainty analysis techniques described below would not identify that parameter as important. However, many parameters in the analyses have associated uncertainties and become highly important to performance. On the other hand, the level of their ranking can depend on the range of uncertainty.

WHY IS THE TSPA-LA MODEL PROBABILISTIC?

The TSPA-LA model uses statistical sampling of many parameters and generates 300 realizations (that is, "future states of the repository system"), each with a unique sampling of parameter values. Such a model is known as a probabilistic model. (Other text boxes describe how this is applied to obtain results.)

Many parameters are not known exactly but rather are represented as a distribution of values, with a probability assigned to each value (one well-known type of distribution is the "bell-shaped curve" or "normal" distribution). A probabilistic model is an appropriate way to produce results that reflect these parameter uncertainties.

In developing the TSPA-LA model used for the analysis in this Repository SEIS, DOE took into consideration the regulatory requirements in the proposed U.S. Environmental Protection Agency and U.S. Nuclear Regulatory Commission standards to provide a perspective on potential radiological impacts during the postclosure period.

At the system level, certain design features of the repository, such as the layout, are not treated as variable. These are modeled without an associated uncertainty. The sensitivities to performance for certain parameters of this type, such as waste package thickness, have been examined in subsystem models and factored into the selection of the parameter. The determination of the parameters or components that are most important depends on the particular performance measure. The 1993 and 1995 TSPAs (DIRS 100111-CRWMS M&O 1994, all; DIRS 100191-Wilson et al. 1994, all; DIRS 100198-CRWMS M&O 1995, all) demonstrated this point. These analyses showed, for example, that the important parameters would be different for 10,000-year doses than for post-10,000-year period doses.

There are several techniques for the analysis of uncertainties, which include the use of scatter plots where the results (for example, annual individual dose) are plotted against input parameters and visually inspected for trends. In addition, performance measures can be plotted against various subsystem outputs or surrogate performance measures (for example, waste package lifetime) to determine if that subsystem or performance surrogate would be important to performance. There are several formal mathematical techniques for evaluation of the sets of realizations from a Monte Carlo analysis to extract information about the effects of parameters. Such an analysis determined the principal factors that would affect the performance of the repository.

5.3.4.3 Uncertainty Analysis for the TSPA-LA

The *Total System Performance Assessment Model/Analysis for the License Application* (DIRS 183478-SNL 2008, all) documented the methodology used to develop a comprehensive quantitative analysis of the possible future behavior of a *Yucca Mountain Repository*. The methodology combined detailed conceptual and numerical models of each individual and coupled process in a single probabilistic model for use in assessment of how a repository might perform over long periods.

DOE has always recognized that uncertainties will remain in any assessment of the performance of a repository over thousands to hundreds of thousands of years. For this reason, one part of the DOE approach to uncertainty relies on multiple lines of evidence that can contribute to the understanding of the performance of the repository. Another part of the DOE approach is a commitment to continual testing, monitoring, and analysis beyond the licensing of the repository.

DOE performed a sensitivity analysis to determine the parameters that contribute most to the uncertainties in the postclosure performance results in Section 5.5. These parameters are the main contributors to variations in calculated impacts. In any case, the range of values in the distribution for these parameters exerts the strongest influence on the uncertainty of the results.

DOE used regression analysis as a tool to quantify the strength of input-output relationships in the TSPA-LA model. The analysis fitted an incremental linear rank regression model between individual dose at a given time (or some other performance measure) and all randomly sampled input variables. It ranked parameters on the basis of how much their exclusion would degrade the explanatory power of the regression model. The importance-ranking measure that DOE used for this purpose was the partial rank correlation coefficient. This uncertainty importance factor quantifies the proportion of the total spread (variance) in total dose explained by the regression model that can be attributed to the variable of interest.

5.3.5 SENSITIVITY ANALYSIS RESULTS

For different time frames in the analysis, different epistemic parameters emerge as important to the overall uncertainty in the results (DIRS 183478-SNL 2008, all). Table 5-3 lists the results of the sensitivity analysis. The important parameters, which the table lists, are as follows:

- IGRATE. This parameter is the probability of an igneous event, which is the annual frequency, as a cumulative distribution function, of an intersection of the repository by a volcanic dike. As discussed in Appendix F, Section F.4.2.1.1, DOE assumed that an igneous intrusion event would destroy all drip shields and waste packages and, therefore, they would offer no barrier to seepage and radionuclide transport.

- SCCTHRP. This parameter is the residual stress threshold for the Alloy 22 waste package outer barrier. If the residual stress in the waste package outer barrier exceeded this threshold value, stress corrosion cracks could form, which could allow radionuclides to migrate from the waste package. The primary causes of residual stresses in the waste package outer barrier would be low-frequency, high-peak ground velocity seismic ground motions, which could cause impacts from waste package to waste package, from waste package to emplacement pallet, and from waste package to drip shield. These impacts could cause dynamic loads that dent the waste package, which could result in structural deformation with residual stress.

- WDGCA22. This parameter relates to the temperature dependence for the general corrosion rate of the Alloy 22 waste package outer barrier. It determines the magnitude of this temperature dependence and directly influences the short-term and long-term general corrosion rates of the Alloy 22; the larger this value is, the higher the earlier general corrosion rates during the thermal period and

Table 5-3. Top-ranking uncertainty importance parameters.

Time after closure (years)	Two most important parameters	
3,000	SCCTHRP	IGRATE
5,000	SCCTHRP	IGRATE
10,000	SCCTHRP	IGRATE
125,000	IGRATE	SCCTHRP
250,000	WDGCA22	IGRATE
500,000	IGRATE	WDGCA22
1,000,000	IGRATE	WDGCA22

Source: DIRS 183478-SNL 2008, Section 8.1.1.7[a].

the lower the long-term corrosion rates when the repository temperatures were near *ambient* in-situ temperature.

The parameters in Table 5-3 that most affect the total uncertainty in the TSPA-LA model are factors that would govern degradation of the waste packages or the rate at which igneous intrusion would destroy all waste packages.

5.4 Locations for Impact Estimates

Yucca Mountain is in southern Nevada in the Mojave Desert. It is in a semiarid region with linear mountain ranges and intervening valleys, current average rainfall that ranges from about 100 to 250 millimeters (4 to 10 inches) a year, sparse vegetation, and a low population. This section describes the regions where possible human health impacts could occur.

Figure 5-3 shows the general direction of groundwater movement from Yucca Mountain. Shading indicates major areas of groundwater discharge through a combination of springs and *evapotranspiration* by plants. The general path of water that infiltrates through Yucca Mountain is south toward Amargosa Valley into and through the area around Death Valley Junction in the lower *Amargosa Desert*. Natural discharge of groundwater from beneath Yucca Mountain probably occurs farther south at Franklin Lake Playa (DIRS 100376-Czarnecki 1990, pp. 1 to 12), and spring discharge in Death Valley is a possibility (DIRS 100131-D'Agnese et al. 1997, pp. 64 and 69). Although groundwater from the Yucca Mountain vicinity flows under and to the west of Ash Meadows in the volcanic tuff or alluvial aquifers, the carbonate aquifer feeds the surface discharge areas at Ash Meadows and Devils Hole (Figure 5-3). While these two aquifers are connected at some locations, the carbonate aquifer has a hydraulic head that is higher than that of the volcanic or alluvial aquifer. Because of this pressure difference, water from the volcanic aquifer does not flow into the carbonate aquifer; rather, the reverse occurs. Therefore, contamination from Yucca Mountain is not likely to mix with carbonate aquifer waters and discharge to the surface at Ash Meadows or Devils Hole (DIRS 104983-CRWMS M&O 1999, all) under current conditions.

Because there would be no contamination of this discharge water under current conditions, no human health impacts would be expected. Further, no impacts to the endangered Ash Meadows Amargosa pupfish (*Cyprinodon nevadensis mionectes*) or Devils Hole pupfish (*Cyprinodon diabolis*) at those locations would be expected.

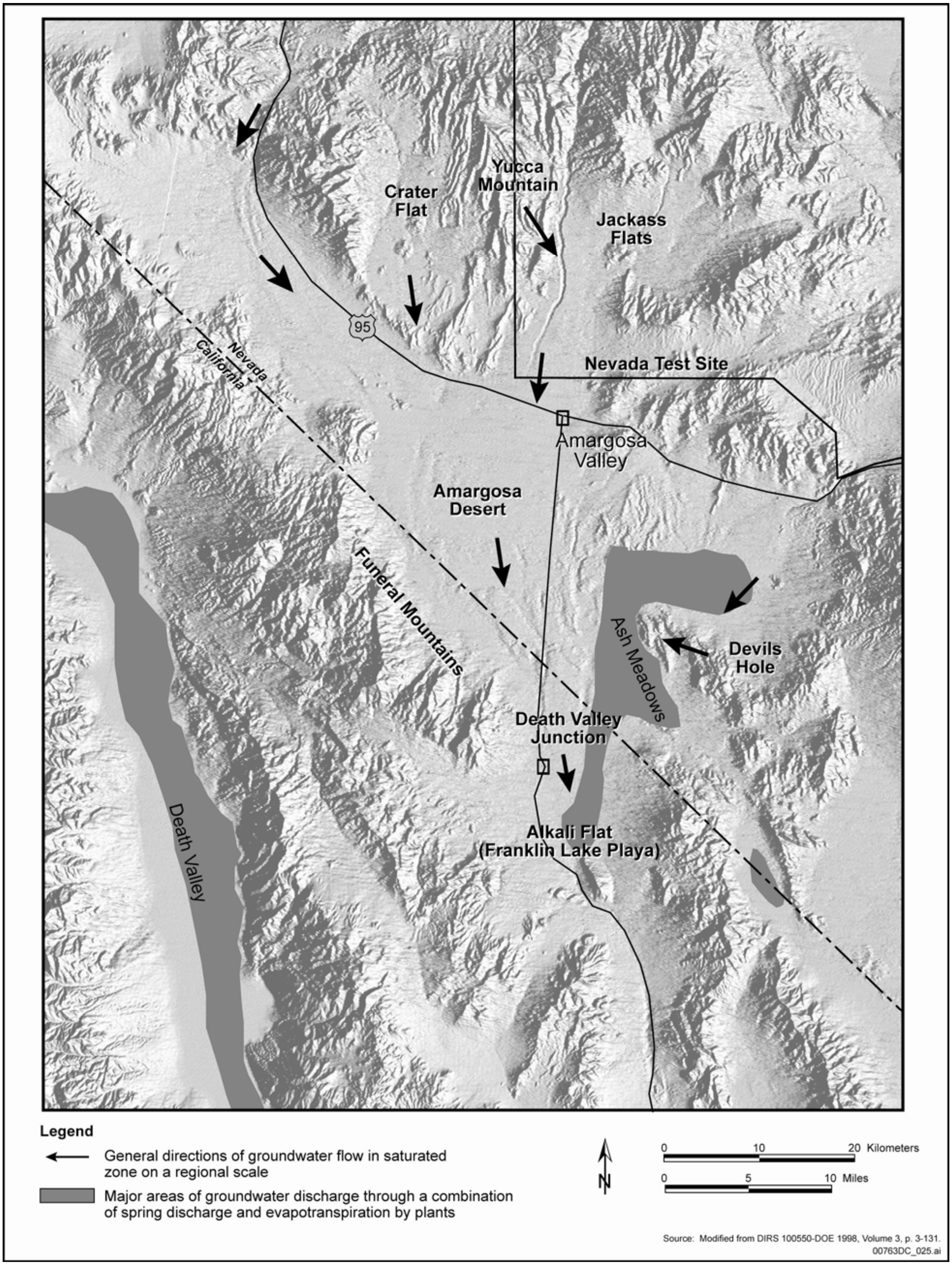


Figure 5-3. Saturated groundwater flow system.

5.5 Postclosure Radiological Impacts

The following sections discuss the annual committed effective *dose equivalent* to the RMEI, a hypothetical individual who would live south of Yucca Mountain. DOE assumed that this individual would use contaminated groundwater and have lifestyle characteristics that EPA defined in 40 CFR 197.21. By definition, because of the highly conservative nature of the criteria to be applied to the RMEI, the RMEI would receive the high end of the range of potential dose distribution for the exposed population. The following criteria apply, by regulation, to the RMEI:

1. Lives in the accessible environment above the highest concentration of radionuclides in the plume of contamination. The accessible environment is any point outside the *controlled area*, which is defined as the surface area identified by passive institutional controls, that would encompass no more than 300 square kilometers (120 square miles) (40 CFR 197.2). It must not extend farther south than 36 degrees, 40 minutes, 13.661 seconds north latitude, in the predominant direction of groundwater flow, and no more than 5 kilometers (3 miles) from the repository footprint in any other direction. The southernmost point of the controlled area, which is approximately 18 kilometers (11 miles) south of the repository, is the location of the RMEI in the TSPA-LA.

2. Has a diet and living style representative of the people who now reside in the town of Amargosa Valley. DOE must use projections based on surveys of the people who live in the town of Amargosa Valley to determine their diets and living styles and use the mean values of these factors in the assessments for 40 CFR 197.20 and 40 CFR 197.25.

3. Drinks 2 liters (0.5 gallon) of water per day from wells at the location criterion 1 specifies.

The analysis converted the annual committed effective dose equivalent, referred to as the annual individual dose, to the probability of contracting a fatal cancer (a latent cancer fatality) due to exposure to radioactive materials in the water. DOE based the analysis on the radionuclide inventories that would be transported to the RMEI location. The analysis included the entire carbon-14 inventory of the commercial spent nuclear fuel as a solid in the groundwater release models. This approach is conservative (tends to overstate the risk) because 2 percent of the carbon-14 is in the fuel as a gas (Section 5.6). Therefore, the groundwater models slightly overestimate (by approximately 2 percent) the potential impacts from carbon-14.

DOE performed probabilistic model simulations using the TSPA-LA model for the RMEI location [18 kilometers (11 miles) from Yucca Mountain]. Each of the probabilistic simulations used 300 separate sampled values for epistemic uncertain parameters and generated 300 realizations of annual individual dose as a function of time for up to 1 million years after repository closure. These annual individual dose histories were used to determine the mean, median, and 95th-percentile annual dose projections for the RMEI.

DOE estimated doses and groundwater impacts in this section for the RMEI location using the representative volume of 3.7 million cubic meters (3,000 acre-feet) of groundwater (10 CFR 63.332) to calculate the concentration of radionuclides. The TSPA-LA model collected all the radionuclides released to the groundwater in the representative volume.

Development of the TSPA-LA model started with completion of the features, events, and processes screening analysis and forming of the scenario classes for inclusion in the performance assessment (Appendix F, Section F.2). This produced the Nominal Scenario Class, Early Failure Scenario Class, and two disruptive event scenario classes that describe possible igneous and seismic events. Appendix F, Section F.2 describes these scenario classes and the modeling cases that represent them in the TSPA-LA in greater detail.

The Nominal Scenario Class includes a single modeling case that considers the expected corrosion degradation processes of the drip shields and waste packages. The Early Failure Scenario Class considers the possible early failure of drip shields and waste packages due to manufacturing, material defects, or preemplacement operations that include improper heat treatment. This class includes two modeling cases, one for drip shield early failure and one for waste package early failure. DOE used modeling cases to represent different modes of degradation of the Engineered Barrier System features for separate analysis and then combined them to evaluate the total dose to the RMEI and groundwater impacts.

DOE used the Seismic Scenario Class to analyze possible seismic disruption of the repository and its effect on repository performance (Appendix F, Section F.2.11). This class includes (1) a modeling case that addresses features, events, and processes for the effects of ground motion damage to Engineered Barrier System features, and (2) a modeling case that addresses features, events, and processes for the effects of fault displacement damage to Engineered Barrier System features.

CALCULATION OF MEAN, MEDIAN, AND 95TH-PERCENTILE RESULTS

Because of the probabilistic nature of the TSPA-LA results, it is informative to examine the mean and median results, which are measures of central tendencies or average values, and the 95th percentiles, which represent the high extreme values.

The Igneous Scenario Class includes features, events, and processes that describe the possibility that low-probability igneous activity could affect repository performance (Appendix F, Section F.2.10). This class includes the Igneous Intrusion Modeling Case, which addresses the features, events, and processes for the possibility that magma (molten rock), in the form of a dike (ridge of material), could intrude into the repository and disrupt expected repository performance. The Igneous Scenario Class also includes a Volcanic Eruption Modeling Case that includes features, events, and processes that describe an eruptive conduit that would rise through the repository, damage a number of waste packages, and erupt at the surface. This low-probability volcanic eruption could disperse volcanic tephra and entrained radionuclides into the atmosphere and deposit it on land surfaces where soil and near-surface geomorphic processes would redistribute it. In this Repository SEIS, the total annual dose to the RMEI includes the contribution of dose from the igneous eruption event (Appendix F, Section F.4.3).

All modeling cases are for groundwater release with the exception of the single atmospheric release case, the Volcanic Eruption Modeling Case. The TSPA-LA model implemented the various modeling cases separately to calculate annual doses and groundwater impacts at the RMEI location. It then combined the performance quantities from each modeling case appropriately to calculate total groundwater impacts and the total annual dose to the RMEI (Sections 5.5.1 and 5.5.2 for the first 10,000 years and post-10,000 years, respectively). The analysis evaluated the impacts of a Human Intrusion Scenario that involves inadvertent drilling separately (Section 5.8).

The following two sections summarize the results of annual dose and groundwater performance analysis. Table 5-4 summarizes the estimated radiological impacts to the RMEI during the first 10,000 years after repository closure and for the post-10,000-year period up to 1 million years.

Table 5-4. Estimated radiological impacts to the RMEI—combined scenario classes.

	Mean		Median		95th-percentile	
Period	Annual individual dose would not exceed (millirem)	Probability of LCF per year	Annual individual dose would not exceed (millirem)	Probability of LCF per year	Annual individual dose would not exceed (millirem)	Probability of LCF per year
First 10,000 years	0.24	1.4×10^{-7}	0.13	7.7×10^{-8}	0.67	4.0×10^{-7}
Post-10,000-year	2.0	1.2×10^{-6}	0.96	5.7×10^{-7}	9.1	5.4×10^{-6}

LCF = Latent cancer fatality.

5.5.1 POSTCLOSURE RADIOLOGICAL IMPACTS FOR THE FIRST 10,000 YEARS AFTER CLOSURE

This section presents the combined radiological results from all scenario classes that DOE considered in the assessment of repository performance. Appendix F, Section F.4.1 (for undisturbed repository performance) and Section F.4.2 (for disruptive events) summarize the radiological impacts from different scenario classes and modeling cases. Section F.4.3 summarizes the calculation of combined annual dose results.

COLOR FIGURES

The figures illustrating results of the performance analysis presented in Chapter 5 and Appendix F can be found in color on the CD on the inside back cover of the Summary of this Repository SEIS and the Office of Civilian Radioactive Waste Management Web site: http://www.ocrwm.doe.gov. Some of the figures can also be found in color in the Summary.

The performance analysis for the combined scenario classes indicated that for the first 10,000 years after closure there would be very limited combined releases from all scenario classes with small radiological impacts for the total of all classes (Figure 5-4). The values in Table 5-4 indicate that for the first 10,000 years after repository closure, the mean annual individual dose to the RMEI could be approximately 0.2 millirem. This is about 1 percent of the EPA standard, which allows up to a 15-millirem annual committed effective dose equivalent during the first 10,000 years. The median and 95th-percentile values are well below the EPA standard as well. (The remainder of this chapter refers to the "annual committed effective dose equivalent" as the "annual individual dose.")

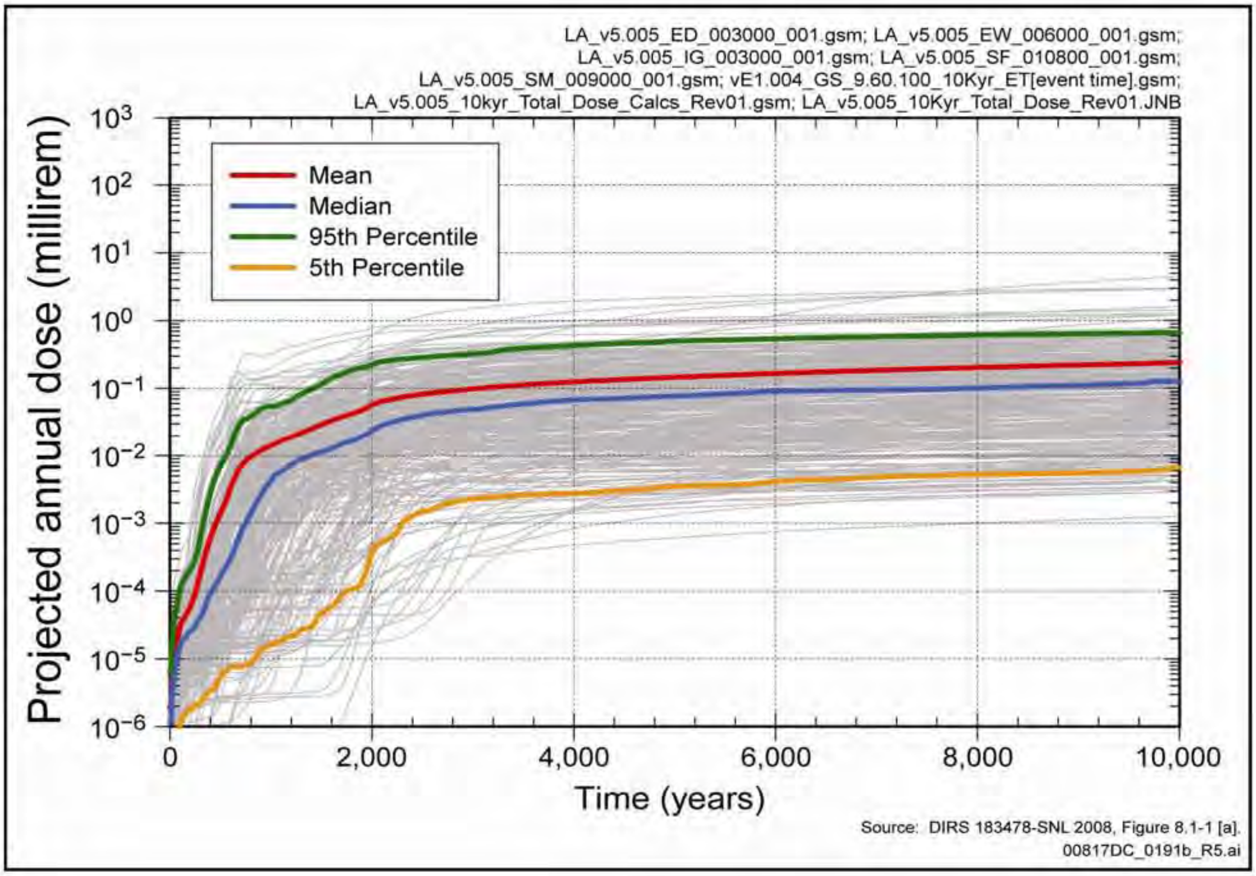


Figure 5-4. Total projected annual dose for the first 10,000 years after repository closure—combined scenario classes.

COMPARISON OF RESULTS WITH THE YUCCA MOUNTAIN FEIS

In the radiological dose calculations for this Repository SEIS, the impacts are for the combination of all scenario classes (nominal + seismic + early failure + igneous intrusion + volcanic eruption). The comparable section of the Yucca Mountain FEIS reported the results for the nominal scenario class and reported the additional scenario classes in separate subsections. Further, the nominal scenario class in the Yucca Mountain FEIS included damage to commercial spent nuclear fuel cladding due to seismic vibratory ground motion. Appendix F discusses the results for all scenario classes in this Repository SEIS.

The radionuclides that would contribute the most to individual dose in the first 10,000 years would be dissolved technetium-99, carbon-14, plutonium-239, and iodine-129 in groundwater (Figure 5-5). The mean consequence at 18 kilometers (11 miles) has technetium-99 contributing more than 50 percent of the total annual individual dose rate, carbon-14 contributing approximately 15 percent, and plutonium-239 and iodine-129 each contributing approximately 10 percent. Plutonium-240, chlorine-36, selenium-79, and neptunium-237 would provide additional, smaller contributions. The groundwater modeling for this waterborne radiological impacts analysis conservatively assumed that all carbon-14 migrated in the groundwater.

MULTI-REALIZATION PLOTS

The main result of the Monte Carlo simulation process is a set of realizations for the expected annual dose histories of the reasonably maximally exposed individual, which are generally plotted in the form of a multi-realization plot. The multi-realization plots developed for demonstrating compliance with the Individual Protection Standard are in Figures 5-4 and 5-6.

Curves for the mean, median, and 5th- and 95th-percentile dose histories are superimposed on each multi-realization plot. The total mean annual dose history, which is plotted as the red curve (second curve from the top), was computed by taking the arithmetic average of the 300 expected annual dose values for the individual time planes along the curves. Similarly, the median dose history, plotted as the blue curve (third curve from the top), was constructed from points obtained by sorting the 300 expected values from the lowest to highest, and then averaging the two middle values. Curves for the 5th- and 95th-percentile dose histories are also plotted to illustrate the spread in the expected annual dose histories; 90 percent (or 270 of the 300 epistemic realizations) of the protected dose histories fall between these two percentile curves. For a detailed description of the calculation of the total annual dose, see the *Total System Performance Assessment Model/Analysis for the License Appilcation* (DIRS 183478-SNL 2008, Section 6.1.2.2).

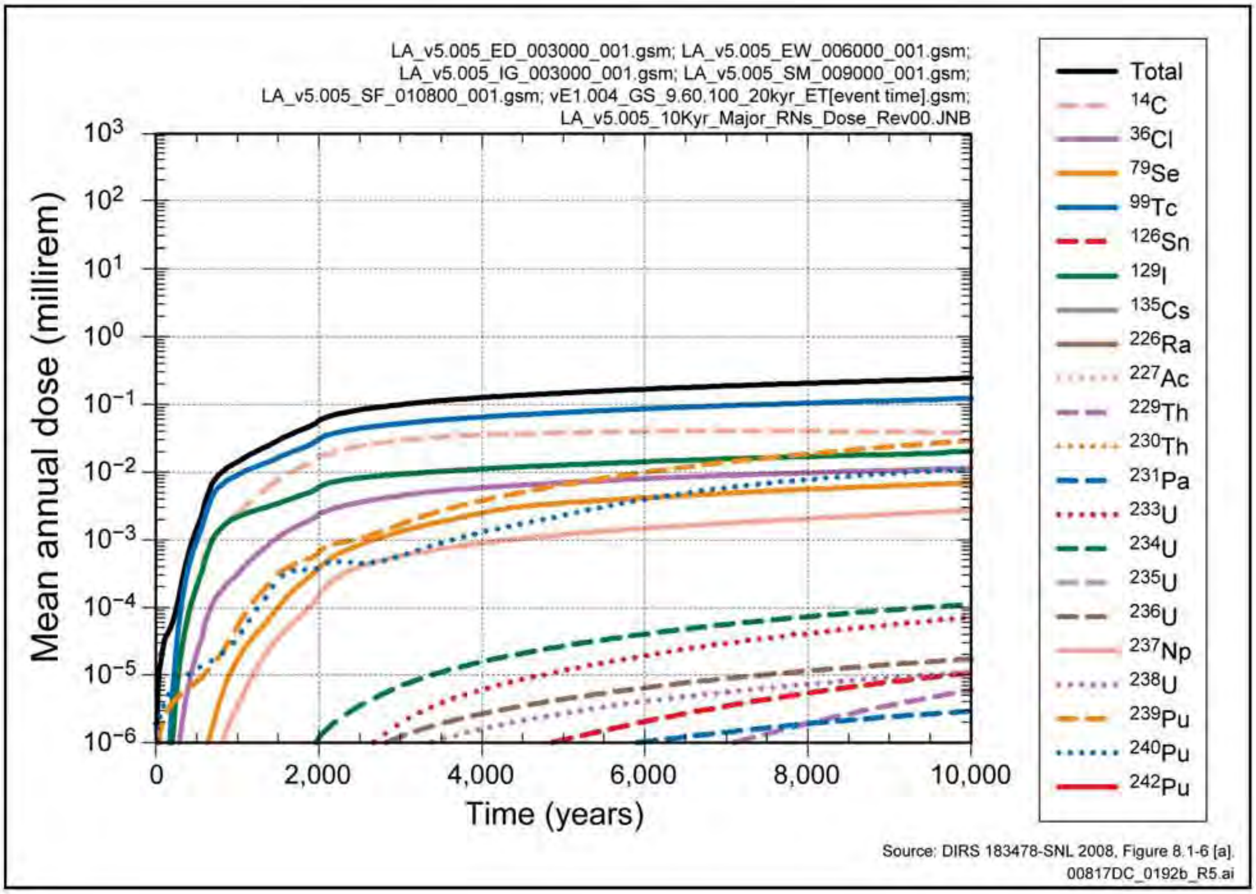


Figure 5-5. Contribution of individual radionuclides to total mean annual dose for the first 10,000 years after repository closure—combined scenario classes.

In relation to the groundwater protection standards in 40 CFR 197.30, both the mean and 95th-percentile estimated levels during the 10,000-year regulatory period are estimated to be substantially less than the regulatory limits (Table 5-5). As shown in the table, the 95th-percentile value for the combined radium concentration is less than the mean value. This result was a consequence of a few realizations that projected relatively high, but still small, radium concentrations that skewed the distribution of radium concentrations and caused the mean value to be higher than the 95th-percentile value. The groundwater protection standards in 40 CFR 197.30 require exclusion of unlikely natural processes and events in the performance assessment evaluation for the groundwater protection standard. Unlikely events are those that have less than 1 chance in 10 and at least 1 chance in 10,000 of occurring within 10,000 years of disposal. Likely events are those that have a 10-percent chance of occurring within 10,000 years of disposal. Therefore, the assessment of groundwater protection included the Nominal Scenario Class, the Early Failure Scenario Class, and the likely portion of the Seismic Ground Motion Modeling Case, which extends across the likely-unlikely boundary. That is, ground motions potentially occur with recurrence frequencies that are both above and below 1 chance in 10 within 10,000 years of disposal.

Table 5-5. Comparison of postclosure impacts at the RMEI location with groundwater protection standards during the first 10,000 years after repository closure—combined Nominal, Early Failure, and Seismic (seismic ground motion events with exceedance frequencies greater than 1×10^{-5} per year) scenario classes.

Radionuclide or type of radiation emitted	EPA limit	Mean would not exceed	95th-percentile would not exceed	Mean background
Combined radium-226 and radium-228 (picocuries per liter)	5	1.3×10^{-7}	9.9×10^{-8}	0.5
Gross alpha activity (including radium-226 but excluding radon and uranium) (picocuries per liter)	15	6.7×10^{-5}	3.2×10^{-3}	0.5
Combined beta- and photon-emitting radionuclides (millirem per year) to the whole body or any organ, based on drinking 2 liters (0.5 gallon) of water per day from the representative volume	4	0.3	0.8	Background not included in limit

Source: DIRS 183478-SNL 2008, all.
EPA = U.S. Environmental Protection Agency.

5.5.2 POSTCLOSURE RADIOLOGICAL IMPACTS FOR THE POST-10,000-YEAR PERIOD AFTER CLOSURE

Table 5-4 lists estimated individual doses to the RMEI for the post-10,000-year period in mean, median, and 95th-percentile values. Figure 5-6 shows the mean, median, 5th- and 95th-percentile annual individual doses at the RMEI location up to 1 million years after repository closure. The values in Table 5-4 indicate that, for the post-10,000-year period, the mean and median annual individual doses could be approximately 2.0 millirem and 0.96 millirem, respectively. The estimated median value is about 0.3 percent of the proposed EPA standard, which allows up to a 350-millirem annual committed effective dose equivalent for the post-10,000-year period. In addition, the mean and 95th-percentile values are well below the EPA standard.

The radionuclides that DOE estimated to contribute the most to the mean annual individual dose would be plutonium-242, iodine-129, neptunium-237, radium-226, and technetium-99 (Figure 5-7). The estimated mean annual individual dose at the RMEI location would consist of approximately 30 percent from

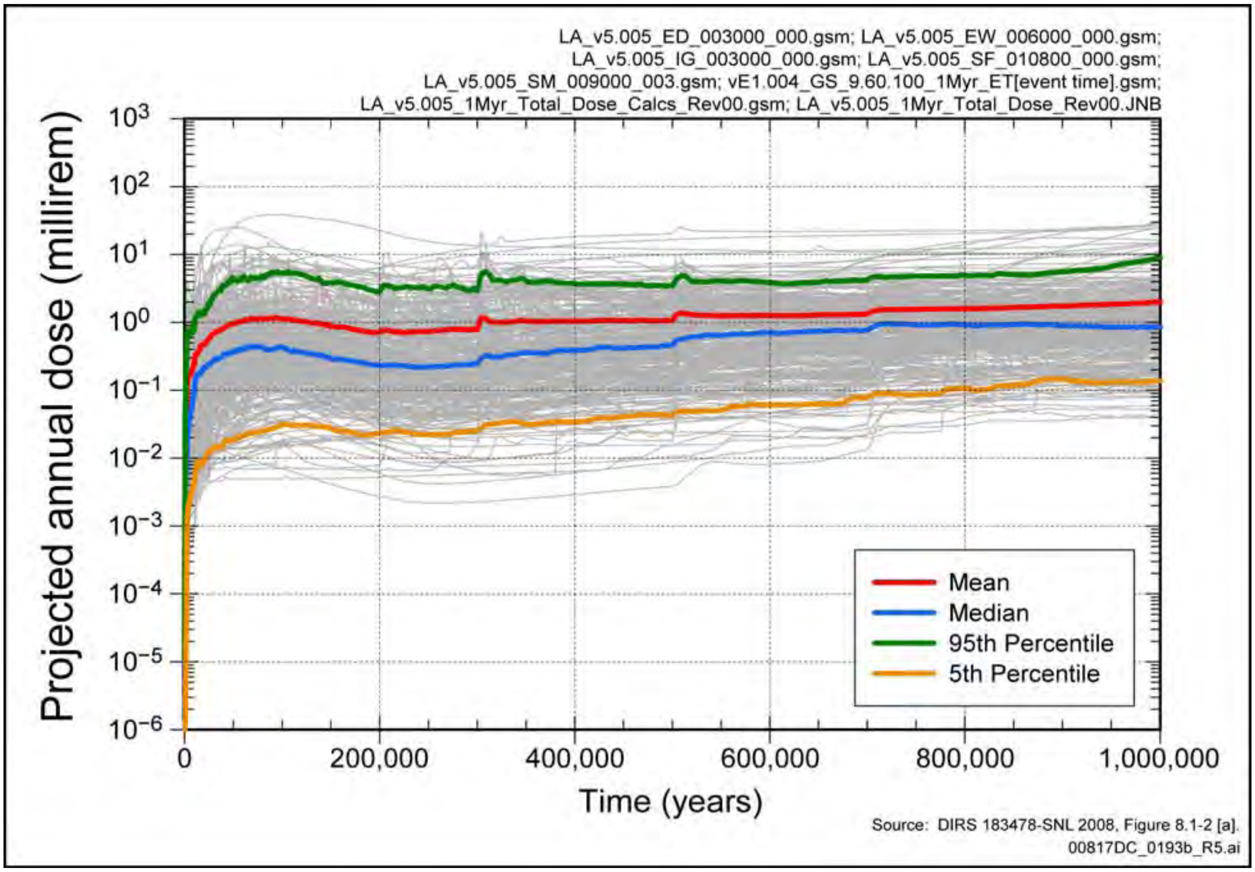


Figure 5-6. Total projected annual dose for the post-10,000-year period—combined scenario classes.

plutonium-242, about 20 percent from each of iodine-129 and neptunium-237, about 15 percent from radium-226, and about 8 percent from technetium-99.

5.6 Atmospheric Radiological Impacts from Other than Volcanic Eruption

The Yucca Mountain FEIS contained an analysis of the radiological impacts of atmospheric release from other than volcanic eruption. There are no changes to the *Proposed Action* that would have a significant effect on *source terms* or release rates. Because the results showed extremely small effects, there would be no significant change to the information the FEIS presented if DOE performed a new analysis. This section summarizes the analysis and results from the FEIS. DOE did not update the results to the new latent cancer fatality conversion factor or the increase in population; these adjustments would have resulted in about a 50-percent increase but would not significantly change the low order of magnitude quantities. DOE has incorporated the more detailed discussion on atmospheric radiological impacts by reference to Appendix I, Section I.7 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. I-62 to I-67).

After DOE closed the repository, there would be limited potential for releases to the atmosphere because the waste would be isolated far below the ground surface. Still, the rock is porous and does allow gas to flow. Therefore, in the Yucca Mountain FEIS, DOE analyzed possible airborne releases. In the FEIS, a

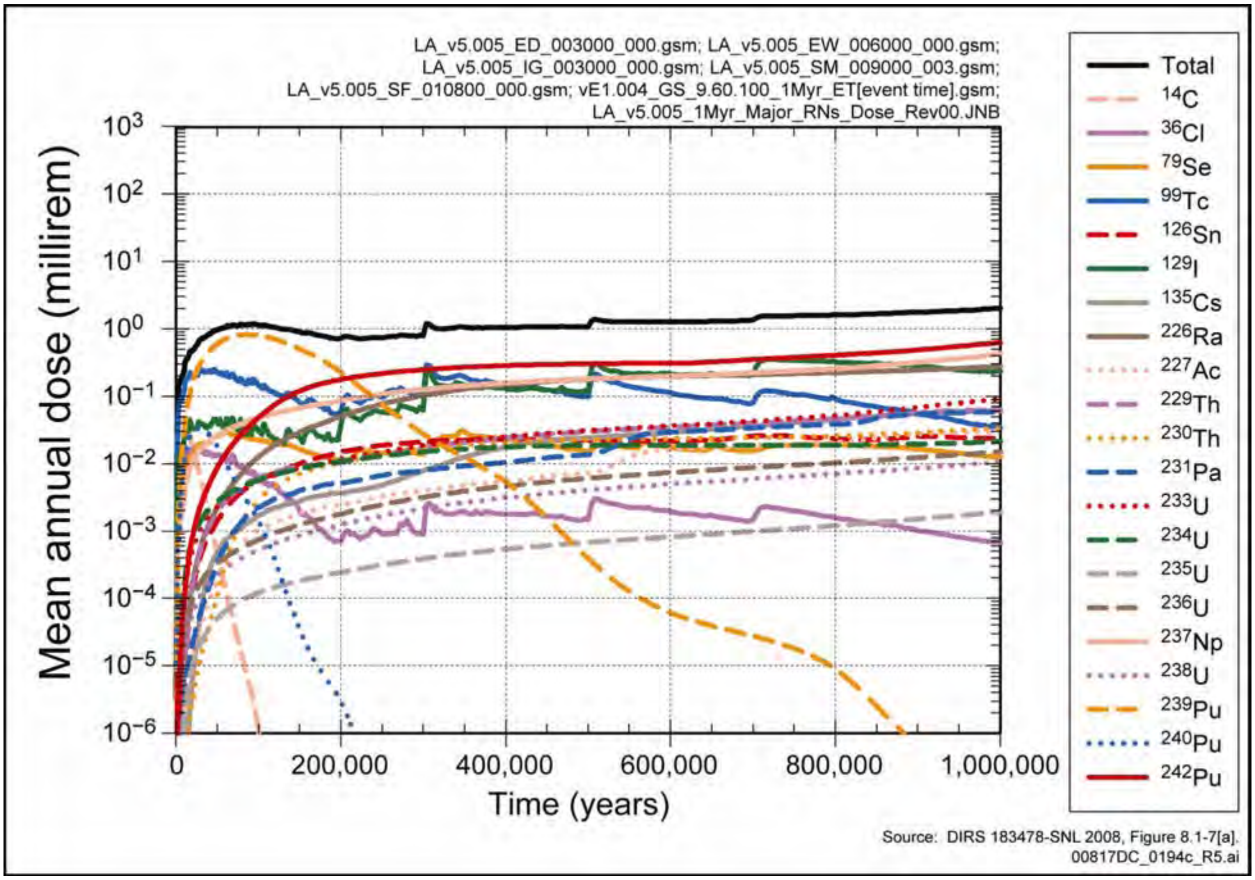


Figure 5-7. Contribution of individual radionuclides to total mean annual dose for the post-10,000-year period—combined scenario classes.

screening analysis showed that a full analysis was necessary only for carbon-14. Iodine-129 can exist in a gas phase, but it is highly soluble and, therefore, would be more likely to dissolve in infiltrating water rather than migrate as a gas. The screening analysis in Appendix I, Section I.3.3 of the FEIS eliminated other gas-phase isotopes (DIRS 155970-DOE 2002, p. I-29), usually because they have short half-lives and are not decay products of long-lived isotopes. Because the radioactive decay constant for radon-222 is 0.18145 per day, radioactive decay would reduce the amount of radon-222 in the air by approximately 90 orders of magnitude to negligible levels in the time it took the air to travel from the repository horizon through 200 meters (700 feet) of overlying rock. Therefore, DOE anticipates no human effects from the atmospheric release of radon-222 in the waste package.

DOE used the GENII program (DIRS 100953-Napier et al. 1988, all) to model human health impacts in the Yucca Mountain FEIS for the population in the 80-kilometer (50-mile) region around the repository. About 2 percent of the carbon-14 in commercial spent nuclear fuel is in a gas phase in the space (or gap) between the fuel and the *cladding* around the fuel (DIRS 103446-Oversby 1987, p. 92). This means that there would be 0.122 *curie* of carbon-14 per waste package of commercial spent nuclear fuel at the time of emplacement.

The Yucca Mountain FEIS reported a maximum 80-kilometer (50-mile) annual population dose on the order of 1×10^{-8} *person-rem*. This dose corresponds to about 1×10^{-12} latent cancer fatality in the regional population during each year at the maximum carbon-14 release rate. This annual population radiological dose corresponds to a 70-year lifetime radiological population dose on the order of 1×10^{-6} person-rem, which corresponds to about 1×10^{-10} latent cancer fatality during the 70-year period of the maximum release.

The location for airborne releases would depend on wind speed and direction, and the analysis considered it only for those locations where people currently reside (it is not a predetermined location). The analysis showed that the maximum dose to individuals would occur at 24 kilometers (15 miles) south of the repository. For a maximum release rate, the individual maximum radiological dose rate is estimated to be on the order of 1×10^{-13} *rem* per year, which corresponds to about a 1×10^{-17} probability of a latent cancer fatality. The 70-year lifetime dose is estimated to be on the order of 1×10^{-11} rem, which represents about a 1×10^{-15} probability of a latent cancer fatality.

5.7 Impacts from Chemically Toxic Materials

DOE performed an analysis that conservatively assumed a constant rate of release of chemically toxic materials (Appendix F, Section F.5.2.4). The analysis conveyed this release rate directly to the well at the RMEI location and calculated concentrations that ignored any attenuating effects from transport through the groundwater. Table 5-6 summarizes impacts estimated from this analysis. Note that this table does not contain values for chromium because it was screened out (Sections 5.1.2 and 5.2.2). The table lists the bounding well concentrations and compares the resulting intake with the oral reference dose. The oral reference dose is described in the EPA Integrated Risk Information System (DIRS 148228-EPA 199, all). It expresses dose as an intake based on water consumption of 2 liters (0.5 gallon) per day by a 70-kilogram (154-pound) person. The oral reference dose represents a daily exposure that is likely to be without an appreciable risk of deleterious effects during a lifetime. All estimated impacts are below the oral reference dose.

Table 5-6. Estimated impacts and applicable standards for waterborne chemically toxic materials release during 10,000 years after repository closure.

Material	Estimated concentration (milligram per liter)	Intake[a] (milligram per kilogram of body mass per day)	Intake standard: Oral Reference Dose (milligram per kilogram of body mass per day)
Molybdenum	0.042	0.0012	0.005[b]
Nickel	0.19	0.0054	0.02[c]
Vanadium	0.00019	0.0000054	0.007[d]

Source: Appendix F, Section F.5.2.5.

a. Assumes daily intake of 2 liters (0.5 gallon) per day by a 70-kilogram (154-pound) individual.
b. DIRS 148228-EPA 1999, all.
c. DIRS 148229-EPA 1999, all.
d. DIRS 103705-EPA 1997, all

5.8 Impacts from Human Intrusion

This section presents the estimated radiological impacts of a hypothetical Human Intrusion Scenario of inadvertent drilling into the repository. EPA's proposed standard specifies the presentation of the performance assessment for the Human Intrusion Scenario separately; the proposed standard does not include this scenario as part of the TSPA requirements (Section 5.5) for the individual protection standard. The proposed EPA standard for human intrusion, however, parallels the individual protection standard in that the doses must not exceed the annual dose limits of 15 millirem for the first 10,000 years and 350 millirem for the post-10,000-year period.

5.8.1 HUMAN INTRUSION SCENARIO

DOE used the TSPA-LA model to analyze the radiological impacts of a Human Intrusion Scenario. The scenario assumed an inadvertent drilling into the repository that penetrated a drip shield and waste package and created a direct pathway to the groundwater. The NRC defines the Human Intrusion Scenario, which includes the following drilling event characteristics (10 CFR 63.322):

- There would be a single human intrusion as a result of exploratory drilling for groundwater [10 CFR 63.322(a)].
- The intruders would drill a *borehole* directly through a degraded waste package and into the uppermost aquifer that underlies the repository [10 CFR 63.322(b)].
- The drillers would use the common techniques and practices for exploratory drilling for groundwater in the Yucca Mountain region [10 CFR 63.322(c)].
- Careful sealing of the borehole would not occur; natural degradation processes would gradually modify the borehole [10 CFR 63.322(d)].
- No particulate waste material would fall into the borehole [10 CFR 63.322(e)].
- The exposure scenario includes only radionuclides that water would transport to the saturated zone (for example, water would enter the waste package, release radionuclides, and transport them by way of the borehole to the saturated zone) [10 CFR 63.322(f)].
- No releases would be due to unlikely natural processes and events [10 CFR 63.322(g)]. The regulation defines unlikely natural processes and events as those with a probability of less than 1 chance in 10 and at least 1 chance in 10,000 of occurring in a 10,000-year period (10 CFR 63.342).
- The conceptualization of the drilling event includes vertical transport through the unsaturated zone, horizontal transport along the saturated zone, and then withdrawal at the RMEI location. [10 CFR 63.312(a) through (e) define the RMEI exposure characteristics.]

The EPA standard specifies that the DOE must: (1) determine the earliest time after disposal that a waste package would degrade sufficiently that a drilling intrusion could occur, (2) demonstrate a reasonable expectation that the RMEI would not receive an annual dose of 15 millirem within the first 10,000-year period after closure or 350 millirem within the post-10,000-year period, and (3) perform a consequence analysis that includes all potential environmental pathways of radionuclide transport and exposure (40 CFR 197.25).

To address the first requirement of the human intrusion standard [40 CFR 197.25(a)], DOE performed a detailed technical analysis of the drilling intrusion scenario (DIRS 177432-SNL 2007, Section 6.7). The analysis indicated that an inadvertent penetration of a waste package without recognition by the driller was difficult to envision because of the design of the *engineered barriers* (drip shields and waste packages). The materials that would be used to fabricate the drip shields and waste packages would have very high strength and resistance to a variety of degradation mechanisms. It is more plausible that the engineered barriers would deflect or divert a borehole that penetrated the repository. Moreover, based on considerations such as drill penetration rates (in rock versus the engineered barriers) and loss of drilling fluids, it is also more plausible that the drillers would recognize the intrusion.

The findings of the detailed analysis notwithstanding, DOE adopted a simple conservative calculational method to estimate the earliest time for drilling intrusion. The Department based the method on the fact that the waste package would be susceptible to drilling once the drip shield failed, which is defined as loss of structural integrity by plate thinning (degradation by corrosion processes) or rupture or puncture (seismic-induced damage). Therefore, if there was a drip shield failure, DOE conservatively assumed that there would be a simultaneous waste package failure and loss of structural integrity such that the driller would not recognize the intrusion.

The features, events, and processes screening analysis concluded that seismic ground motion events would be insufficient to significantly alter the mechanical properties of the drip shield, so that inadvertent intrusion would be noticed by a driller within the first 10,000 years after closure. Therefore, the estimate of time the earliest drip shield failure could occur was based on the time nominal general corrosion would cause the drip shield to fail. The earliest time at which a drip shield could fail was estimated using a very high predicted titanium corrosion rate (0.999 quantile rate for the topside and underside of 75.44 nanometers per year). Using this conservative rate, the first failures of the drip shields due to general corrosion would not occur until approximately 200,000 years after repository closure under nominal conditions (using a drip shield thickness of 15 millimeters (0.6 inch) (DIRS 183478-SNL 2008, Section 8.1.3.1). Based on this analysis, the earliest time after repository closure that a waste package would degrade sufficiently such that a drilling intrusion could occur would be 200,000 years.

5.8.2 HUMAN INTRUSION IMPACTS

To address the second requirement of the human intrusion standard [40 CFR 197.25(b)], DOE conducted a TSPA-LA calculation for the drilling intrusion scenario. The Department used a probabilistic approach analogous to that used to evaluate conformance with the individual protection and groundwater protection standards to evaluate the dose *risk* for the human intrusion standard. It performed dose calculations for all environmental pathways, as 40 CFR 197.25(c) specifies.

Figure 5-8 shows the mean, median, and 5th- and 95th-percentile values for the annual individual doses for the post-10,000-year period that could result from a human intrusion 200,000 years after repository closure for the set of 300 epistemic realizations. The values in Figure 5-8 represent the dose from a single waste package; they are not combinations of releases from other waste packages that would fail due to other processes. The mean and median annual individual doses from human intrusion are estimated to be approximately 0.01 millirem and occur approximately 2,000 years after intrusion (DIRS 183478-SNL 2008, Section 8.1.3.2[a]). These results indicate that the repository would be sufficiently robust and resilient to limit releases from human intrusion to values well below the individual protection standard for human intrusion of 350 millirem of annual individual dose for intrusions in the post-10,000-year period (10 CFR 63.321).

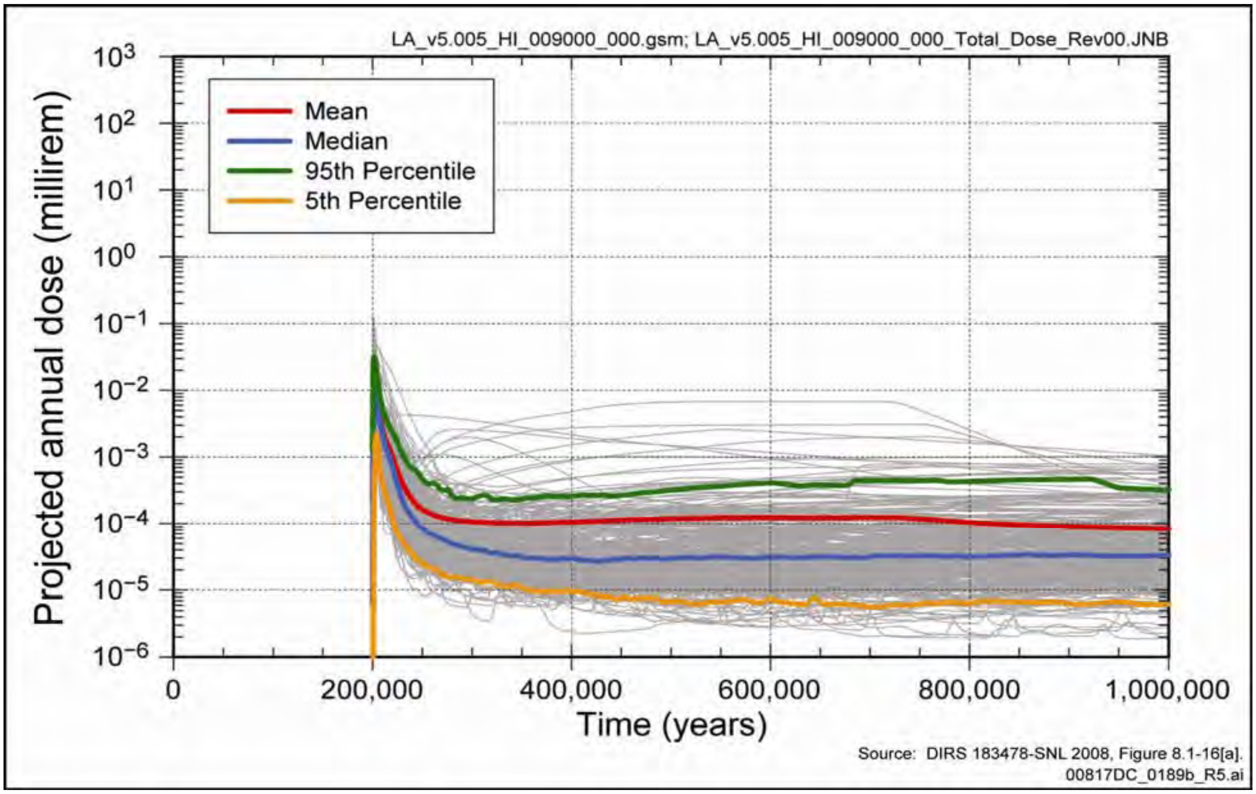


Figure 5-8. Estimated annual individual dose at the RMEI location from human intrusion 200,000 years after repository closure.

5.9 Nuclear Criticality

The Yucca Mountain FEIS contained a detailed discussion of nuclear criticality. Since the completion of the FEIS, there have been no significant changes in the waste package design or contents that would change the nuclear criticality analysis. Further, there has been no new information about the chemistry in the package or host rock environment that suggest changes to the criticality analysis should be made. Therefore, this section summarizes studies of the probability of isolated nuclear criticality events in waste packages and in surrounding rock. It incorporates by reference the more detailed discussion of criticality in Section 5.8 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 5-38 to 5-41).

One of the necessary conditions for nuclear criticality is the presence of a moderator such as water. Water could enter the waste package only if the package failed. The combination of natural and engineered barriers would greatly limit the ability of water to enter a specific package; therefore, any configuration of a waste package filled with water is very conservative.

DOE analyzed the probability of internal criticality in commercial spent nuclear fuel packages. The analysis considered factors such as package failure with water entry, loss of *neutron* absorbers, and degradation of internal components that would lead to a loss of internal configuration. The calculated probability of a criticality in the total inventory of the waste packages that contained commercial spent nuclear fuel is estimated to be below the regulatory screening criteria for consideration (that is, less than 1 chance in 10,000 of occurring over 10,000 years) [10 CFR 63 Part 114(d)]. In other words, criticality would not be required to be included in the TSPA model for estimating repository performance.

DOE evaluated the criticality potential of waste packages that would contain high-level radioactive waste glass (which could include immobilized plutonium waste) and certain types of codisposed DOE spent nuclear fuel. The probability of criticality for these fuel types is estimated to be below the regulatory screening criteria for consideration (that is, less than 1 chance in 10,000 of occurring over 10,000 years) [10 CFR 63 Part 114(d)]. In comparison to a waste package for commercial spent nuclear fuel, a DOE spent fuel package would have lower fissile loading and greater flexibility in the use of a neutron absorber.

DOE also evaluated the probability of external criticality. This event, while highly unlikely, could occur if there was a release of enough fissile material from the waste package. The probability of an external criticality in the repository or the rock beneath it after repository closure is estimated to be much less than the regulatory criteria for excluding it from consideration.

DOE analyzed the potential effects of a steady-state criticality on the radionuclide inventory. If a steady-state criticality occurred, it would be unlikely to have a power level greater than 5 kilowatts. As the power level increased, the temperature would rise, which would evaporate any water. Water would be a moderator for neutrons so, as the water evaporated, the power would tend to decrease. In other words, the power would be self-limiting. For a typical commercial spent nuclear fuel waste package, a steady-state criticality would result in an increase of the inventory of certain radionuclides in that waste package. For the conservative duration of 10,000 years, this increase is estimated at less than 30 percent for the radionuclides in that package. DOE evaluated the incremental effect of steady-state criticality events in a single package on the total inventory for the repository, and estimated that the change to the total inventory of the repository would be extremely small.

In the extremely unlikely event that a transient criticality occurred, a rapid initiating event could produce a peak power level of up to 10 megawatts for less than 60 seconds. After this brief period, rapid boiling of the water moderator would shut down the criticality. The short duration would limit the increase in radionuclide inventory to a factor of 100,000 smaller than that of the 10,000-year steady-state criticality. Other impacts of a transient criticality would be a peak temperature of 233°C (451°F) and a peak overpressure of 20 atmospheres. Both conditions would last 10 seconds or less and would be unlikely to cause enough damage to the waste package or change its environment enough to have a significant impact on repository performance.

In the case of autocatalytic criticality, there would have to be such a high concentration of fissile material that there would be an excess of critical mass and high rates of fission could occur before any of the shutdown mechanisms occurred. The result could be a “runaway” *chain reaction*, which could result in a steam explosion or, in the case of a nuclear bomb, a nuclear explosion. Such a configuration is extremely difficult to achieve and requires very deliberate engineering. An autocatalytic criticality is not credible for the proposed repository. Because the igneous rock at Yucca Mountain is unlikely to contain deposits that could efficiently accumulate fissile material, the probability of creating such a critical mass would be so low as to be not credible.

In addition, DOE studied the potential impacts of disruptive natural events, such as seismic activity or igneous intrusion, on the risk of criticality in the repository and concluded that no sufficiently probable mechanisms for the accumulation of a critical mass would occur. In summary, criticality was therefore excluded from the TSPA-LA analysis.

5.10 Impacts to Biological Resources and Soils

DOE considered whether the proposed repository would affect biological resources in the Yucca Mountain vicinity after closure through heating of the ground surface and radiation exposure as the result of radionuclide migration through groundwater to discharge points.

Table 5-7 lists the results of soil temperature analysis for a heat loading of 85 *metric tons of heavy metal* (MTHM) per acre, as analyzed in the Yucca Mountain FEIS. The Proposed Action for this Repository SEIS calls for a heat loading of 57 with a design that accommodates up to 79 MTHM per acre, so the soil temperature changes would be considerably less than those the FEIS analyzed. Therefore, DOE performed no additional analyses for biological resources and soils for the repository design and operational plan modifications made after the completion of the FEIS because DOE would expect the potential impacts to biological resources and soils to be no greater than those the FEIS discussed. This section summarizes and incorporates by reference Section 5.9 of the FEIS, which discussed in detail the postclosure impacts to biological resources and soils (DIRS 155970-DOE 2002, pp. 5-41 to 5-43).

Surface soil temperatures would start to increase about 200 years after repository closure and would peak more than 1,000 years after closure. The temperature would then gradually decline and would approximate prerepository conditions after 10,000 years (DIRS 103618-CRWMS M&O 1999, Figure 4-13). The maximum increase in temperature would occur directly in soils above the repository and would affect approximately 5 square kilometers (1,250 acres). The effects of repository heat on

Table 5-7. Estimated temperature changes of near-surface soils under an 85-MTHM-per-acre thermal load scenario.

	Estimated temperature increase	
Soil depth [meters (feet)]	Dry soil [°C (°F)]	Wet soil [°C (°F)]
0.5 (1.6)	1.5 (2.7)	0.2 (0.36)
1.0 (3.3)	3.0 (5.4)	0.4 (0.72)
2.0 (6.6)	6.0 (10.8)	0.8 (1.4)

Source: DIRS 103618-CRWMS M&O 1999, p. 45.
°C = degrees Celsius.
°F = degrees Fahrenheit.

surface soil temperatures would gradually decline with distance from the repository (DIRS 103618-CRWMS M&O 1999, p. 49). The estimated increase in temperature would extend as far as 500 meters (1,600 feet) beyond the edge of the repository. A shift in the plant species composition, if any, would be limited to the area within 500 meters of the repository footprint [that is, as much as 8 square kilometers (2,000 acres)]. A shift in the plant community probably would lead to localized changes in the animal communities that depended on it for food and shelter.

Impacts to biological resources probably would consist of an increase of heat-tolerant species over the repository and a decrease of less tolerant species. In general, areas that could be affected by repository heating could experience a loss of shrub species and an increase in annual species.

Some reptiles, including the desert tortoise (*Gopherus agassizii)*, exhibit temperature-dependent sex determination (DIRS 103463-Spotila et al. 1994, pp. 103 to 116). Temperature increases of clutches at that depth based on modeling results (DIRS 103618-CRWMS M&O 1999, pp. 44 to 48) would be less than 0.5°C (0.9°F). Given the ranges of critical temperatures that were reported in *Effects of Incubation*

Conditions on Sex Determination, Hatching Success, and Growth of Hatchling Desert Tortoises, Gopherus Agassizii (DIRS 103463-Spotila et al. 1994), an increase of this magnitude would be unlikely to cause adverse effects such as sex determination.

Dose rates to plants and animals are estimated at much less than 100 millirad per day. The International Atomic Energy Agency concluded that chronic dose rates less than 100 millirad per day are unlikely to cause measurable detrimental effects in populations of the more radiosensitive species in terrestrial *ecosystems* (DIRS 103277-IAEA 1992, p. 53).

The desert tortoise is the only threatened or *endangered species* in the *analyzed land withdrawal area* (DIRS 104593-CRWMS M&O 1999, p. 3-14). Desert tortoises are rare or absent on or around playas (DIRS 101914-Rautenstrauch and O'Farrell 1998, pp. 407 to 411; DIRS 103160-Bury and Germano 1994, pp. 64 and 65); therefore, DOE anticipates no impacts to this species from contaminated water resources at Franklin Lake Playa in the future.

Impacts to surface soils would be possible. Changes in the plant community as a result of the presence of the repository could lead to an increase in the amount of rainfall runoff and, therefore, an increase in the erosion of surface soils, which would increase the sediment load in ephemeral surface water in the immediate Yucca Mountain vicinity. The exact secondary impact of this sediment load is undetermined.

5.11 Summary

Impacts from radioactive materials in the waterborne pathway under the Proposed Action would dominate potential postclosure impacts to human health from a repository at Yucca Mountain. Tables 5-4 and 5-5 list estimated impacts from groundwater releases of radionuclides after repository closure. Table 5-4 summarizes the mean, median, and 95th-percentile annual individual doses to the RMEI. The estimated mean annual individual dose of 0.24 millirem at the RMEI location in Table 5-4 is about 2 percent of the limit of the 15-millirem standard in 40 CFR Part 197 for the first 10,000 years after closure. The estimated median annual individual dose of 0.96 millirem for the post-10,000-year period is less than 1 percent of the proposed limit of 350 millirem. Table 5-5 compares concentrations with groundwater protection standards and shows that the concentrations are well below the standard values.

EPA has proposed annual dose limits of 350 millirem to an individual for human intrusion (40 CFR Part 197) if it were to occur after 10,000 years following closure. The estimated mean annual dose from a human intrusion 200,000 years after repository closure is less than 0.01 millirem, or about 0.003 percent of the EPA limit.

As Table 5-6 demonstrates, significant human impacts from chemically toxic materials would be unlikely.

Atmospheric releases of carbon-14 would yield an estimated 80-kilometer (50-mile) population impact on the order of 1×10^{-10} latent cancer fatality (Section 5.6) during the 70-year period of maximum release.

As discussed in Section 5.10, DOE does not anticipate adverse impacts to biological resources from repository heating effects or the migration of radioactive materials.

REFERENCES

155950 BSC 2001 BSC (Bechtel SAIC Company) 2001. *FY 01 Supplemental Science and Performance Analyses, Volume 1: Scientific Bases and Analyses*. TDR-MGR-MD-000007 Rev 00 ICN 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010801.0404; MOL.20010712.0062; MOL.20010815.0001.

169734 BSC 2004 BSC (Bechtel SAIC Company) 2004. *Yucca Mountain Site Description.* TDR-CRW-GS-000001 Rev 02 ICN 01. Two volumes. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20040504.0008.

169855 BSC 2004 BSC (Bechtel SAIC Company) 2004. *Development of Numerical Grids for UZ Flow and Transport Modeling.* ANL-NBS-HS-000015 Rev 02. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20040901.0001.

103160 Bury & Germano 1994 Bury, R.B. and Germano, D.J., eds. 1994. *Biology of North American Tortoises.* Fish and Wildlife Research Report 13. Washington, D.C.: U.S. Department of the Interior. ACC: MOL.20010803.0373.

100111 CRWMS M&O 1994 CRWMS M&O 1994. *Total System Performance Assessment - 1993: An Evaluation of the Potential Yucca Mountain Repository*. B00000000-01717-2200-00099 Rev 01. Las Vegas, Nevada: CRWMS M&O. ACC: NNA.19940406.0158.

100198 CRWMS M&O 1995 CRWMS M&O 1995. *Total System Performance Assessment - 1995: An Evaluation of the Potential Yucca Mountain Repository*. B00000000-01717-2200-00136 Rev 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19960724.0188.

103618 CRWMS M&O 1999 CRWMS M&O 1999. *Impact of Radioactive Waste Heat on Soil Temperatures.* BA0000000-01717-5700-00030 Rev 0. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990309.0403.

104593 CRWMS M&O 1999 CRWMS M&O 1999. *Geology/Hydrology Environmental Baseline File.* B00000000-01717-5700-00027 Rev 01 DCN 1. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990609.0156.

104983 CRWMS M&O 1999 CRWMS M&O 1999. *Geology/Hydrology Environmental Baseline File.* B00000000-01717-5700-00027 Rev 01 DCN 1. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990609.0156.

153246	CRWMS M&O 2000	CRWMS M&O 2000. *Total System Performance Assessment for the Site Recommendation.* TDR-WIS-PA-000001 Rev 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.
100376	Czarnecki 1990	Czarnecki, J.B. 1990. *Geohydrology and Evapotranspiration at Franklin Lake Playa, Inyo County, California*. Open-File Report 90-356. Denver, Colorado: U.S. Geological Survey. ACC: NNA.19901015.0195.
100131	D'Agnese et al. 1997	D'Agnese, F.A.; Faunt, C.C.; Turner, A.K.; and Hill, M.C. 1997. *Hydrogeologic Evaluation and Numerical Simulation of the Death Valley Regional Ground-Water Flow System, Nevada and California.* Water-Resources Investigations Report 96-4300. Denver, Colorado: U.S. Geological Survey. ACC: MOL.19980306.0253.
100550	DOE 1998	DOE (U.S. Department of Energy) 1998. *Total System Performance Assessment.* Volume 3 of *Viability Assessment of a Repository at Yucca Mountain.* DOE/RW-0508. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.19981007.0030.
155970	DOE 2002	DOE (U.S. Department of Energy) 2002. *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada.* DOE/EIS-0250F. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20020524.0314; MOL.20020524.0315; MOL.20020524.0316; MOL.20020524.0317; MOL.20020524.0318; MOL.20020524.0319; MOL.20020524.0320.
103705	EPA 1997	EPA (U.S. Environmental Protection Agency) 1997. *Health Effects Assessment, Summary Tables, FY-1997 Update.* EPA 540/R-97-036. Washington, D.C.: U.S. Environmental Protection Agency. ACC: MOL.20010724.0301.
148228	EPA 1999	EPA (U.S. Environmental Protection Agency) 1999. "Molybdenum; CASRN 7439-98-7." IRIS (Integrated Risk Information System). Washington, D.C.: U.S. Environmental Protection Agency. Accessed June 10, 1999. ACC: MOL.20010719.0363. URL: http://www.epa.gov/iris/subst/0425.htm

148229	EPA 1999	EPA (U.S. Environmental Protection Agency) 1999. "Nickel, Soluble Salts; CASRN Various." IRIS (Integrated Risk Information System). Washington, D.C.: U.S. Environmental Protection Agency. Accessed June 10, 1999. ACC: MOL.20010719.0364. URL: http://www.epa.gov/iris/subst/0271.htm
103277	IAEA 1992	IAEA (International Atomic Energy Agency) 1992. *Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards.* Technical Reports Series No. 332. Vienna, Austria: International Atomic Energy Agency. TIC: 243768.
101836	ICRP 1991	ICRP (International Commission on Radiological Protection) 1991. "1990 Recommendations of the International Commission on Radiological Protection." Volume 21, No. 1-3 of *Annals of the ICRP*. ICRP Publication 60. New York, New York: Pergamon Press. TIC: 235864.
172935	ICRP 2001	ICRP (International Commission on Radiological Protection) 2001. *The ICRP Database of Dose Coefficients: Workers and Members of the Public.* ICRP Publication 72. New York, New York: Elsevier. TIC: 255638.
100953	Napier et al. 1988	Napier, B.A.; Peloquin, R.A.; Strenge, D.L.; and Ramsdell, J.V. 1988. *GENII - The Hanford Environmental Radiation Dosimetry Software System.* Three volumes. PNL-6584. Richland, Washington: Pacific Northwest Laboratory. ACC: NNA.19920626.0034; NNA.19920626.0036; NNA.19920626.0041.
103446	Oversby 1987	Oversby, V.M. 1987. "Spent Fuel as a Waste Form – Data Needs to Allow Long Term Performance Assessment under Repository Disposal Conditions." *Scientific Basis for Nuclear Waste Management X, Symposium held December 1-4, 1986, Boston, Massachusetts.* Bates, J.K. and Seefeldt, W.B., eds. *84,* 87-101. Pittsburgh, Pennsylvania: Materials Research Society. TIC: 203663.
101914	Rautenstrauch and O'Farrell 1998	Rautenstrauch, K.R. and O'Farrell, T.P. 1998. "Relative Abundance of Desert Tortoises on the Nevada Test Site." *Southwestern Naturalist, 43,* (3), 407-411. Lubbock, Texas: Southwestern Association of Naturalists. TIC: 242257.
177424	SNL 2007	SNL (Sandia National Laboratories) 2007. *Radionuclide Screening.* ANL-WIS-MD-000006 Rev 02. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20070326.0003.

177432	SNL 2007	SNL (Sandia National Laboratories) 2007. *Number of Waste Packages Hit by Igneous Events.* ANL-MGR-GS-000003 Rev 03. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20071002.0001.
178519	SNL 2007	SNL (Sandia National Laboratories) 2007. *General Corrosion and Localized Corrosion of Waste Package Outer Barrier.* ANL-EBS-MD-000003 Rev 03. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20070730.0003; DOC.20070807.0007.
179466	SNL 2007	SNL (Sandia National Laboratories) 2007. *Total System Performance Assessment Data Input Package for Requirements Analysis for Subsurface Facilities.* TDR-TDIP-PA-000001 Rev 00. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20070921.0007.
179590	SNL 2007	SNL (Sandia National Laboratories) 2007. *Output for ANL-EBS-MD-000049 Multiscale Thermohydrologic Model for the Mean Host-Rock Thermal Conductivity, 10-Percentile Percolation Flux, Collapsed-Drift, High and Low Rubble Thermal Conductivity Cases*. LL0702PA027MST.082. Submittal date: 02/15/2007.
184614	SNL 2007	SNL (Sandia National Laboratories) 2007. *UZ Flow Models and Submodels.* MDL-NBS-HS-000006 Rev 03 AD 01. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20080108.0003; DOC.20080114.0001.
182145	SNL 2008	SNL (Sandia National Laboratories) 2008. *Simulation of Net Infiltration for Present-Day and Potential Future Climates*. MDL-NBS-HS-000023 Rev 01 AD 01. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20080201.0002.
183478	SNL 2008	SNL (Sandia National Laboratories) 2008. *Total System Performance Assessment Model /Analysis for the License Application.* MDL-WIS-PA-000005 Rev 00 AD 01. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20080312.0001.
103463	Spotila et al. 1994	Spotila, J.R.; Zimmerman, L.C.; Binckley, C.A.; Grumbles, J.S.; Rostal, D.C.; List, A., Jr.; Beyer, E.C.; Phillips, K.M.; and Kemp, S.J. 1994. "Effects of Incubation Conditions on Sex Determination, Hatching Success, and Growth of Hatchling Desert Tortoises, Gopherus Agassizii." *Herpetological Monographs*, (8), 103-116. Champaign, Illinois: Herpetologists' League. TIC: 242868.

100191	Wilson et al. 1994	Wilson, M.L.; Gauthier, J.H.; Barnard, R.W.; Barr, G.E.; Dockery, H.A.; Dunn, E.; Eaton, R.R.; Guerin, D.C.; Lu, N.; Martinez, M.J.; Nilson, R.; Rautman, C.A.; Robey, T.H.; Ross, B.; Ryder, E.E.; Schenker, A.R.; Shannon, S.A.; Skinner, L.H.; Halsey, W.G.; Gansemer, J.D.; Lewis, L.C.; Lamont, A.D.; Triay, I.R.; Meijer, A.; and Morris, D.E. 1994. *Total-System Performance Assessment for Yucca Mountain – SNL Second Iteration (TSPA-1993).* SAND93-2675. Executive Summary and two volumes. Albuquerque, New Mexico: Sandia National Laboratories. ACC: NNA.19940112.0123.

6

Environmental Impacts of Transportation

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

6. ENVIRONMENTAL IMPACTS OF TRANSPORTATION

The U.S. Department of Energy (DOE or the Department) completed the *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DIRS 155970-DOE 2002, all) (Yucca Mountain FEIS) in February 2002. In the Yucca Mountain FEIS, DOE evaluated two national transportation scenarios, referred to as the mostly legal-weight truck scenario and the mostly rail scenario, and three Nevada transportation *alternatives*—shipment by legal-weight truck, by rail, and by *heavy-haul truck*. After DOE completed the FEIS in 2002, it issued a Record of Decision that selected the mostly rail scenario for the transportation of *spent nuclear fuel* and high-level *radioactive* waste to the proposed *repository* (69 FR 18557, April 8, 2004). Since completing the FEIS, DOE has continued to develop the repository design and associated operational plans. The Department now plans to operate the repository with the use of a *primarily canistered approach* that calls for the packaging of most *commercial spent nuclear fuel* at the commercial sites in *transportation, aging, and disposal* (TAD) *canisters* and most DOE materials in *disposable canisters* at the DOE sites.

DOE has prepared this *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F-S1) (Repository SEIS) to evaluate the potential environmental *impacts* of the repository design and operational plans. This chapter describes the potential environmental impacts of the transportation of spent nuclear fuel and high-level radioactive waste from 72 commercial and 4 DOE sites to the *Yucca Mountain site* under the mostly rail scenario.

DOE has assessed potential transportation impacts of the *Proposed Action*, which include all activities necessary to transport spent nuclear fuel and high-level radioactive waste, from loading at the commercial and DOE sites to delivery at the proposed repository. Most, but possibly not all, rail shipments to the repository would use *dedicated trains* (see Section 2.1) (DIRS 182833-Golan 2005, all). Two examples of when DOE would use trucks include (1) shipments from generator sites that cannot handle rail *casks* would use trucks to transport truck casks to the repository, and (2) shipments from generator sites that can handle rail casks but that lack rail access would use heavy-haul trucks or barges to carry rail casks to nearby railheads for shipment to the repository.

The decision to ship most spent nuclear fuel and high-level radioactive waste to the repository by rail would require construction of a *railroad* in Nevada. In the Rail Alignment EIS, DOE considers *alignments* for the *construction* and *operation* of a *railroad* in the Caliente and Mina *rail corridors*. Therefore, in this Repository SEIS, national rail routes from the generator sites to the repository would connect to the new DOE railroad at one of two locations in Nevada—Caliente or Hawthorne. Routes that connected in the Caliente area would continue to the repository on a railroad that DOE would construct in the Caliente rail *corridor*. Routes that connected in the Hawthorne area would continue to the repository on a DOE-built railroad in the Mina rail corridor.

Section 6.1 summarizes changes reflected in the impacts presented in this Repository SEIS chapter from the methods and data DOE used in the Yucca Mountain FEIS to evaluate transportation impacts. Section 6.2 summarizes the impacts from loading operations at the generator sites. Section 6.3 summarizes the impacts of national transportation of spent nuclear fuel and high-level radioactive waste from the 72 commercial and 4 DOE sites to Yucca Mountain. Section 6.4 summarizes and incorporates by reference Chapter 4 of the Rail Alignment EIS. Chapter 4 of the Rail Alignment EIS discusses the impacts of transportation in Nevada and discusses the impacts of the construction and operation of a railroad in the Caliente or Mina rail corridor. Section 6.4 also discusses the impacts of the transportation of materials and personnel for the construction and operation of the repository, which would include workers, construction materials, *waste packages*, and *drip shields.*

Chapter 8 discusses the *cumulative impacts* related to the transportation activities described in this chapter. The following appendices present further information and analyses on the transportation of spent nuclear fuel and high-level radioactive waste:

- Appendix A presents sensitivity analyses related to transportation activities,
- Appendix G contains details on methods and data DOE used to evaluate transportation impacts, and
- Appendix H provides information that could help readers understand the subject of nuclear waste transportation and lists regulations related to the transportation of spent nuclear fuel and high-level radioactive waste.

6.1 Changes since Completion of the Yucca Mountain FEIS

Since it completed the Yucca Mountain FEIS, DOE has acquired new information and analytical tools to estimate the potential impacts associated with transportation of spent nuclear fuel and high-level radioactive waste. There have also been changes to some of the data DOE used to estimate *radiation* doses and radiological impacts. The following sections describe the changes that most affect the estimates of potential impacts.

6.1.1 LATENT CANCER FATALITY CONVERSION FACTORS

In the Yucca Mountain FEIS, DOE based the estimates of *latent cancer fatalities* on the received radiation *dose* and on radiation dose-to-health effect conversion factors from International Commission on Radiological Protection Publication 60 (DIRS 101836-ICRP 1991, all). The Commission estimated that, for the general population, a collective radiation dose of 1 *person-rem* would yield 0.0005 excess latent *cancer* fatality. For radiation workers, a collective radiation dose of 1 person-rem would yield an estimated 0.0004 excess latent cancer fatality.

Since the completion of the Yucca Mountain FEIS, the Interagency Steering Committee on Radiation Standards has updated its recommended radiation dose-to-health effect conversion factors (DIRS 174559-Lawrence 2002, p. 2). The recommended conversion factor is 0.0006 excess latent cancer fatality per person-rem for workers and the general population (DIRS 174559-Lawrence 2002, p. 2); DOE has used this factor in this Repository SEIS to estimate the number of latent cancer fatalities.

For workers, an increase in the radiation dose-to-health effect conversion factor from 0.0004 to 0.0006 excess latent cancer fatality per person-rem increases the estimates of radiological impacts by 50 percent. For the general population, an increase in the conversion factor from 0.0005 to 0.0006 excess latent cancer fatality per person-rem increases the estimates of radiological impacts by 20 percent.

6.1.2 RADIATION DOSIMETRY

Releases of radioactive material into the *environment* can affect persons who come in contact with it. Mechanisms for transport of radioactive material include air, water, soil, and food. The ways an individual or population can come into contact with radioactive material are known as *exposure pathways*. DOE evaluated five pathways in the Yucca Mountain FEIS:

- Inhalation of radioactive material,
- Ingestion of radioactive material,
- Inhalation of previously deposited radioactive material resuspended from the ground (*resuspension*),
- External *exposure* to radioactive material deposited on the ground (*groundshine*), and
- External exposure to radioactive material in the air (*immersion* or *cloudshine*).

Dose coefficients are the factors used to convert estimates of *radionuclide* intake (by inhalation or ingestion) or exposure (by groundshine or immersion) to a radiation dose. In the Yucca Mountain FEIS, DOE used the inhalation and ingestion dose coefficients from Federal Guidance Report No. 11 (DIRS 101069-Eckerman et al. 1988, all) and the groundshine and immersion dose coefficients from Federal Guidance Report No. 12 (DIRS 107684-Eckerman and Ryman 1993, all). These dose coefficients are based on recommendations in International Commission on Radiological Protection Publication 26 (DIRS 101075-ICRP 1977, all).

The International Commission on Radiological Protection has updated its recommended dose coefficients. In this Repository SEIS, DOE uses the updated inhalation and ingestion dose coefficients from *The ICRP Database of Dose Coefficients: Workers and Members of the Public* (DIRS 172935-ICRP 2001, all) and the updated groundshine and immersion dose coefficients from *Federal Guidance Report 13, CD Supplement, Cancer Risk Coefficients for Environmental Exposure to Radionuclides* (DIRS 175544-EPA 2002, all) to estimate the radiation doses from transportation *accidents*. These dose coefficients are based on the recommendations in International Commission on Radiological Protection Publication 60 (DIRS 101836-ICRP 1991, all) and incorporate the dose coefficients from International Commission on Radiological Protection Publication 72 (DIRS 152446-ICRP 1996, all).

6.1.3 ADDITIONAL ESCORTS

In the Yucca Mountain FEIS, DOE based the estimates of transportation impacts on one escort in rural areas and two escorts in urban and suburban areas. In this Repository SEIS, the Department based estimates of transportation impacts on additional escorts in all areas (urban, suburban, and rural). DOE considers these escorts to be workers, and the presence of additional workers increases the estimates of transportation impacts.

6.1.4 DEDICATED TRAINS

This Repository SEIS reflects DOE’s policy to use dedicated trains for most shipments (DIRS 182833-Golan 2005, all). For commercial spent nuclear fuel, the Department based transportation impacts on three casks per train. For *DOE spent nuclear fuel* and high-level radioactive waste, it based transportation impacts on five casks per train. In both cases, the trains would include two *buffer cars*, two locomotives, and one *escort car*. In the Yucca Mountain FEIS, DOE based impacts on the use of general freight trains with one escort car and one cask car in each shipment; the buffer cars would be the other cars in a general freight train. In general, the use of dedicated trains would reduce the impacts to members of the public because there would be fewer delays in rail yards. The only significant source of radiation exposure for escorts would be from the last cask in the train. Therefore, impacts to escorts would generally be smaller because there would be more casks in a single train rather than one cask per train. Nonradiological impacts would be greater because estimates of impacts would account for all railcars in the train (locomotives, buffer cars, cask cars, and escort cars), not just the cask cars and the escort cars.

6.1.5 AVAILABILITY OF 2000 CENSUS POPULATION DENSITY DATA AND UPDATED RAIL AND TRUCK TRANSPORTATION NETWORKS

In the Yucca Mountain FEIS, DOE used the HIGHWAY and INTERLINE computer programs to determine representative transportation routes to the repository (DIRS 104780-Johnson et al. 1993, all; DIRS 104781-Johnson et al. 1993, all) and based transportation impacts on census data it extrapolated to 2035. The TRAGIS computer program (DIRS 181276-Johnson and Michelhaugh 2003, all) has replaced HIGHWAY and INTERLINE.

USE OF REPRESENTATIVE ROUTES IN IMPACT ANALYSIS

At this time, before receipt of a construction authorization for the repository and years before a possible first shipment, DOE has not identified the actual routes it would use to ship spent nuclear fuel and high-level radioactive waste to Yucca Mountain. However, the highway and rail routes that DOE used for analysis in this Repository SEIS are representative of routes that it could use. The highway routes conform to U.S. Department of Transportation regulations (49 CFR 397.101). These regulations, which the Department of Transportation developed for Highway Route-Controlled Quantities of Radioactive Materials, require such shipments to use preferred routes that would reduce the time in transit. A preferred route is an Interstate System highway, bypass, beltway, or an alternative route designated by a state routing agency. Alternative routes can be designated by states and tribes under U.S. Department of Transportation regulations (49 CFR 397.103) that require consideration of the overall risk to the public and prior consultation with local jurisdictions and other states. Federal regulations do not restrict the routing of spent nuclear fuel and high-level radioactive waste shipments by rail. However, for this analysis and to be consistent with rail industry practice, DOE assumed routes for rail shipments by giving priority to the use of rail lines that have the most rail traffic (which are the best maintained and have the highest quality track), giving priority to originating railroads, minimizing the number of interchanges between railroads, and minimizing the travel distance.

For this Repository SEIS, DOE used the TRAGIS computer program (DIRS 181276-Johnson and Michelhaugh 2003, all) to determine representative transportation routes to the repository. The Department used 2000 Census data to estimate population densities along the routes. The projected start date for repository *operations* would be 2017. Because the analysis considered that the repository would operate for 50 years, DOE extrapolated population densities along the routes from 2000 to 2067. The Department used a two-step process to do this; it used (1) Bureau of the Census population estimates for 2000 through 2030 and (2) population estimates for 2026 through 2030 to extrapolate population densities for 2031 to 2067. In Nevada, DOE used the *Regional Economic Model, Inc.* (REMI) computer model and data from the Nevada State Demographer to extrapolate population densities.

For this Repository SEIS, DOE evaluated the impacts of severe transportation accidents and sabotage *events* for an urban area. The Department based the population density in this urban area on the population densities in the 20 most populous urban areas with the use of 2000 Census data. The 2000 Census data do not include Las Vegas, Nevada, among the 20 most populous urban areas. Therefore, DOE included the Las Vegas resident and tourist populations in the urban population density. Because the analysis considered that the repository would operate for 50 years, DOE extrapolated the population density in this urban area to 2067.

6.1.6 OVERWEIGHT TRUCKS

In the Yucca Mountain FEIS, DOE estimated that the trucks that carried truck casks would have gross vehicle weights less than 80,000 pounds (36,300 kilograms) and were therefore "legal weight" (23 CFR 658.17). DOE has determined that trucks that carried truck casks would be more likely to have gross vehicle weights in the range of 36,300 to 52,200 kilograms (80,000 to 115,000 pounds). Events that could cause the weight of the truck to exceed 36,300 kilograms include adding non-fuel-bearing components to the payload, weight growth during design and fabrication of the tractor-trailer, tractor or trailer modifications after testing, and regulatory requirements that increase the weight of tractors (DIRS 185236-Hill et al. 1993, p. 286). Figures 6-0a and 6-0b illustrate a legal-weight truck and an overweight truck, respectively. As can be seen in Figure 6-0b, the length of the *overweight truck* would likely be in the range of 17.4 to 18.3 meters (57 to 60 feet), while the length of the legal-weight truck would be about 17.1 meters (56 feet) (Figure 6-0a).

These overweight trucks are not the same as the heavy-haul trucks that DOE would use to transport rail casks from commercial generator sites to nearby railheads. These heavy-haul trucks would have gross vehicle weights of as much as 227,000 kilograms (500,000 pounds), and their impacts would differ from the impacts of overweight or legal-weight trucks. Figure 6-0c illustrates a heavy-haul truck transporting a rail cask. As can be seen in Figure 6-0c, the length of the heavy-haul truck would be about 67.1 meters (220 feet).

Trucks with gross vehicle weights that exceeded 36,300 kilograms (80,000 pounds) would be overweight and would be subject to the permitting requirements in each state through which they traveled. Permit requirements typically address such matters as the time of day when overweight trucks can travel and whether they can travel on holidays and weekends. Seasonal frost restrictions might apply in some areas.

DOE has previously studied a marginally overweight truck operating scenario (DIRS 185236-Hill et al. 1993, all). In this study, DOE defined a marginally overweight truck as a truck that exceeded the gross vehicle weight limit of 36,300 kilograms (80,000 pounds) but weighed less than 43,500 kilograms (96,000 pounds) that followed axle and axle group weight limits from the *Surface Transportation Assistance Act of 1982* (Public Law 97-424, 96 Stat. 2097) and conformed to dimensional restrictions to operate on most major highways and the Federal Bridge Formula (which relates to the number of axles, axle and axle group spacing, and the weight on axles and axle groups). This study found that overweight truck shipments would be more complex because states independently set policy and regulations for such shipments.

DOE's marginally overweight truck study (DIRS 185236-Hill et al. 1993, p. 290) found that the design, features, and overall performance of the vehicle would affect driver recruitment and retention. The driver's work environment (the vehicle) could affect employee satisfaction, safety, or equipment

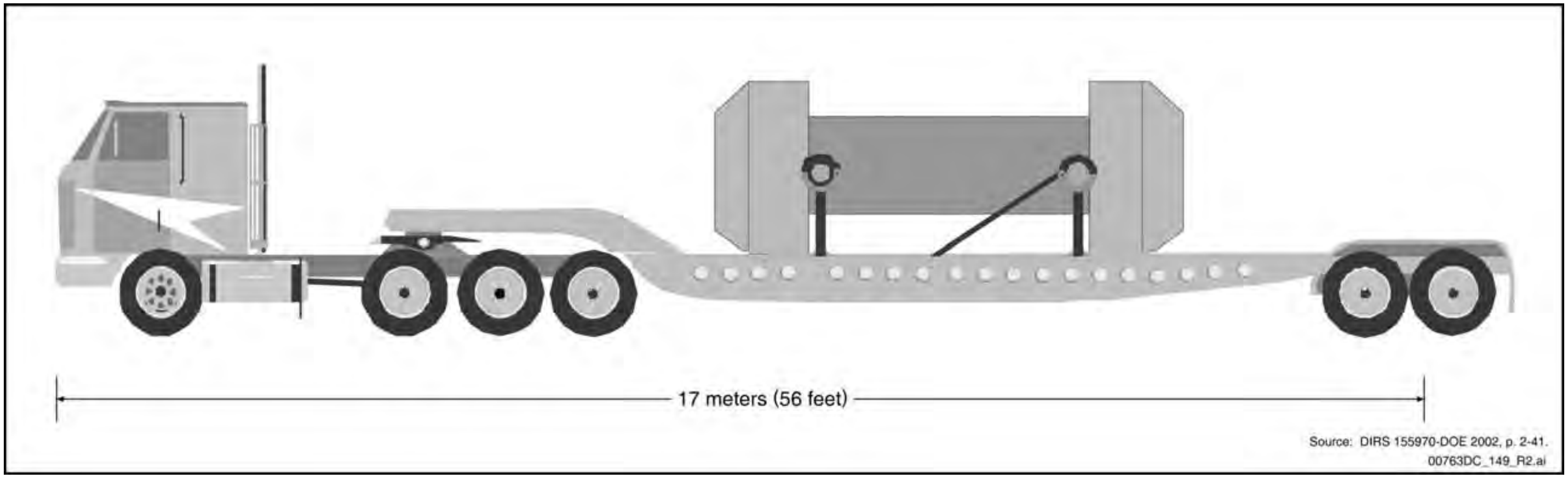


Figure 6-0a. Truck cask on a legal-weight tractor-trailer truck.

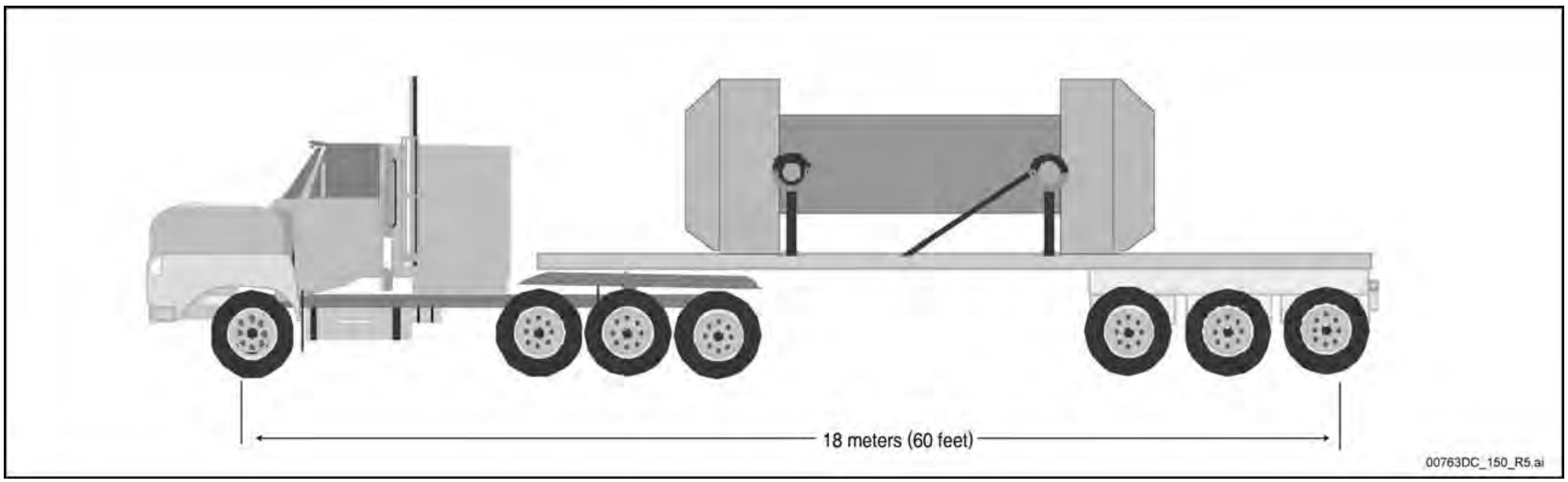


Figure 6-0b. Marginally overweight vehicle concept .

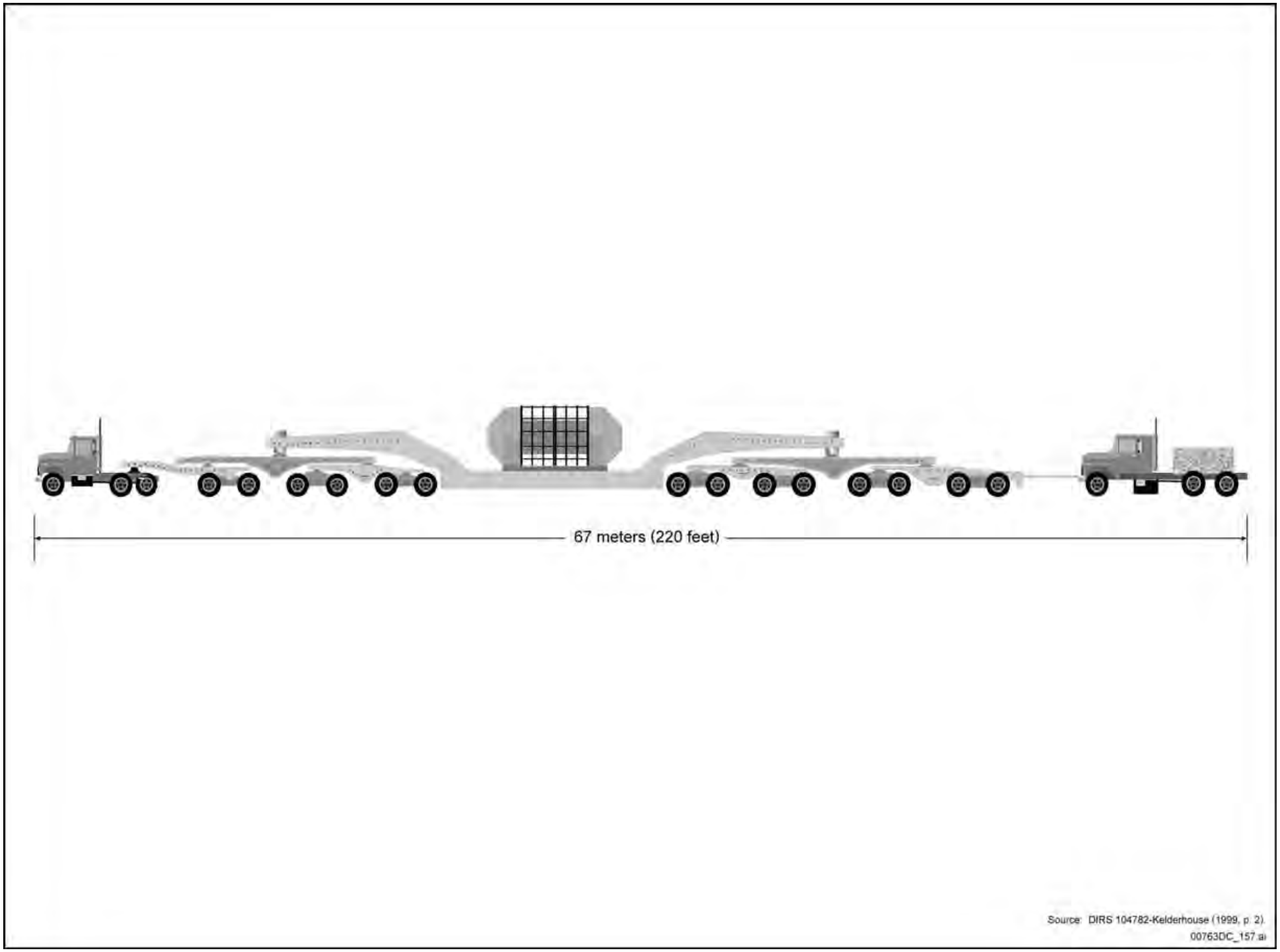


Figure 6-0c. Heavy-haul truck transporting a rail cask.

reliability. Adding weight to the tractor would increase the feasibility of adding options to improve the work environment (for example, more powerful engine, larger sleeper berth). The study (DIRS 185236-Hill et al. 1993, p. 290) also examined the worker radiation exposure from overweight truck shipments and found that they would result in 13 percent less radiation exposure for workers than legal-weight trucks. However, another study found 12 percent higher radiation doses because of increased restrictions on travel that slightly increased the transport times and associated doses (DIRS 101747-Schneider et al. 1987, pp. 5.5 and 5.6). Based on these two studies, it is likely that the radiation doses from overweight truck shipments would be similar to the radiation doses for legal-weight trucks.

Cask behavior in a truck accident environment has been analyzed for legal-weight trucks, and because DOE would use the same cask for both the overweight and legal-weight truck transport, there should be no effect on the accident severity distribution (consequence of the crash) in relation to the cask size and weight. After an accident, recovery of an overweight truck would be expected to use equipment similar, if not identical, to that for recovery of a legal-weight truck.

6.1.7 SHIPMENT ESTIMATES

DOE has developed updated estimates of shipments that incorporate the use of TAD *canisters* at each commercial *reactor* site. The Department based shipment estimates on 90 percent [by *metric tons of heavy metal* (MTHM)] of the commercial spent nuclear fuel being shipped in rail casks that contained TAD canisters. Shipment of the remaining 10 percent of the commercial spent nuclear fuel would be in rail casks that contained other types of canisters such as *dual-purpose canisters* or as *uncanistered spent nuclear fuel* in truck casks. Appendix A, Section A.2 also evaluates shipment estimates based on 75 percent of commercial spent nuclear fuel shipments in rail casks that contained TAD canisters.

These new estimates project the shipment of approximately 9,500 rail casks and 2,700 truck casks of spent nuclear fuel and high-level radioactive waste to the repository (DIRS 181377-BSC 2007, all). Shipment of 9,500 rail casks would require about 2,800 trains. The increase in estimated truck shipments over that analyzed in the Yucca Mountain FEIS was primarily a result of using recent data regarding the handling capabilities at the generator sites.

6.1.8 RADIONUCLIDE INVENTORIES

Appendix A of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. A-1 to A-71) provided the basis for the radionuclide inventory that DOE used in the transportation analysis in the FEIS (DIRS 155970-DOE 2002, Chapter 6 and Appendix J). Since the completion of the FEIS, the Department has updated these inventories through additional data collection and analyses:

- The radionuclide inventory for DOE spent nuclear fuel, to incorporate the inventories from *Source Term Estimates for DOE Spent Nuclear Fuels* (DIRS 169354-DOE 2004, all), and
- The radionuclide inventory for high-level radioactive waste, to incorporate the inventories from *Recommended Values for HLW Glass for Consistent Usage on the Yucca Mountain Project* (DIRS 184907-BSC 2008, all).

DOE has updated the radionuclide inventory for commercial spent nuclear fuel to incorporate the inventories from *Characteristics for the Representative Commercial Spent Nuclear Fuel Assembly for*

Preclosure Normal Operations (DIRS 180185-BSC 2007, all), in which the representative *pressurized-water-reactor* spent nuclear *fuel assembly* had a burnup of 50,000 megawatt-days per MTHM (DIRS 180185-BSC 2007, p. 47). In this Repository SEIS, DOE increased the burnup of the representative pressurized-water-reactor spent nuclear fuel assembly from 50,000 to 60,000 megawatt-days per MTHM and reduced the enrichment from 4.2 percent to 4.0 percent. This is the same burnup as the representative pressurized-water-reactor spent nuclear fuel assembly that DOE used for repository *shielding* and waste package design (DIRS 161120-BSC 2002, Section 5.5.2) and yields slightly higher estimates of impacts than the spent nuclear fuel used for *preclosure* normal operations or the spent nuclear fuel DOE used in the Yucca Mountain FEIS. Table 6-1 lists the characteristics of the representative pressurized- and *boiling-water-reactor* spent nuclear fuel that DOE analyzed for the Yucca Mountain FEIS and for this Repository SEIS. Appendix G, Section G.4 contains radionuclide inventories for commercial and DOE spent nuclear fuel and high-level radioactive waste.

Table 6-1. Characteristics of representative spent nuclear fuel.

	Yucca Mountain FEIS[a]		Repository SEIS[b]	
Characteristic	PWR spent nuclear fuel	BWR spent nuclear fuel	PWR spent nuclear fuel	BWR spent nuclear fuel
Burnup (MWd/MTHM)	50,000	40,000	60,000	50,000
Enrichment (weight percent)	4.3	3.5	4.0	4.0
Decay time (years)	15	14	10	10

a. DIRS 155970-DOE 2002, pp. A-21 and A-22.
b. DIRS 180185-BSC 2007, p. 47, with burnup increased from 50,000 MWd/MTHM and enrichment reduced from 4.2 percent to 4.0 percent.

BWR = Boiling-water reactor.
FEIS = Final environmental impact statement.
MTHM = Metric ton of heavy metal.
MWd = Megawatt-day.
PWR = Pressurized-water reactor.
SEIS = Supplemental environmental impact statement.

6.1.9 TRUCK AND RAIL ACCIDENT RATE AND FATALITY RATE DATA

In the Yucca Mountain FEIS, DOE used state-specific accident and fatality rate data for 1994 to 1996 (DIRS 103455-Saricks and Tompkins 1999, all) to estimate transportation impacts. For trucks, the FEIS used accident and fatality rate data from the U.S. Department of Transportation, Federal Motor Carrier Safety Administration’s Motor Carrier Management Information System. Since completion of the FEIS, the Federal Motor Carrier Safety Administration has evaluated the data in the Motor Carrier Management Information System. For 1994 through 1996, it found that accidents were underreported by about 39 percent and fatalities were underreported by about 36 percent (DIRS 181755-UMTRI 2003, Table 1, p. 4, and Table 2, p. 6). Therefore, in this Repository SEIS, DOE increased the state-specific truck accident and fatalities rates by factors of 1.64 and 1.57, respectively, to account for the underreporting.

In this Repository SEIS, DOE updated rail accident rates to reflect data from 1995 to 1999 and estimated these rates from data for Class 3 track (DIRS 180220-Bendixen and Facanha 2007all). Higher classes of track have lower accident rates, and the use of Class 3 track is conservative if the track is actually rated higher (Class 4 or 5). DOE anticipates that most of the distance rail shipments would travel would be on higher classes of track.

Because DOE has adopted a policy to use dedicated trains that it expects would contain 8 to 10 cars on average for most shipments to the repository, this Repository SEIS uses a combination of rail accident rates based on both train kilometers and railcar kilometers to estimate rail accident *risks.* DOE also updated rail fatality rates to reflect data from 2000 to 2004 (DIRS 178016-DOT 2005, all). These fatality rates were in terms of fatalities per railcar kilometer.

6.1.10 SHIPPING PERIOD AND REPOSITORY OPERATIONAL PERIOD

In the Yucca Mountain FEIS, DOE based transportation impacts on shipments of 70,000 MTHM of spent nuclear fuel and high-level radioactive waste to the repository over 24 years. Because the repository could operate for up to 50 years, in this Repository SEIS the Department based transportation impacts on the shipment of the same amount of spent nuclear fuel and high-level radioactive waste over a period of up to 50 years that would start in 2017 and end in 2067.

6.1.11 SABOTAGE RELEASE FRACTIONS

In the Yucca Mountain FEIS, DOE referred to *Projected Source Terms for Potential Sabotage Events Related to Spent Fuel Shipments* for estimates of the fraction of spent nuclear fuel materials that a sabotage event could release (*release fractions*) (DIRS 104918-Luna et al. 1999, all) to estimate the impacts of possible sabotage events that involved spent nuclear fuel in truck or rail casks. In this Repository SEIS, the Department used more recent estimates of release fractions from *Release Fractions from Multi-Element Spent Fuel Casks Resulting from HEDD Attack* (DIRS 181279-Luna 2006, all) to estimate the impacts of such events that involved spent nuclear fuel in truck or rail casks. The more recent estimates of release fractions (DIRS 181279-Luna 2006, all) are based on the release fractions in *Projected Source Terms for Potential Sabotage Events Related to Spent Fuel Shipments* (DIRS 104918-Luna et al. 1999, all), but incorporated data from additional tests sponsored by *Gesellschaft für Anlagen - und Reaktorsicherheit* in Germany and conducted in France in 1994 that were not available for the earlier report. The information the German investigators provided was useful because the fuel pins used in the tests were pressurized to simulate the gas pressure in commercial spent nuclear fuel pins. As a consequence, these tests provided additional information that had not yet been considered and that allowed a determination of the effects of aerosol blowdown from pin-plenum gas release after a breach of the fuel pin *cladding*. These additional test data suggest that the consequences of a sabotage event in the Yucca Mountain FEIS could be overstated by a factor of between 2.5 and 12.

6.2 Impacts from Loading Activities at Generator Sites

In the Yucca Mountain FEIS, the impacts from loading activities at the generator sites were limited to placement of spent nuclear fuel into rail or truck casks; most of the commercial spent nuclear fuel was not placed in canisters before shipment. In this Repository SEIS, most commercial spent nuclear fuel would be placed in TAD canisters before shipment in rail casks, and the impacts from loading activities would include the impacts from loading these canisters. Chapter 8 addresses the impacts of loading commercial spent nuclear fuel into dual-purpose canisters as cumulative impacts. The impacts from storing commercial or DOE spent nuclear fuel or high-level radioactive waste are also addressed as cumulative impacts in Chapter 8 of this SEIS.

For rail shipments of commercial spent nuclear fuel from the generator sites, loading operations would include placement of the spent nuclear fuel into TAD canisters, placement of the TAD or other types of canisters into a rail *transportation cask*, and placement of the transportation cask on a railcar or heavy-haul truck. For truck shipments of commercial spent nuclear fuel, the generator sites would place uncanistered spent nuclear fuel in a truck transportation cask and place the truck cask on a truck trailer.

DOE would load its spent nuclear fuel and high-level radioactive waste into disposable canisters at the four DOE sites. Therefore, loading operations at the DOE sites would consist of placement of the canisters into a rail transportation cask and placement of the transportation cask on a railcar. DOE would also load a small amount of uncanistered commercial spent nuclear fuel into truck casks at the DOE sites.

This section summarizes the potential impacts to workers and members of the public of loading of spent nuclear fuel into TAD canisters, loading the TAD and other canisters into transportation casks, and loading the transportation casks onto transportation vehicles at the 72 commercial sites. It includes the potential impacts to workers and members of the public of loading canisters that contained DOE spent nuclear fuel and high-level radioactive waste into transportation casks and loading the casks onto transport vehicles at the four DOE sites.

6.2.1 TRANSPORTATION OF CANISTERS TO GENERATOR SITES

DOE would operate the repository with the use of a primarily canistered approach in which most commercial spent nuclear fuel would be packaged at the generator sites into TAD or other types of canisters. This would require shipment of about 6,500 empty TAD canisters to the commercial generator sites. These shipments of empty canisters would be made by truck. About 1,000 additional empty TAD canisters would be shipped directly to the repository to package commercial spent nuclear fuel that could not be shipped from the generator sites using rail casks. The impacts of shipping these 1,000 empty TAD canisters to the repository were included in Section 6.4.2. Prior to the loading of a truck or rail transportation cask, equipment used in the handling and loading of the cask, known as a campaign kit, would also be shipped to the generator sites. There would be about 4,900 of these shipments, which would be by truck.

The shipments of canisters would not be radioactive material shipments, so there would be no radiation dose to the public or to workers from the shipments. The campaign kits could become contaminated during use, but would be decontaminated before shipment. Therefore, the radiation dose and radiological risks of the shipment of campaign kits would be negligible.

DOE based the estimates of the number of traffic fatalities that would result from these shipments on fatality rates for 2001 through 2005 for trucks (DIRS 182082-FMCSA 2007, Table 13) and based the estimates of the number of vehicle emission fatalities that would result from these shipments on a unit risk factor of 1.5×10^{-11} fatality per kilometer per person per square kilometer (9.3×10^{-12} fatality per mile per person per square mile) (DIRS 157144-Jason Technologies 2001, p. 98). The impacts from shipping the canisters or campaign kits were based on shipping the canisters or campaign kits a distance of 3,000 kilometers (1,900 miles).

DOE estimated that a total of 1.2 traffic fatalities and about 0.23 fatality from vehicle emissions would result from the shipment of the canisters and campaign kits.

6.2.2 RADIOLOGICAL IMPACTS TO THE PUBLIC FROM LOADING AT GENERATOR SITES

Radiation doses to members of the public near generator sites could occur due to the venting of radioactive gases during the handling of spent nuclear fuel in spent fuel pools and dry transfer casks. The estimated *population dose* to members of the public within 16 kilometers (10 miles) of the generator sites would be 2.9 person-rem over the duration of loading operations (DIRS 104794-CRWMS M&O 1994, p. 3-7). The *probability* of a latent cancer fatality based on the estimated dose would be 0.0017, or about 1 chance in 600 that one member of the exposed population would develop a latent cancer fatality. The estimated radiation dose to the *maximally exposed individual* 800 meters (0.5 mile) from the generator site would be 7.7×10^{-6} *rem* (DIRS 104794-CRWMS M&O 1994, p. 3-6). The estimated probability of a latent cancer fatality for this individual would be 4.6×10^{-9} or about 1 chance in 200 million.

6.2.3 RADIOLOGICAL IMPACTS TO WORKERS FROM LOADING AT GENERATOR SITES

At commercial generator sites, impacts to *involved workers* would result from loading of spent nuclear fuel into canisters, loading of canisters into rail transportation casks and, at some sites, loading of spent nuclear fuel into truck casks. For DOE spent nuclear fuel and high-level radioactive waste, impacts would result from loading of canisters that contained these materials into rail transportation casks and a small amount of uncanistered commercial spent nuclear fuel into truck casks.

For the loading of spent nuclear fuel into canisters at commercial generator sites, DOE based radiation doses on utility data compiled by the U.S. Nuclear Regulatory Commission (NRC) for the loading of 87 *dry storage* canisters at four commercial sites (DIRS 181757-NRC 2002, Attachment 3; DIRS 181758-Spitzberg 2004, Attachment 2; DIRS 181759-Spitzberg 2005, Attachment 2; DIRS 181760-Spitzberg 2005, Attachment 2).

Lifetime Dose to the Maximally Exposed Worker

The lifetime radiation exposure for the maximally exposed individual worker is estimated to be 25 rem based on the assumption that he or she would receive an annual administrative limit of 500 millirem for a 50-year working life. The use of the maximum annual results based on the administrative dose limit of 500 millirem would tend to overestimate the actual exposure of the maximally exposed individual worker, even assuming that the worker remained in the same job for 50 years, which is unlikely.

Industry experience indicates that the worker radiation doses will be much lower. For example, Progress Energy has conducted a total of 210 shipments, which includes 375 casks and 5,205 spent fuel assemblies. All shipments were conducted by rail using IF-300 casks (DIRS 185461-Edwards 2008, all). Forty-four of those shipments were from the Robinson Plant to the Brunswick Plant. Thirty-seven shipments were from the Robinson Plant to the Harris Plant. One hundred twenty-nine shipments were from the Brunswick Plant to the Harris Plant. During these shipments, all shipment escorts, train crew, and passengers were monitored for radiation exposure using thermoluminescent dosimeters. Dose rates at 2 meters from the cask were measured at less than 2 millirem per hour, and during these shipments there was zero recordable radiation dose to escorts, crew, and passengers. The collective radiation dose for crews loading, unloading, and decontaminating the casks at the shipping and receiving plants is generally less than 0.250 person-rem for a shipment, which includes the combined dose for all workers supporting the shipping and receiving plants.

DOE used data from *Health and Safety Impacts Analysis for the Multi-Purpose Canister System and Alternatives* (DIRS 104794-CRWMS M&O 1994, pp. A-9 and A-24) to estimate radiation doses for the loading of (1) canisters that contained commercial spent nuclear fuel into rail casks and uncanistered spent nuclear fuel assemblies into truck casks, (2) canisters that contained high-level radioactive waste or DOE spent nuclear fuel into rail casks, and (3) rail casks onto railcars and truck casks onto truck trailers.

Table 6-2 lists estimated radiological impacts for workers who would perform loading activities. The estimated collective radiation dose for these workers would be 10,000 person-rem. In the exposed population of workers, this radiation dose would result in an estimated 6.0 latent cancer fatalities. Latent cancer fatalities from loading operations would not occur among *noninvolved workers* because these workers would not be exposed to radiation from the operations. Appendix G, Section G.1 contains more details on these estimated impacts.

Table 6-2. Estimated radiological impacts to involved workers from loading and storage operations.

Worker category/impact	Dose	LCFs
Maximally exposed individual (rem)	25[a]	0.015
Involved worker population (person-rem)		
Commercial spent nuclear fuel loading	8,300	5.0
High-level radioactive waste loading	1,300	0.77
DOE spent nuclear fuel loading	510	0.30
Total involved worker population[b]	10,000	6.0

a. Based on a radiation dose of 500 millirem per year for 50 years.
b. All involved workers at all facilities.
LCF = Latent cancer fatality.

It would be highly unlikely for a radiation worker to work for the entire period of operations (50 years) and receive the administrative dose limit of 500 *millirem* per year (DIRS 156764-DOE 1999, p. 2-3) during each year of employment. The radiation dose for this worker would be 25 rem. Even under such unlikely circumstances, the estimated probability of a latent cancer fatality for this worker would be about 0.015 or about 1 chance in 70.

Evaluation of loading activities at the generator sites resulted in radiological impacts to workers that were greater than the impacts DOE presented in the Yucca Mountain FEIS. The primary reasons for the increase in the impacts were the 50-percent increase in the latent cancer fatality conversion factor and the additional handling of the commercial spent nuclear fuel required when TAD canisters would be loaded at the generator sites rather than at the repository.

6.2.4 INDUSTRIAL SAFETY IMPACTS FROM LOADING AT GENERATOR SITES

Table 6-3 lists estimated impacts to involved workers from industrial (nonradiological) accidents at the 72 commercial sites and 4 DOE sites. DOE based incidence and fatality rates for involved workers on Bureau of Labor Statistics data for 2005 (DIRS 179131-BLS 2006, all; DIRS 179129-BLS 2007, all) for workers in the transportation and warehousing industries. For noninvolved workers, the Department based the rates on the professional and business services industries. From these data and estimates of the number of casks that would be shipped, the estimated probability would be about 0.25 that a fatality would occur among the involved and noninvolved workers. Appendix G, Section G.1 contains more details on these estimated impacts.

For involved and noninvolved workers who would commute to generator sites, DOE estimated that traffic fatalities would be unlikely to occur and no health impacts would result from exposure to vehicle emissions.

Table 6-3. Estimated industrial safety impacts to involved and noninvolved workers during loading operations.

Worker category/impact	Impact
Involved workers	
Total recordable cases	110
Lost workday cases	73
Industrial fatalities	0.24
Vehicle emission fatalities	0.00070
Traffic accident fatalities	0.13
Noninvolved workers	
Total recordable cases	8.1
Lost workday cases	4.0
Industrial fatalities	0.012
Vehicle emission fatalities	0.00018
Traffic accidentfatalities	0.031

6.2.5 IMPACTS OF LOADING ACCIDENTS AT GENERATOR SITES

In this Repository SEIS, DOE bases the impacts of accidents at the generator sites during the loading of TAD canisters and transportation casks on information in *A Pilot Probabilistic Risk Assessment of a Dry Cask Storage System at a Nuclear Power Plant* (DIRS 181343-Bjorkman et al. 2007, all). The dry cask storage system this study analyzed consisted of a multipurpose canister that would confine the spent nuclear fuel, a transfer overpack that would shield workers from radiation during preparation of the canister for storage, and a storage overpack that would shield people from radiation and mechanically protect the canister during storage. A TAD canister would be similar to the multipurpose canister evaluated in this study.

The study covered all phases of the dry cask storage *process*: loading fuel from the spent fuel pools into dry storage canisters, preparing canisters for storage, transferring loaded canisters into dry storage overpacks, transferring the overpacks that contained canisters outside reactor buildings, moving the loaded overpacks from reactor buildings to storage pads, and storing the overpacks containing loaded canisters for 20 years on storage pads. The potential accidents considered in this study included dropping a spent nuclear fuel assembly, a transfer cask that contained a canister loaded with spent nuclear fuel, a canister that contained spent nuclear fuel, and a storage overpack that contained a canister loaded with spent nuclear fuel. In addition, the study considered the effects of *earthquakes*, floods, high winds, lightning strikes, aircraft crashes, and pipeline explosions. It based the radionuclide inventory of spent nuclear fuel on 10-year-cooled boiling-water-reactor spent nuclear fuel. The study considered weather conditions and the population *distribution* in the vicinity of a specific boiling-water-reactor site. The analysis based other parameters on characteristics of the Surry Nuclear Power Plant in Virginia.

This study quantified the impacts of accidents in terms of the probability of a latent cancer fatality within 16 kilometers (10 miles) of the site. It estimated that these probabilities would range from 1.5×10^{-12} (1 chance in 700 billion) for an accident that involved the drop of a spent nuclear fuel assembly to 3.6×10^{-4} (1 chance in 3,000) for an accident that involved the drop of a transfer cask (DIRS 181343-Bjorkman et al. 2007, p. 7-6).

6.3 Impacts Associated with National Transportation

This section presents estimates of the national impacts of the shipment of spent nuclear fuel and high-level radioactive waste from 72 commercial and 4 DOE sites to the proposed repository. It presents the potential impacts to the public and workers that could occur from *incident-free* (routine) transportation, transportation accidents, and potential sabotage events along across-the-country shipping routes that the shipments could use. The section also presents an overview of the methods DOE used to estimate the impacts.

Shipments of spent nuclear fuel and high-level radioactive waste would travel an annual distance of 850,000 truck kilometers (530,000 truck miles) and 3.7 million railcar kilometers (2.3 million railcar miles) on existing highways and railroads. For comparison, the average annual total travel of trucks and trains in the United States is about 350 billion truck kilometers (220 billion truck miles) and 61 billion railcar kilometers (38 billion railcar miles) (DIRS 181280-DOT 2006, all; DIRS 181282-AAR 2006, all). Shipments of spent nuclear fuel and high-level radioactive waste would represent a very small fraction of total national highway and railroad annual traffic (0.0002 percent for trucks, 0.006 percent for railcars, and about 0.1 percent for trains).

With the exception of occupational and public health and safety impacts evaluated in this section, because shipments of spent nuclear fuel and high-level radioactive waste would comprise only small fractions of total national highway and rail traffic, the environmental impacts of the shipments on land use and ownership; *hydrology*; biological resources and soils; cultural resources; socioeconomics; noise and vibration; aesthetics; utilities, energy, and materials; and waste management would be small in comparison with the impacts of other nationwide transportation activities.

To determine if pollutants of concern from truck and rail transport would degrade *air quality* in areas not in compliance with U.S. Environmental Protection Agency (EPA) standards for *criteria pollutants* (*nonattainment areas*), DOE reviewed traffic volumes in those areas. The Department found that the numbers of vehicles (truck and rail) bound for Yucca Mountain would be small in relation to normal traffic volumes. Therefore, the impact on air quality in these areas would be small.

Radiological impacts of accidents on biological resources would be unlikely. A severe accident scenario in which a release of radioactive materials occurred, such as the maximum reasonably foreseeable accident discussed in Section 6.3.3.2, would be unlikely. The probability of the maximum reasonably foreseeable accident scenarios would be about 5 in 1 million per year and the probability of this accident in a specific location would be much less than 5 in 1 million per year. Because of the low probability of occurrence, the risk of an accident during the transport of spent nuclear fuel and high-level radioactive waste that caused adverse impacts to any endangered or *threatened species* or impacts to other plants and animals would be small.

6.3.1 METHODS TO ESTIMATE TRANSPORTATION IMPACTS

In this Repository SEIS, DOE estimates the impacts from incident-free transportation and from transportation accidents. Incident-free transportation impacts would be those from routine transportation if no accidents occurred to affect the shipment. These impacts could be from the radiation emitted from the transportation cask, which federal regulations restrict to 10 millirem per hour at a distance of 2 meters

(6.6 feet) from the truck or railcar (10 CFR 71.47), or they could be from the exhaust and *fugitive dust* emitted by the truck or train.

RADIATION LEVELS EMITTED FROM TRANSPORTATION CASKS

The radiological impact analysis for spent nuclear fuel and high-level radioactive waste transportation assumes that the external radiation levels emitted from each transportation cask would be at the regulatory limit of 10 millirem per hour at a distance of 2 meters (6.6 feet). This assumption would tend to overestimate the radiation dose to workers and the public because not all casks would be loaded with spent nuclear fuel or high-level radioactive waste that has the characteristics that would result in the cask external dose rate being at the regulatory limit. In its report *Assessment of Incident Free Transport Risk for Transport of Spent Nuclear Fuel to Yucca Mountain Using RADTRAN 5.5*, the Electric Power Research Institute noted that more than 40 percent of the spent nuclear fuel shipped is likely to have been stored for times greater than 20 years (DIRS 185330-EPRI 2005, p. 5-2). The longer spent nuclear fuel is stored, the lower the radiation dose rate would be when the spent nuclear fuel is shipped, and cask external dose rates would be lower than the regulatory limit. Appendix J of the Yucca Mountain FEIS discussed this issue (DIRS 155970-DOE 2002, Section J.1.3.2.4). The FEIS analysis estimated that the cask dose rate would be 50 to 70 percent of the regulatory limit. Based on this analysis, DOE expects that the radiological risks to workers and public from incident-free transportation would be 50 to 70 percent of the values estimated in this Repository SEIS.

Radiological impacts from transportation accidents would be a consequence of one of three possible situations. In declining order of the potential impacts that could occur:

1. A severe accident could release radioactive material from a cask.

2. A cask could emit higher levels of radiation if the shielding degraded during a severe accident.

3. As would be the case in more than 99.99 percent of all accidents, the casks and shielding would remain intact and the casks would emit normal radiation levels and remain stationary until accident recovery operations were complete.

Radiation doses were estimated for two groups, workers and members of the public. For each group, radiation doses were estimated for the collective population and maximally exposed individuals. For members of the public, the collective population was the population within 800 meters (0.5 mile) of the transportation routes and was determined using U.S. Census data. The 800-meter (0.5-mile) distance is based on the distance used to estimate radiation doses in *Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants* (DIRS 185281-AEC 1972, p. 110). The distances of maximally exposed individuals from the transportation routes were based on the distances used in the Yucca Mountain FEIS (DIRS 157144-Jason Technologies 2001, all). Within Nevada, these distances were determined using geographic information system data and imagery.

For transportation accidents, radiation doses were estimated out to 80 kilometers (50 miles) from the accident. This distance is based on the distance used to estimate radiation doses from accidents in *Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants* (DIRS 185281-AEC 1972, p. 94).

The nonradiological impacts from transportation accidents would be a consequence of traffic fatalities that involved truck shipments and from fatalities that involved rail shipments of spent nuclear fuel and high-level radioactive waste. The rail-related fatalities would be primarily from highway-rail crossing incidents and trespassers on railroad property.

DOE used the following computer programs to estimate incident-free transportation impacts and impacts from transportation accidents for this Repository SEIS:

- The Total System Model program (DIRS 181377-BSC 2007, all) to estimate the number of truck and rail casks that DOE would ship to the repository,
- The TRAGIS program (DIRS 181276-Johnson and Michelhaugh 2003, all) to identify representative highway and rail routes that shipments could use and to provide estimates of the number of people who lived along these routes,
- The RADTRAN 5 program (DIRS 150898-Neuhauser and Kanipe 2000, all; DIRS 155430-Neuhauser et al. 2000, all) to estimate (1) radiation doses to populations and transportation workers during incident-free transportation and (2) radiological accident risks to populations and transportation workers from transportation accidents, and
- The RISKIND program (DIRS 101483-Yuan et al. 1995, all) to estimate (1) radiation doses to maximally exposed individuals and to the general population during incident-free transportation and (2) radiation doses to maximally exposed individuals and the general population from severe transportation accidents and from potential sabotage events.

6.3.2 IMPACTS OF INCIDENT-FREE TRANSPORTATION

This section discusses the national impacts of incident-free transportation of spent nuclear fuel and high-level radioactive waste by truck and rail from 72 commercial and 4 DOE sites to the proposed repository. Appendix G, Section G.5 contains more information on the methods and data that DOE used to estimate incident-free transportation impacts and the assumed conditions upon which these estimates were based. The analysis evaluated two categories of incident-free impacts: radiological impacts to involved workers and members of the public, and impacts from vehicle emissions. DOE evaluated two cases for transportation in Nevada. In the first, impacts were based on national rail routes that would terminate in the Caliente area; subsequent travel to the repository would use the Caliente rail corridor. In the second, impacts were based on national rail routes that would terminate in the Hawthorne area; subsequent travel to the repository would use the Mina rail corridor.

Figure 6-1 shows the truck and rail routes DOE used to estimate transportation impacts if it used the Caliente rail corridor for rail shipments. The figure also shows the locations of the 72 commercial and 4 DOE generator sites and Yucca Mountain. Figure 6-2 shows the truck and rail routes DOE used to estimate transportation impacts if it used the Mina rail corridor. In both cases, the selected rail and truck routes are representative of actual routes that DOE could use.

DOE based the identification of the representative national rail routes for the analysis in this Repository SEIS on historical railroad industry routing practices. The analysis selected routes by giving priority to the use of rail lines that have the most rail traffic (which are the best maintained and have the highest quality track), giving priority to originating railroads, minimizing the number of interchanges between

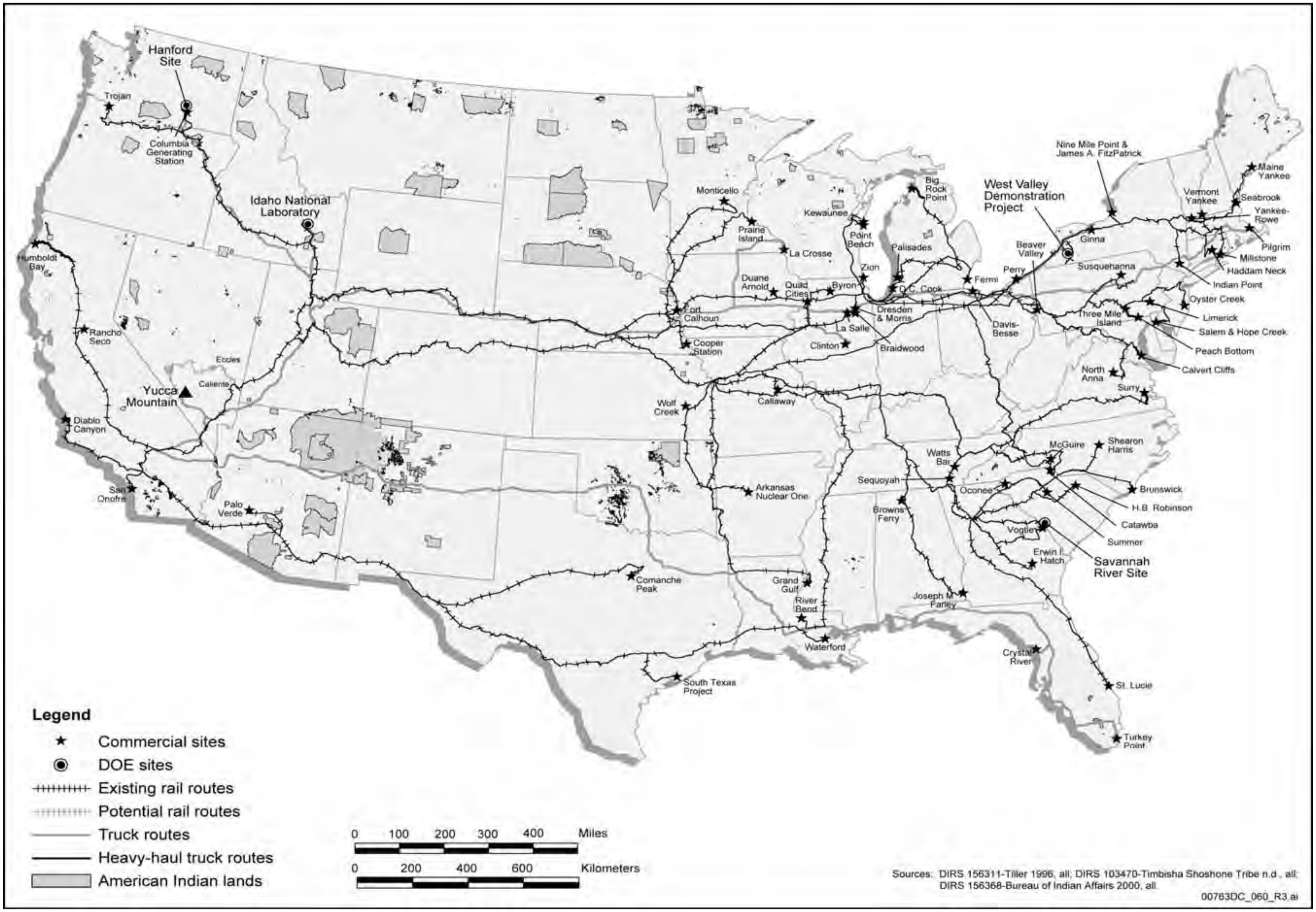


Figure 6-1. Representative rail and truck transportation routes if DOE selected the Caliente rail corridor in Nevada.

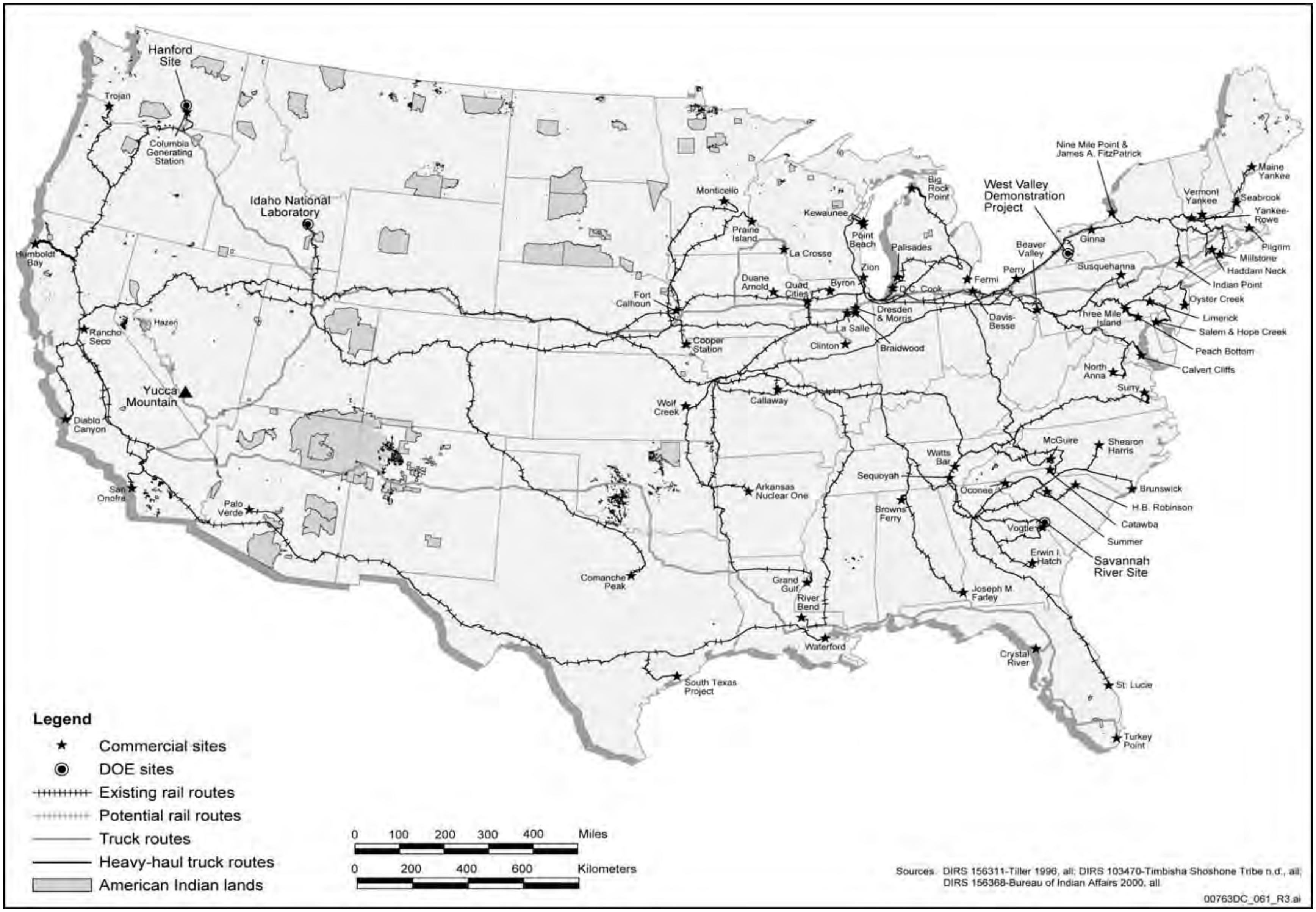


Figure 6-2. Representative rail and truck transportation routes if DOE selected the Mina rail corridor in Nevada.

railroads, and minimizing the travel distance. Highway routes would conform to the routing requirements of 49 CFR 397.101, "Requirements for Motor Carriers and Drivers."

Table 6-4 lists estimates of incident-free impacts for involved workers and members of the public. DOE estimated that about 4 latent cancer fatalities could occur in the population of transportation workers exposed to radiation from the shipments. Because many workers would be involved, the risk for an individual worker would be small. DOE estimated that there would be about 1 (0.7) latent cancer fatality among members of the public who would be exposed to radiation. Because this estimate is for the entire population of exposed individuals along the transportation routes over the course of shipments to the repository, the risk for a single individual would be small. Appendix G, Section G.5 contains more details on these estimated impacts.

Table 6-4. Estimated incident-free radiation doses and impacts for members of the public and involved workers from national transportation.[a]

Rail corridor	Members of the public radiation dose (person-rem)	Involved workers radiation dose (person-rem)	Members of the public (LCFs)	Involved workers (LCFs)	Vehicle emission fatalities	Total incident-free fatalities
Caliente						
Rail	800	4,700	0.48	2.8	0.99	4.3
Truck	350	880	0.21	0.53	0.13	0.87
Total	1,200	5,600	0.69	3.4	1.1	5.2
Mina						
Rail	700	5,100	0.42	3.0	0.88	4.3
Truck	350	880	0.21	0.53	0.13	0.87
Total	1,100	5,900	0.63	3.6	1.0	5.2

Note: Values are rounded to two significant figures; therefore, totals might differ from sums of values.

a. Impacts are for the entire duration (up to 50 years) of shipping spent nuclear fuel and high-level radioactive waste to the repository.

LCF = Latent cancer fatality.

For nonradiological impacts of shipments, DOE estimated that vehicle emissions would result in 1 fatality among members of the public over the course of shipments along the routes to the repository. The risk for any individual would be small.

Therefore, the total estimated impacts of incident-free shipment of spent nuclear fuel and high-level radioactive waste would be about 5 fatalities. This number of fatalities, which would occur over as many as 50 years, would not be discernable from the 600,000 people who die from cancer every year in the United States.

The estimates of incident-free transportation impacts in this Repository SEIS are higher than those in the Yucca Mountain FEIS primarily due to (1) the increase in the radiation dose-to-latent cancer fatality conversion factor, (2) the use of additional shipment escorts in all areas, and (3) extrapolation of impacts to 2067. The increase in impacts due to these factors is partially offset by a decrease in impacts from the use of dedicated trains (Section 6.1.4).

Table 6-5 lists estimates of impacts for maximally exposed workers and members of the public. These impacts are at the national level and would not depend on the Nevada rail corridor that DOE selected. Among workers, escorts and inspectors would receive the highest estimated radiation doses, in large part because of their proximity to casks and the amount of time they were exposed. The maximally exposed

Table 6-5. Estimated incident-free radiation doses and impacts for maximally exposed involved workers and members of the public from national transportation.[a]

Category	Dose (rem)	Probability of LCFs
Involved workers		
Escort	25[b]	0.015
Rail inspector	25[b]	0.015
Railyard crew member	4.8	0.0029
Truck driver	25[b]	0.015
Truck inspector	11	0.0065
Public		
Resident along rail route [18 meters (60 feet)]	0.0078	0.0000047
Resident near rail stop	0.030	0.000018
Resident along truck route	0.00061	0.00000037
Person in traffic jam	0.016	0.0000096
Person at service station	0.21	0.00013

a. Impacts are for the entire 50-year shipping period.
b. Based on a 500-millirem-per-year administrative dose limit.
LCF = Latent cancer fatality.

worker would receive an estimated radiation dose of 25 rem over as many as 50 years of repository operations, based on a 500-millirem-per-year administrative dose limit (DIRS 174942-BSC 2005, Section 4.9.3.3). The probability of a latent cancer fatality for this worker would be 0.015 or about 1 chance in 70.

Members of the public would receive lower estimated radiation doses than workers from incident-free transportation because they would not be as close to the casks as workers and would not be exposed for as long as workers. The member of the public with the highest estimated individual radiation dose would be a service station attendant who refueled the trucks during shipments of spent nuclear fuel and high-level radioactive waste. Under assumptions that tend to overstate the risks, the same person would refuel about 600 trucks and receive an estimated radiation dose of 0.21 rem over as many as 50 years of shipments. Under these assumptions, the probability of a latent cancer fatality for this individual would be 0.00013, or about 1 chance in 8,000.

6.3.3 IMPACTS OF TRANSPORTATION ACCIDENTS

Appendix G, Sections G.6 and G.7 describe the methods, data, and assumed conditions DOE used to estimate transportation accident risks and the consequences of severe transportation accidents, respectively. Radiological impacts from a transportation accident would be a consequence of one of three possible situations identified above in Section 6.3.1.

The analysis used estimates of the number of traffic fatalities that could occur to quantify the nonradiological impacts of accidents. Together, estimates of radiological and nonradiological accident risks provide perspective on the impacts of accidents in the shipment of spent nuclear fuel and high-level radioactive waste.

To estimate the potential radiological impacts of transportation accidents, DOE performed two types of analyses. The first estimated the radiological and nonradiological risks from accidents during the transportation of spent nuclear fuel and high-level radioactive waste. The analysis of radiological risks of accidents considered a spectrum of accidents that ranged from high-probability accidents of low severity and consequences to severe accidents with radiological consequences that have a low probability of occurrence. They included accidents in which the functional performance of a cask would not be degraded, accidents in which no radioactive material would be released but shielding would be deformed because of lead shield displacement, and accidents that released radioactive material. Radiological accident risks are defined as the sum over a complete spectrum of transportation accidents of each accident’s probability multiplied by its radiological consequences. For accidents in which the cask was not damaged and no radioactive materials were released, DOE based estimates of the radiation dose to the public on an estimate of the time required to recover from the accident and the radiation dose to the nearby public while recovery operations were under way.

In the second type of analysis, DOE developed estimates of the impacts of the most severe transportation accidents that could reasonably be expected to occur. These are called maximum reasonably foreseeable accidents. To be reasonably foreseeable, the transportation accident must have an expected frequency of occurrence that is greater than 1 in 10 million (0.0000001) per year (DIRS 172283-DOE 2002, p. 9). Accidents that are less frequent are not considered to be reasonably foreseeable.

Appendix G, Section G.7 describes the methods and data DOE used to estimate impacts from transportation accidents. The analysis included impacts of postulated accidents during the transportation of commercial spent nuclear fuel in truck casks by trucks from the seven commercial sites that cannot handle or load large rail casks, and from a small number of truck shipments of commercial spent nuclear fuel that would originate at the Hanford Site and the Idaho National Laboratory. The analysis considered the impacts from accidents that could involve the heavy-haul trucks that would transport spent nuclear fuel to nearby railheads from the 22 commercial sites that can load a rail cask but are not served by a railroad.

6.3.3.1 Risk of Accidents

Table 6-6 lists the radiological and nonradiological accident risks of the shipment of spent nuclear fuel and high-level radioactive waste to the proposed repository. The estimated radiological accident risk of a single latent cancer fatality for the entire population within 80 kilometers (50 miles) of the rail and truck transportation routes would be about 0.0025 (1 chance in 400) during as many as 50 years of shipments to the repository. Because this risk is for the entire population of individuals along the transportation routes, the risk for any single individual would be small.

The estimates of radiological accident risks in this Repository SEIS are higher than those in the Yucca Mountain FEIS, primarily due to (1) the increase in the radiation dose-to-latent cancer fatality conversion factor, (2) the extrapolation of impacts to 2067, (3) the use of updated accident rate data, and (4) the use of the radionuclide inventory contained in 10-year-old spent nuclear fuel instead of the 14- or 15-year-old spent nuclear fuel used in the Yucca Mountain FEIS.

The estimated nonradiological impacts of accidents (traffic fatalities) could be 3 fatalities during as many as 50 years of shipments to the proposed repository. For perspective, about 40,000 people die each year in traffic accidents in the United States.

Table 6-6. Estimated accident risks for national transportation.[a]

Rail corridor	Radiological accident dose risk (person-rem)	Radiological accident risk (LCFs)	Traffic fatalities	Total fatalities
Caliente				
Rail	4.1	0.0025	2.1	2.1
Truck	0.068	4.1×10^{-5}	0.57	0.57
Total	4.2	0.0025	2.7	2.7
Mina				
Rail	3.7	0.0022	2.2	2.2
Truck	0.068	4.1×10^{-5}	0.57	0.57
Total	3.7	0.0022	2.8	2.8

Note: Values are rounded to two significant figures; therefore, totals might differ from sums.
a. Impacts are for the entire 50-year shipping period.
LCF = Latent cancer fatality.

6.3.3.2 Impacts of the Maximum Reasonably Foreseeable Accident

About 99.99 percent of transportation accidents would not be severe enough to result in a release of radioactive material from the transportation cask or degradation in the cask's shielding. The 0.01 percent of accidents that could result in a release of radioactive material or degradation of shielding are known as severe transportation accidents.

SEVERE TRANSPORTATION ACCIDENTS: AN OPPOSING VIEWPOINT

The State of Nevada has provided analyses that indicate that the consequences of severe transportation accidents would be much higher than those in this Repository SEIS. For example, the State has estimated that a rail accident in an urban area could result in 13 to 40,868 latent cancer fatalities in the exposed population (DIRS 181756-Lamb et al. 2001, pp. 24 and 25), while DOE estimates that about 9 latent cancer fatalities would occur in the exposed population.

The State estimated these consequences using computer programs that DOE developed and uses. However, the State's analysis used values for parameters that would be at or near their maximum values. DOE guidance for the evaluation of accidents in environmental impact statements (DIRS 172283-DOE 2002, p. 6) specifically cautions against the evaluation of scenarios for which conservative (or bounding) values are selected for multiple parameters because the approach yields unrealistically high results.

DOE's approach to accident analysis estimates the consequences of severe accidents having frequencies as low as 1×10^{-7} per year (1 in 10 million) (DIRS 172283-DOE 2002, p. 9) using realistic yet cautious methods and data. DOE believes that the State of Nevada estimates are unrealistic and that they do not represent the reasonably foreseeable consequences of severe transportation accidents.

The most severe transportation accidents that would be likely to occur with a frequency of about 1×10^{-7} per year or greater are known as maximum reasonably foreseeable accidents. In general, DOE considers accidents with frequencies below 1×10^{-7} per year not to be reasonably foreseeable. Based on the 20 accident cases (Appendix G, Section G.7) the transportation accident that is reasonably foreseeable and that would have the highest (or maximum) consequences (the maximum reasonably foreseeable accident) would be expected to occur with a frequency of about 5×10^{-6} per year. This accident would involve a long-duration, high-temperature fire that would engulf a cask.

IMPACTS OF SEVERE ACCIDENTS

DOE has assumed for the purposes of estimating the radiological consequences of severe accidents and sabotage events that there would be no interdiction or cleanup for 1 year after the accident or sabotage event. However, DOE anticipates that for any significant release emergency response, interdiction, and cleanup actions would be initiated. Therefore, the assumption that no interdiction or cleanup would take place for 1 year after a severe accident or sabotage event would tend to result in overestimation of the impacts of severe accidents and sabotage events.

Table 6-7 lists estimates of the impacts of this maximum reasonably foreseeable accident. If the accident occurred in an urban area, the estimated population radiation dose would be about 16,000 person-rem. The number of latent cancer fatalities based on the estimated dose would be about 9. If the accident occurred in a rural area, the estimated population radiation dose would be about 21 person-rem, and the estimated probability of a single latent cancer fatality based on the estimated dose would be 0.012 (1 chance in 80). Because these risks are for the entire population exposed during the accident, the risk for any single individual would be small. In an urban area or rural area, the radiation dose from the accident for the maximally exposed individual would be 34 rem; this is based on the individual being 330 meters (1,100 feet) downwind from the accident, where the maximum dose would occur. The estimated probability of a latent cancer fatality for this individual would be 0.020 (1 chance in 50).

Table 6-7. Radiological impacts from the maximum reasonably foreseeable transportation accident in urban and rural areas.

Impact	Urban area	Rural area
Maximum reasonably foreseeable accident		
Population dose (person-rem)	16,000	21
LCF	9.4	0.012
Maximally exposed individual dose (rem)	34	34
Probability of LCF	0.020	0.020
First responder		
Maximally exposed responder dose (rem)	0.14 – 2.0	0.14 – 2.0
Probability of LCF	$8.2 \times 10^{-5} – 1.2 \times 10^{-3}$	$8.2 \times 10^{-5} – 1.2 \times 10^{-3}$

LCF = Latent cancer fatality.

First responders would normally approach a transportation accident from the upwind direction to minimize their potential exposures. Therefore, DOE based the radiation dose for the first responder on exposure to radiation from a cask with degraded shielding. This individual would be between 2 and 10 meters (6.6 and 33 feet) from the damaged cask for 30 minutes. The estimated radiation dose to this first responder would range from 0.14 to 2.0 rem. The estimated probability of a latent cancer fatality for this first responder would range from 8.2×10^{-5} (1 chance in 10,000) to 1.2×10^{-3} (1 chance in 800).

6.3.4 EVALUATION OF POTENTIAL SABOTAGE EVENTS

6.3.4.1 Transportation Sabotage Considerations

In response to the terrorist attacks of September 11, 2001, and to intelligence information that has been obtained since then, the U.S. Government has initiated nationwide measures to reduce the threat of sabotage. These measures include security enhancements to prevent terrorists from gaining control of commercial aircraft, such as (1) more stringent screening of airline passengers and baggage by the Transportation Security Administration, (2) increased presence of federal air marshals on many flights,

(3) improved training of flight crews, and (4) hardening of aircraft cockpits. Additional measures have been imposed on foreign passenger carriers and domestic and foreign cargo carriers, as well as charter aircraft.

Beyond these measures to reduce the potential for terrorists to gain control of an aircraft, DOE has adopted an approach that focuses on ensuring that safety and security requirements are adequate and effective in countering and mitigating the effects of sabotage events that would involve transportation casks. The Federal Government has greatly improved the sharing of intelligence information and the coordination of response actions among federal, state, and local agencies. DOE has been an active participant in these efforts; it has regular and frequent communications with other federal, state, and local government agencies and industry representatives to discuss and evaluate the current threat environment, to assess the adequacy of security measures at DOE facilities and, when necessary, to recommend additional actions. In addition to its domestic efforts, DOE is a member of the International Working Group on Sabotage for Transport and Storage Casks, which is investigating the consequences of sabotage events and exploring opportunities to enhance the physical protection of casks.

In addition, the NRC has promulgated rules (10 CFR 73.37) and interim compensatory measures (67 FR 63167, October 10, 2002) specifically to protect the public from harm that could result from sabotage of spent nuclear fuel casks. The purposes of these security measures are to minimize the possibility of sabotage and to facilitate recovery of spent nuclear fuel shipments that could come under the control of unauthorized persons. These measures include the use of armed escorts to accompany all shipments, safeguarding of the detailed shipping schedule information, monitoring of shipments through satellite tracking and a communication center with 24-hour staffing, and coordination of logistics with state and local law enforcement agencies, all of which would contribute to shipment security. The Department has committed to following these rules and measures (see 69 FR 18557, April 8, 2004).

The Department, as required by the *Nuclear Waste Policy Act*, as amended (NWPA) (42 U.S.C. 10101 et seq.), would use *transportation casks* certified by the NRC. Each cask design must meet stringent requirements for structural, thermal, shielding, and criticality performance and confinement integrity for routine (incident-free) and accident events. Spent nuclear fuel is protected by the robust metal structure of the transporation cask, and by cladding that surrounds the fuel pellets in each fuel rod of an assembly. Further, the fuel is in a solid form, which would tend to reduce dispersion of radioactive particulates beyond the immediate vicinity of the cask, even if a sabotage event were to result in a breach of the multiple layers of protection.

Based on this knowledge, the Department has analyzed plausible threat scenarios, required enhanced security measures to protect against these threats, and developed emergency planning requirements that would mitigate potential consequences for certain scenarios. DOE would continue to modify its approach to ensuring safe and secure shipments of spent nuclear fuel and high-level radioactive waste, as appropriate, between now and the time of shipments.

For the reasons stated above, DOE believes that under generally credible threat conditions the probability of a sabotage event that resulted in a major radiological release would be low. Nevertheless, because of the uncertainty inherent in the assessment of the likelihood of a sabotage event, DOE has evaluated events in which a military jet or commercial airliner would crash into a spent nuclear fuel cask or a modern weapon (high-energy-density device) would penetrate a spent nuclear fuel cask (Section 6.3.4.2).

6.3.4.2 Consequences of Potential Sabotage Events

Whether acts of sabotage or terrorism would occur, and the exact nature and location of the events or the magnitude of the consequences of such acts if they were to occur, is inherently uncertain—the possibilities are infinite. Nevertheless, the Yucca Mountain FEIS and, consistent with Departmental guidance (DIRS 172283-DOE 2002, all), this Repository SEIS took a hard look at the consequences of potential acts of sabotage or terrorism during the transport of spent nuclear fuel and high-level radioactive waste by evaluating two fundamentally different scenarios: one involving aircraft and one involving a weapon or device that struck a transportation cask loaded with commercial spent nuclear fuel. DOE estimated the consequences of these scenarios without regard to their probability of occurrence; that is, DOE assumed the scenarios would occur and under conditions that would reasonably maximize the consequences.

To estimate the consequences of aircraft crashes, DOE identified the aircraft parts most likely to penetrate a transportation cask, identified the military and commercial aircraft most likely to be involved in a crash in an urban area (for example, Las Vegas, Nevada), and estimated the speed of the aircraft at impact (DIRS 155970-DOE 2002, Section J.3.3.1). DOE first considered the ability of aircraft parts to penetrate a transportation cask and concluded that the parts with the highest chance of penetration would be the engines and engine shafts. Based on flight information from Nellis Air Force Base, DOE selected the F-15 and F-16 high-performance jet fighters, which represent more than 70 percent of military flight operations. For the commercial aircraft analysis, DOE selected the B-767, a relatively large and widely used jet. Last, DOE selected aircraft impact speeds of 550 kilometers per hour (340 miles per hour). Based on this analysis, DOE determined that neither the engine nor engine shafts of any of the three aircraft would penetrate the wall of a transportation cask to a sufficient depth to cause a release of radioactive materials. Further analysis determined that if the impact and resultant fire caused a cask seal to fail, little radiation would escape and there would be less than 0.65 latent cancer fatality in the affected urban population.

In selecting the high-energy-density devices, DOE first performed a survey of weapons and devices that might be capable of penetrating a full-size spent nuclear fuel cask. From the many different types of weapons and devices the survey considered, the Department selected four general types for further evaluation: conical-shaped charges, contact-breaching charges, platter charges, and pyrotechnic torches. Analyses that subjected both simulated and actual spent nuclear fuel truck casks to the four types of high-energy-density devices provided data for selection of a high-energy-density device that would show the greatest potential to penetrate a full-size spent nuclear fuel cask and disperse its contents. As DOE reported in the Yucca Mountain FEIS (DIRS 155970-DOE 2002, Section 6.2.4.2.3), two specific high-energy-density devices were chosen for more detailed analysis. The first high-energy-density device was designed to produce the maximum cavity volume from its explosive impact, was near the weight limit that a single individual could carry, and had been used in the full-scale cask penetration test of a truck spent nuclear fuel cask. The second high-energy-density device was an anti-tank weapon that was designed to achieve maximum penetration depth in an armored vehicle and could be delivered remotely using a launch and guidance system. DOE then modeled the incidents and benchmarked the results against the physical tests.

To assess the consequences of a weapon or device (also referred to as a high-energy-density device) that penetrated a transportation cask, DOE selected a truck and rail cask and two possible high-energy-density devices, one of which had been shown through various physical tests to penetrate a cask. For this analysis, DOE selected a state-of-the-art truck cask, the General Atomics GA-4 cask, which the NRC has certified for shipments of spent nuclear fuel. The rail cask for the analysis was based on a conceptual design similar in construction to casks the NRC has certified, such as the NAC-STC, NUHOMS MP187, NUHOMS MP197, HI-STAR 100, and others.

To estimate the potential consequences of a sabotage event in which a high-energy-density device penetrated a rail or truck cask, DOE, in the Yucca Mountain FEIS, referred to *Projected Source Terms for Potential Sabotage Events Related to Spent Fuel Shipments* to obtain estimates of the fraction of spent nuclear fuel materials that would be released (release fractions) (DIRS 104918-Luna et al. 1999, all). In this Repository SEIS, the Department used the more recent release fraction estimates from *Release Fractions from Multi-Element Spent Fuel Casks Resulting from HEDD Attack* (DIRS 181279-Luna 2006, all) to estimate the consequences of such events involving spent nuclear fuel in truck or rail casks. These more recent estimates of release fractions (DIRS 181279-Luna 2006, all) are based on the release fractions estimated in 1999 from *Projected Source Terms for Potential Sabotage Events Related to Spent Fuel Shipments* (DIRS 104918-Luna et al. 1999, all), but they also incorporate data from additional tests sponsored by *Gesellschaft für Anlagen - und Reaktorsicherheit* in Germany and conducted in France in 1994 that were not available for the 1999 report. These additional test data suggest that the consequences of the sabotage event DOE analyzed in the Yucca Mountain FEIS could be overstated by a factor of between 2.5 and 12.

Table 6-8 lists estimates of the impacts of potential sabotage events involving truck and rail casks. For truck casks, the analysis estimated that a sabotage event in an urban area could result in a population radiation dose of 47,000 person-rem. The number of latent cancer fatalities based on the estimated dose would be 28. If the event was in a rural area, the estimated population radiation dose would be 92 person-rem. The probability of a single latent cancer fatality based on the estimated dose would be 0.055 (1 chance in 20). Because these risks would be for the entire exposed population, the risk for any single individual would be small. The maximally exposed individual would receive an estimated radiation dose of 43 rem, and the probability of a latent cancer fatality for this individual would be 0.026 (1 chance in 40).

Table 6-8. Estimated impacts of sabotage events involving truck or rail casks.[a]

Impact	Urban area	Rural area
Truck cask		
Impacts to populations		
Population dose (person-rem)	47,000	92
LCF	28	0.055
Impacts to maximally exposed individuals		
Maximally exposed individual dose (rem)	43	43
Probability of LCF	0.026	0.026
Rail cask		
Impacts to populations		
Population dose (person-rem)	32,000	48
LCF	19	0.029
Impacts to maximally exposed individuals		
Maximally exposed individual dose (rem)	27	27
Probability of LCF	0.016	0.016

a. Impacts are based on a sabotage event with High Energy Density Device 1 (DIRS 181279-Luna 2006, all).
LCF = Latent cancer fatality.

For rail casks, the analysis estimated that a sabotage event in an urban area could result in a population radiation dose of 32,000 person-rem. The number of latent cancer fatalities based on the estimated dose would be 19. If the event was in a rural area, the estimated population radiation dose would be 48 person-rem. The probability of a single latent cancer fatality based on the estimated dose would be 0.029 (1 chance in 30). Because these risks would be for the entire exposed population, the risk for any single individual would be small. The maximally exposed individual would receive an estimated radiation dose of 27 rem, and the probability of a latent cancer fatality for this individual would be 0.016 (1 chance in 60).

The State of Nevada in its scoping comments and comments on the Draft Repository SEIS recommended that the DOE sabotage analysis address postulated attacks that involved, for example, multiple weapons, combinations of weapons that were designed to maximize release and dispersal of radioactive materials, environmental and population conditions unique to specific locations and locations with high symbolic value, large groups of well-trained adversaries, suicide attacks, and infiltration of trucking and railroad companies. The State of Nevada also suggested that DOE consider the potential for human error to exacerbate the consequences of such attacks on a transportation cask.

In support of the State of Nevada's contention that DOE has underestimated the potential consequences of a sabotage or terrorist attack, the State commissioned a study to reevaluate the DOE sabotage analysis and concluded that a scenario that used a high-energy-density device, such as an antitank missile, would result in consequences about 10 times greater than those DOE estimated (DIRS 181892-Lamb et al. 2002, p. 19). The State has asserted that the antitank missile would penetrate both sides of a truck or rail cask and cause a much greater release than that DOE estimated (DIRS 181892-Lamb et al. 2002, p. 18), but has provided no credible scientific evidence for this assertion.

Nevada's assertion of higher consequences is contrary to the results of the DOE computer modeling, which the Department benchmarked to physical test results and which demonstrated that a weapon such as that in the State's study would not perforate both sides of the cask (DIRS 104918-Luna et al. 1999, all). In addition, the higher consequences the State predicted were a result of the selection of parameter values that are either incorrect, are based on views not generally accepted by the scientific community, or when taken together inappropriately result in compounding the adverse consequences of the scenarios analyzed. To illustrate:

- Cesium is a key contributor to dose in a release from a cask. In a spent nuclear fuel rod, cesium may reside in three locations: in the gap between the cladding and the fuel pellet, at fuel grain boundaries, and in the fuel matrix. The amount of cesium in the gap between the cladding and the fuel pellet ranges from 0.21 to 10.50 percent of the total cesium inventory, with an average of about 2.95 percent (DIRS 169987-BSC 2004, Table 6-3). The amount of cesium at the fuel grain boundaries ranges from 0.19 to 1.23 percent of the total cesium inventory, with an average of about 0.19 percent of the total cesium inventory (DIRS 169987-BSC 2004, Table 6-3). Collectively, the cesium inventory for the gap between the cladding and the fuel pellet and at the fuel grain boundaries is often referred to as the "gap inventory" and ranges from 0.40 to 11.73 percent of the total cesium inventory, with an average of about 3.7 percent (DIRS 169987-BSC 2004, Table 6-3). In accidents involving spent nuclear fuel, this cesium can be rapidly released if the cladding is ruptured.

  In *Projected Source Terms for Potential Sabotage Events Related to Spent Fuel Shipments* (DIRS 104918-Luna et al. 1999, all), the release of cesium during a sabotage event had two components: the release of the cesium gap inventory in the disrupted spent nuclear fuel rods, and the release of cesium from the fuel matrix in the disrupted spent nuclear fuel rods. All the cesium in the matrix of the disrupted rods was assumed to be released to the cask cavity during a sabotage event. Because much more cesium is present in the fuel matrix than in the gap, the release of cesium was dominated by the release of cesium from the matrix, not the release of cesium from the gap. This is in contrast to most accidents involving spent nuclear fuel, where often only the gap inventory is released when the cladding is ruptured, and there is no release from the fuel matrix.

To estimate its cesium release fraction, the State considered a DOE-funded study that estimated the cesium inventory in the gap to be as high as 9.9 percent, 33 times higher than the gap inventory the State said was used in *Projected Source Terms for Potential Sabotage Events Related to Spent Fuel Shipments* (DIRS 104918-Luna et al. 1999, all). The State apparently assumed that the entire cesium release fraction was proportional to the gap inventory, and accordingly multiplied the total release fraction used by Luna by 33. The State's approach is incorrect because it does not recognize that all of the cesium inventory, that is, the cesium in the gap and that in the matrix, was released to the cask cavity in the Luna study. By increasing the total release fraction by a factor of 33, the State's analysis effectively released 33 times the entire amount of cesium in the disrupted spent nuclear fuel rods, which is clearly incorrect.

- In this Repository SEIS, DOE used the dose-to-health effect conversion factor of 0.0006 latent cancer fatality per person-rem that both the Interagency Steering Committee on Radiation Standards (DIRS 174559-Lawrence 2002, all) and current DOE guidance (DIRS 178579-DOE 2004, pp. 22 to 24) recommend. This value is consistent with the lethality adjusted cancer risk coefficients from the *2007 Recommendations of the International Commission on Radiological Protection*, 0.00041 per person-rem for workers and 0.00055 per person-rem for individuals among the general population (DIRS 182836-ICRP 2007, p. 53); the dose-to-health-effect conversion factors published by the National Research Council in the *Health Risks from Exposure to Low Levels of Ionizing Radiation, BEIR VII Phase 2* (DIRS 181250-National Research Council 2006, p. 15), which ranged from 0.00041 to 0.00061 latent cancer fatality per person-rem for solid cancers and 0.000050 to 0.000070 latent cancer fatality per person-rem for leukemia; and the age-specific dose-to-health-effect conversion factor published by the EPA, 0.000575 latent cancer fatality per person-rem (DIRS 153733-EPA 2000, Table 7.3, p. 179).

  The Dose and Dose Rate Effectiveness Factor is used to account for the lower cancer risks of radiation exposures at low doses and low dose rates as compared with radiation exposures at high doses and high dose rates. The State of Nevada used a dose-to-health effect conversion factor of 0.001 latent cancer fatality per person-rem, which the State estimated by not including a Dose and Dose Rate Effectiveness Factor (that is, by using a Dose and Dose Rate Effectiveness Factor of 1) (DIRS 181892-Lamb et al. 2002, p. 7). The State cites as support for this argument an article by Pierce and Preston. In response, DOE notes that the use of a Dose and Dose Rate Effectiveness Factor of 1.5 to 2 is supported by both the National Research Council (DIRS 181250-National Research Council 2006, p. 15) and the International Commission on Radiological Protection (DIRS 182836-ICRP 2007, p. 53).

  The State also points out that the dose-to-health effect conversion factor depends on age and gender. However, the dose-to-health effect conversion factors developed by the International Commission on

Radiological Protection, the National Research Council, and the EPA already consider age and gender and so no further adjustment to the dose-to-health effect conversion factor is necessary.

- The degree of dispersal of radioactive particles is proportional to the height at which the radioactive particles are released; the lower the height at which the particles are released, the less the dispersion and the higher the consequences. In its study, the State used a release height for all particles of 1.508 meters (4.95 feet) for a truck cask and 2.08 meters (6.82 feet) for a train cask (DIRS 181892-Lamb et al. 2002, p. 6). These release heights are not realistic because they do not account for plume rise as a result of the explosive action of a high-energy-density device. In contrast, DOE accounted for plume rise by using multiple release heights and estimated that 4 percent of the release would occur at a height of 1 meter (3.3 feet), 16 percent at 16 meters (52 feet), 25 percent at 32 meters (100 feet), 35 percent at 48 meters (160 feet), and 20 percent at 64 meters (210 feet) (DIRS 157144-Jason Technologies 2001, p. 189). Indeed, the State acknowledged that an increase in the release height would result "in a decrease in the dose to the MEI [maximally exposed individual]" (DIRS 181892-Lamb et al. 2002, p. 6).

- The meteorological conditions at the time of release from a cask have a bearing on the consequences. The State chose to use stable atmospheric conditions (Class F stability), which represent plume concentrations that would not be exceeded 95 percent of the time in its analysis (DIRS 181892-Lamb et al. 2002, p. 6). In contrast, because it is not possible to forecast the environmental conditions that might exist during an act of sabotage, DOE used neutral atmospheric conditions (Class D stability), which represent plume concentrations that would not be exceeded 50 percent of the time.

DOE recognizes that it could analyze scenarios with, for example, higher aircraft impact velocities or weapons with greater destructive capabilities, or it could postulate scenarios with combinations of factors, such as human error and suicide attacks, as the State suggested, that could produce a much broader range of consequences that are more detrimental than those this Repository SEIS estimates. As an initial matter, for an act of sabotage or terrorism to be carried out, the persons responsible for such acts would have to overcome the security measures in place. The intent of safeguards and security measures (Section 6.3.4) is to thwart such attacks and, in any event, the measures would tend to minimize the consequences of such an attack. The scenarios DOE analyzed are conservative because the Department did not consider the effectiveness of such measures, and that such measures would make the likelihood of a sabotage event even lower.

Further, and setting aside the security measures that would be in place, the effectiveness of a sabotage event would depend on a number of critical factors such as the ability to deliver the weapon perpendicular to the circular surface of a relatively small object [a rail cask is about 2.26 meters (7.4 feet) in diameter and 5.18 meters (17 feet) long], which might be in transit and thus a moving target, the extent to which the individual had the knowledge to select and the training to use the appropriate weapon, and whether the weapon was at the optimal distance from the cask.

As with any aspect of environmental impact analysis, it is always possible to postulate scenarios that could produce higher consequences than previous estimates. In eliminating the requirement that agencies conduct a worst-case analysis, the Council on Environmental Quality has pointed out that "one can always conjure up a worse 'worst case'" by adding more variables to a hypothetical event (50 FR 32234, August 8, 1985), and that "'worst case analysis' is an unproductive and ineffective method…one which can breed endless hypothesis and speculation" (51 FR 15620, April 25, 1986). As indicated in the

Council on Environmental Quality regulations that implement the *National Environmental Policy Act* (NEPA) (42 U.S.C. 4321 et seq.), an agency has a responsibility to address reasonably foreseeable significant adverse effects. The evaluation of impacts is subject to a "rule of reason" ensuring analysis based on credible scientific evidence useful to the decisionmaking process. In applying the rule of reason, an agency does not need to address remote and highly speculative consequences in its EIS. The crafting and analysis of the scenarios the State suggested would be based on conjecture and would not have the support of credible scientific evidence.

DOE has required enhanced security measures to protect against plausible threat scenarios and developed emergency planning requirements that would mitigate potential consequences for certain scenarios. For all the reasons discussed above, under general threat conditions, the probability of a sabotage event against a transportation cask that carried spent nuclear fuel or high-level radioactive waste that could result in a major radiological release would be low. Nevertheless, DOE has taken a hard look by examining potential, but fundamentally different, sabotage scenarios.

6.3.5 ENVIRONMENTAL JUSTICE

Shipments of spent nuclear fuel and high-level radioactive waste would use the nation's existing railroads and highways. DOE estimates that transportation-related impacts to land use; air quality; hydrology; biological resources and soils; cultural resources; socioeconomics; noise and vibration; aesthetics; utilities, energy, and materials; and waste management would be small. The small effect on the population as a whole would be likely for any segment of the population, which includes minorities, *low-income* groups, and members of American Indian tribes.

For this Repository SEIS, DOE analyzed the potential public health effects of incident-free transportation and transportation accidents. For incident-free transportation, DOE considered air emissions and doses from exposure to radioactive materials during transport. Although many people would be exposed nationwide over a long transportation campaign, the air emissions and radiation doses to an exposed individual would be low.

In this Repository SEIS, DOE estimated the impacts to the general public from accidents involving transportation of spent nuclear fuel and high-level radioactive waste. The two mechanisms for such impacts are bodily trauma from collisions and exposure to radiation or radioactive material if a sufficiently severe accident occurred. The analysis estimated the impacts of a national campaign to the general public from trauma sustained in collisions with vehicles that carried spent nuclear fuel or high-level radioactive waste. DOE does not consider such impacts to be large given the number of years involved over a long shipping campaign.

Only a severe accident that resulted in a considerable release of radioactive material could cause serious and adverse health effects to the affected population. Because the risk of such impacts would apply to the entire population along all transportation routes, it would not disproportionately affect any minority or low-income populations.

On the basis of the analysis of incident-free transportation and transportation accidents in this Repository SEIS and the results of the transportation analysis that DOE conducted in the Yucca Mountain FEIS, DOE has not identified any high and adverse potential impacts to members of the public. Further, DOE has not identified subsections of the population, including minority or low-income populations, that would receive disproportionate impacts, and it has identified no unique exposure pathways, sensitivities, or cultural practices that would expose minority or low-income populations to disproportionately high and adverse impacts. Therefore, this SEIS concludes that no disproportionately high and adverse impacts would result from the national transportation of spent nuclear fuel and high-level radioactive waste to Yucca Mountain.

Section 6.4.1.16 discusses *environmental justice* in relation to transportation in Nevada.

6.3.6 GREENHOUSE GAS EMISSIONS

Transportation of spent nuclear fuel and high-level radioactive waste to the repository would result in emissions of carbon dioxide to the atmosphere. In addition, workers who commuted by bus and automobile to and from the repository; transport of construction materials, repository components, and consumables to the repository; and transport of waste from the repository for offsite disposal would result in emissions of carbon dioxide to the atmosphere.

Transport of these commodities would result in annual emissions of 37,000 to 38,000 metric tons (41,000 to 42,000 tons) of carbon dioxide to the atmosphere. In comparison, the overall 2005 emissions of carbon dioxide in the United States was 6.1 billion metric tons (6.7 billion tons) (DIRS 185248-EPA 2007, Table ES-2, p. ES-5). The total emissions of carbon dioxide would increase the overall national carbon dioxide emissions by less than 0.001 percent (about 0.0006 percent) over 2005 levels.

6.4 Impacts Associated with Transportation in Nevada

The following sections of this chapter summarize the potential impacts of transportation within Nevada alone. Section 6.4.1 focuses on the potential impacts of DOE's "mostly rail" scenario, under which most spent nuclear fuel and high-level radioactive waste would be shipped to the repository in dedicated trains. A tabular comparison of impacts from the transportation Proposed Action and its alternatives can be found in Section 2.3, Table 2-3, of this Repository SEIS. Section 6.4.2 examines transportation impacts associated with repository operations.

6.4.1 IMPACTS OF THE MOSTLY RAIL SCENARIO IN NEVADA

This section of the Repository SEIS summarizes and incorporates by reference Chapter 4 of the Rail Alignment EIS. In the Rail Alignment EIS, potential impacts are identified as either direct or indirect, and either short term or long term. Where practicable, DOE has quantified potential impacts. In other cases, it is not practical to quantify impacts and DOE provides a *qualitative* assessment of potential impacts. In the Rail Alignment EIS, DOE has used the following descriptors to characterize impacts qualitatively where quantification of impacts was not practical:

- Small. Environmental effects would not be detectable or would be so minor that they would neither destabilize nor noticeably alter any important attribute of the resource.

- Moderate. Environmental effects would be sufficient to alter noticeably, but not to destabilize, important attributes of the resource.

- Large. Environmental effects would be clearly noticeable and would be sufficient to destabilize important attributes of the resource.

Analyses used throughout the Rail Alignment EIS were designed to provide conservative estimates of the impacts that could occur. Where appropriate, cautious but reasonable assumptions were employed; thus, the analyses have a tendency to overestimate impacts. Unless otherwise noted, potential impacts described in this section would be adverse.

DOE would meet all applicable regulatory requirements during construction and operation of the railroad, and would implement an array of *best management practices* to help ensure compliance with requirements. In addition, DOE could implement measures to mitigate impacts remaining after final design and compliance with regulatory requirements and implementation of best management practices. The following sections summarize environmental impacts for each resource area DOE analyzed.

6.4.1.1 Land Use and Ownership

The *region of influence* for land use and ownership is the nominal width of the rail line *construction right-of-way* and includes all private land, American Indian land, and public land fully or partially within that area. It also includes lands outside the nominal width of the rail line construction right-of-way, where there would be facilities, quarries, borrow sites, and wells to support construction and long-term operation of the railroad.

DOE would need to gain access to private land—up to 1.25 square kilometer (310 acres) for the Caliente *rail alignment* and up to 0.81 square kilometer (200 acres) for the Mina rail alignment (Chapter 2 of this Repository SEIS, Section 2.1.7.3.1, discusses the proposed alignments and *alternative segments*, and the alignments are shown in Figure 2-13). For the Caliente rail alignment, another 0.93 square kilometers (230 acres) of private land would be required to accommodate support facilities. Neither rail alignment would displace existing or planned land uses over a substantial area, nor would they substantially conflict with applicable land-use plans or goals. The areas with the highest density of private land that either rail alignment would cross are the City of Caliente (Caliente rail alignment) and Goldfield (both rail alignments). For the Caliente alternative segment, some structures at the existing Union Pacific train yard and three structures along the former Pioche and Prince Branchline would need to be demolished or relocated. This Caliente alternative segment would also occupy portions of the access road and parking lot of the Caliente Hot Springs Hotel. The proximity of the rail line could adversely affect the hotel and the Department would work with the land owner to mitigate the impacts to the hotel through the process described in Chapter 7 (Best Management Practices and Mitigation) of the Rail Alignment EIS. Through this process, DOE would develop specific measures to avoid, reduce, or mitigate impacts to this property, including measures to maintain access to the motel during construction. Finally, DOE could also negotiate compensation with the land owner if design, construction, or operational accommodations are not sufficient to mitigate the impacts. Alternative segments near Goldfield would cross private (although vacant) land, including patented mining claims and state and county land.

In response to concerns from the Timbisha Shoshone Tribe, DOE avoided Timbisha Shoshone Trust Lands during the development of the Caliente and Mina rail alignments. The closest rail segment, common segment 5, would be approximately 3 kilometers (2 miles) east of Timbisha Shoshone Trust Lands near Scottys Junction. DOE initially studied the Mina rail alignment with the permission of the Walker River Paiute Tribe and the Department designed the Schurz alternative segments with the aim of removing the existing Department of Defense Branchline through the town of Schurz in accordance with the Tribe's request. The Schurz alternative segments would utilize up to 0.5 percent of the land area of the reservation [up to 5.3 square kilometers (1,300 acres)].

The Caliente rail alignment would utilize up to 162 square kilometers (40,000 acres) of Bureau of Land Management-administered land out of a total construction footprint of approximately 170 square kilometers (41,000 acres), and the Mina rail alignment would utilize up to 113 square kilometers (28,000 acres) of Bureau of Land Management-managed land out of a total construction footprint of approximately 125 square kilometers (31,000 acres). A portion of the Eccles alternative alignment and Common Segment 1 would cross through Areas of Critical Environmental Concern under the Ely Proposed Resource Management Plan. These areas were designated after the issuance of the Draft Rail Alignment EIS and would be finalized after further study by the Bureau of Land Management. In consultation with the Bureau of Land Management, DOE would conduct preconstruction surveys and implement avoidance, minimization, and mitigation strategies to protect the resource values of these areas. If the Bureau of Land Management found that through these strategies there would be minimal conflict with the areas' resource values, then the right-of-way could be authorized.

The Mina rail alignment would cross 4.6 square kilometers (1,150 acres) of land within the Hawthorne Army Depot near its northern border, where it would not pose a conflict with the Depot's mission or land uses. Railroad construction would result in surface disturbance across a number of grazing allotments on Bureau of Land Management-administered land. Assuming all the vegetation in the construction right-of-way and support facility footprints across all affected allotments was unavailable for forage, the route with the greatest impact on grazing for either alignment would directly result in a less than 2-percent loss of animal unit months [1 animal unit month equates to approximately 360 kilograms (800 pounds) of forage and is a measure of the forage needed to support one cow, one cow/calf pair, one horse, or five sheep for 1 month]. Additional animal unit months could be lost due to the inaccessibility of forage in locations where the rail line acted as a barrier to livestock, though allotment management plans would be revised to minimize grazing impacts associated with the rail line and DOE would coordinate with permittees and the Bureau of Land Management to institute mitigation measures. The rail line could require livestock on some allotments to adjust to new routes to access water and forage. In most areas, livestock could learn new routes and acclimate to and cross the rail line. DOE would provide temporary feed, water, and assistance in livestock movement during rail line construction to assist with the adjustment of cattle to the presence of the rail line. The rail line could pose an additional risk to ranching operations because livestock could be struck by passing trains. DOE or the railroad's commercial operator would reimburse ranchers for such losses, as appropriate.

Most of the local mining activity along both the Caliente and Mina rail alignments would be outside the rail line construction right-of-way. DOE would need to negotiate the rights to cross the few affected unpatented mining claims the rail line would intersect. Along the Caliente rail alignment, the rail line would intersect unpatented mining claims along South Reveille alternative segments 2 and 3; Caliente common segment 3; Goldfield alternative segments 1, 3, and 4; Oasis Valley alternative segments 1 and 3; and common segment 6. The Mina rail alignment would intersect unpatented mining claims along Montezuma alternative segments 1, 2, and 3; Oasis Valley alternative segments 1 and 3; and common segment 6. Mining activities at the Gemfield deposit by Metallic Ventures Gold, Inc., should they occur, could create direct conflicts with the proposed routes of Goldfield alternative segment 4 and Montezuma alternative segment 2, and the Caliente Maintenance-of-Way Facility. DOE would employ mitigation and avoidance strategies as discussed in Chapter 7 to address this potential conflict. Should it be required, there appears to be sufficient space to relocate both the alternative segment and the Maintenance-of-Way Facility to an area of unoccupied Bureau of Land Management land west of the currently proposed location. This Bureau of Land Management land has topography favorable to the construction of a rail line and Maintenance-of-Way Facility (DIRS 185098-Gehner 2008, p. 2). The rail line could be affected by or affect underground mining tunnels or shafts. During the final engineering design, DOE would perform a survey to verify the locations of mining tunnels and shafts and implement best management practices and mitigation measures to avoid adverse impacts.

The rail alignments have been developed to avoid Wilderness Areas and other scenic and recreational areas. Under either implementing alternative, DOE would construct crossings to prevent the rail line from obstructing access to private and public land. While there could be temporary road closures or detours during the construction phase, there would be no impact to land access during the operations phase. In addition, organized off-highway vehicle events permitted in the past by the Bureau of Land Management might need to alter their routes to avoid the rail line.

The rail alignments would cross a number of utility rights-of-way. DOE would negotiate crossing agreements with right-of-way holders and the Bureau of Land Management. DOE would protect existing utilities from damage so that disruption to utility service or damage to lines would be at most small and temporary. The project would require a Bureau of Land Management right-of-way outside existing Bureau of Land Management planning corridors for utilities; this right-of-way would be outside of right-of-way avoidance areas. Under the longest potential routes, approximately 25 percent of the Caliente rail alignment and 40 percent of the Mina rail alignment (new construction on Bureau of Land Management-managed land) would fall within existing planning corridors. In addition, to avoid the proliferation of new rights-of-way, the Bureau of Land Management could elect to grant future rights-of-way for new utilities adjacent to the proposed rail line.

6.4.1.2 Air Quality and Climate

The air quality and climate region of influence for the Caliente rail alignment encompasses Lincoln, Nye, and Esmeralda counties. The air quality and climate region of influence for the Mina rail alignment encompasses Lyon, Mineral, Esmeralda, and Nye counties, a small portion of Churchill County near Hazen, and the Walker River Paiute Reservation, the bulk of which lies within Mineral County with smaller portions within Lyon and Churchill counties. The Caliente and Mina rail alignments would cross desert and semi-desert areas that generally have abundant hours of cloud-free days, low annual precipitation, and large daily ranges in temperature. All portions of the Caliente and Mina rail alignments would be within areas classified by EPA as in attainment for all *National Ambient Air Quality Standards*

DOE examined emissions inventories to determine county-level increases in air pollutant emissions, and performed air quality simulations to determine potential changes in air pollutant concentrations at specific *receptor* locations (population centers). An adverse impact to air quality would occur if it were shown that a proposed action would conflict with or obstruct implementation of a state or regional air quality management plan, or would exceed a National Ambient Air Quality Standards primary standard or contribute to existing or projected exceedances. DOE determined air pollutant concentrations that could result from railroad construction and operation along the Caliente or Mina rail alignment using the EPA-recommended model for regulatory applications (AERMOD dispersion modeling system version 07026). To assess potential air quality impacts in the region of influence from railroad construction and operation along the Caliente rail alignment DOE modeled emissions and resultant concentrations of criteria air pollutants where there are two population centers that would be near the rail line—Caliente in Lincoln County and Goldfield in Esmeralda County—and compared the modeling results to the National Ambient Air Quality Standards. DOE likewise modeled air quality for the Mina rail alignment near the population centers that would be relatively close to the rail line: Schurz, Hawthorne, and Mina in Mineral County; and in Silver Peak and Goldfield in Esmeralda County. DOE also performed modeling for the Caliente rail alignment for construction-related activities at a potential quarry site northwest of Caliente and a potential quarry site in South Reveille Valley, and for the Mina rail alignment at the potential Garfield Hills and Malpais Mesa quarry sites.

The analysis showed that criteria air pollutant concentrations along the Caliente or Mina rail alignment would not exceed the National Ambient Air Quality Standards during the construction or operations phases, with the following possible exceptions. During the construction phase for the Caliente rail alignment, the 24-hour National Ambient Air Quality Standards for PM_{10} could be exceeded during quarry operations in South Reveille Valley. During the construction phase for the Mina rail alignment, the 24-hour National Ambient Air Quality Standards for both PM_{10} and $PM_{2.5}$ (*particulate matter* with aerodynamic diameter less than or equal to 10 and 2.5 micrometers, respectively) could be exceeded near the construction right-of-way at Mina and Schurz during the relatively short (less than 6 months) construction period, at the Staging Yard at Hawthorne, and at the potential Garfield Hills quarry. However, DOE would be required to obtain a Surface Area Disturbance Permit Dust Control Plan issued by the State of Nevada Department of Environmental Protection prior to quarry and Staging Yard development. It is likely that requirements in the plan would reduce fugitive dust emissions, thus reducing the possibility of a National Ambient Air Quality Standards exceedance.

For the Caliente rail alignment, DOE determined that the highest increase in air pollutant emissions would occur during the construction phase. During the operations phase for the Caliente rail alignment, the highest increase would occur in the vicinity of the railroad operations support facilities. The highest increase in emissions would be for *nitrogen oxides* emissions in Nye County, where construction emissions could be as much as 8,100 metric tons (8,900 tons) per year over the county’s 2002 annual nitrogen oxides emissions, which were 1,436 metric tons (1,600 tons). However, these emissions would be distributed over the entire length of the rail alignment in the county and no air quality standard would be exceeded. The peak year increase in carbon dioxide emissions during construction would increase the national carbon dioxide emission rate by less than 1,219,000 tons (0.02 percent) over 2005 levels. During the operations phase, the highest increase in criteria air emissions would occur in the vicinity of the railroad operations support facilities. Carbon dioxide emissions during operations would increase the national carbon dioxide emission rate by about 94,000 tons (0.001 percent) over 2005 levels.

For the Mina rail alignment, DOE determined that the highest increase in air pollutant emissions would occur during the construction phase. During the operations phase for the Mina rail alignment, the highest increase in air emissions from railroad operations would occur in the vicinity of the operations support facilities. The highest increase in criteria air pollutant emissions would be for nitrogen oxides in Esmeralda County during the construction phase, where emissions could be 3,570 metric tons (3,940 tons) per year higher than the 2002 county-wide nitrogen oxides emissions, which were 149 metric tons (160 tons). However, these emissions would be distributed over the entire length of the rail alignment in the county and no air quality standard would be exceeded. The peak year increase in carbon dioxide emissions during construction would increase the national carbon dioxide emission rate by less than 1,097,000 tons (0.02 percent) over 2005 levels. During the operations phase, the highest increase in criteria air emissions from railroad operations would occur in the vicinity of the railroad operations support facilities. Carbon dioxide emissions would increase the national carbon dioxide emission rate by about 73,000 tons (0.001 percent) over 2005 levels.

DOE determined that railroad construction and operations along either the Caliente or Mina rail alignment would not cause conflicts with state or regional air quality management plans.

Under the Shared-Use Options for both the Caliente and Mina rail alignments, total emissions would be increased marginally. DOE anticipates that impacts to air quality along the Caliente or Mina rail alignment under the Shared-Use Option would be similar to those under the Proposed Action without shared use. Pollutant emissions and estimated concentrations resulting from construction and operations of the railroad within the repository region of influenceare detailed in Tables 6-9 through 6-14.

Table 6-9. Rail line construction pollutant release rates in the analyzed land withdrawal area from surface equipment during the construction period.

Pollutant	Period	Mass of pollutant per averaging period [kilograms (pounds)]	Emission rate[a] (grams per second)
Nitrogen dioxide	Annual	590,000 (1,300,000)	19
Sulfur dioxide	Annual	420 (930)	0.013
	24-hour	1.7 (3.7)	0.038
	3-hour	0.62 (1.4)	0.038
Carbon monoxide	8-hour	1,800 (4,000)	42
	1-hour	230 (510)	42
Carbon dioxide	Annual	44,000,000 (97,000,000)	1,400
PM_{10}	24-hour	140 (310)	3.2
$PM_{2.5}$	Annual	34,000 (75,000)	1.1
	24-hour	140 (310)	3.1

Note: Numbers are rounded to two significant figures.
a. Based on a 12-hour release for averaging periods of 24 hours or less.

Table 6-10. Rail line construction air quality impacts from construction equipment in the analyzed land withdrawal area during the construction period (micrograms per cubic meter).

Pollutant	Period	Maximum concentration	Regulatory limit	Percent of regulatory limit
Nitrogen dioxide	Annual	2.7	100	2.7
Sulfur dioxide	Annual	0.0019	80	0.0024
	24-hour	0.15	365	0.040
	3-hour	0.61	1,300	0.047
Carbon monoxide	8-hour	250	10,000	2.5
	1-hour	2000	40,000	5.1
PM_{10}	24-hour	12	150	8.2
$PM_{2.5}$	Annual	0.16	15	1.0
	24-hour	12	35	34

Notes: Numbers are rounded to two significant figures. Receptors at boundary of analyzed land withdrawal area.

Table 6-11. Rail Equipment Maintenance Yard and associated facilities pollutant release rates from surface equipment during the construction period in the analyzed land withdrawal area.

Pollutant	Period	Mass of pollutant per averaging period [kilograms (pounds)]	Emission rate[a] (grams per second)
Nitrogen dioxide	Annual	84,000 (190,000)	2.7
Sulfur dioxide	Annual	71 (160)	0.0022
	24-hour	0.28 (0.62)	0.0098
	3-hour	0.11 (0.24)	0.0098
Carbon monoxide	8-hour	300 (660)	11
	1-hour	38 (84)	11
Carbon dioxide	Annual	7,500,000 (17,000,000)	240
PM_{10}	24-hour	22 (49)	0.76
$PM_{2.5}$	Annual	5,300 (12,000)	0.17
	24-hour	21 (46)	0.73

Note: Numbers are rounded to two significant figures.

a. Based on an 8-hour release for averaging periods of 24 hours or less.

Table 6-12. Rail Equipment Maintenance Yard and associated facilities air quality impacts from construction equipment during the construction period in the analyzed land withdrawal area (micrograms per cubic meter).

Pollutant	Period	Maximum concentration	Regulatory limit	Percent of regulatory limit
Nitrogen dioxide	Annual	0.071	100	0.071
Sulfur dioxide	Annual	0.000058	80	0.000073
	24-hour	0.0084	365	0.0023
	3-hour	0.067	1,300	0.0052
Carbon monoxide	8-hour	27	10,000	0.27
	1-hour	220	40,000	0.54
PM_{10}	24-hour	0.65	150	0.43
$PM_{2.5}$	Annual	0.0044	15	0.030
	24-hour	0.63	35	1.8

Notes: Numbers are rounded to two significant figures. Receptors at boundary of analyzed land withdrawal area.

Table 6-13. Annual pollutant emissions (kilograms)[a] from the Rail Equipment Maintenance Yard and associated facilities and activities during the operations period in the analyzed land withdrawal area.

	Rail Equipment Maintenance Yard	Rail Equipment Maintenance Yard trucks	Rail Equipment Maintenance Yard switch train locomotives	Fuel oil storage	Total rail facility emissions
Nitrogen dioxide	34,000	170	360,000	0	400,000
Sulfur dioxide	800	1.0	210	0	1,000
Carbon monoxide	10,000	190	110,000	0	120,000
Carbon dioxide	930,000	110,000	41,000,000	0	42,000,000
PM_{10}	1,100	9.6	11,000	0	12,000
$PM_{2.5}$	1,000	8.9	9,600	0	11,000
Hydrocarbons	4,100	89	27,000	150	31,000

Note: Numbers are rounded to two significant figures; therefore, totals might differ from sums.

a. To convert kilograms to pounds, multiply by 2.2046.

Table 6-14. Air quality impacts from the Rail Equipment Maintenance Yard and associated facilities and activities during the operations period in the analyzed land withdrawal area (micrograms per cubic meter).

Pollutant	Period	Maximum concentration	Regulatory limit	Percent of regulatory limit
Nitrogen dioxide	Annual	0.33	100	0.33
Sulfur dioxide	Annual	0.00086	80	0.0011
	24-hour	0.12	365	0.034
	3-hour	0.98	1,300	0.075
Carbon monoxide	8-hour	42	10,000	0.42
	1-hour	340	40,000	0.84
PM_{10}	24-hour	1.4	150	0.94
$PM_{2.5}$	Annual	0.0089	15	0.060
	24-hour	1.3	35	3.6

Note: Numbers are rounded to two significant figures.

6.4.1.3 Physical Setting

DOE examined the region of influence for physical setting to determine the potential for impacts on physiography, geology, and soils. The region of influence for physical setting includes the areas that would be directly and indirectly affected by construction and operation of the proposed railroad, and incorporates the nominal width of the rail line construction right-of-way [300 meters (1,000 feet) centered on the rail alignment]. It also includes the footprints of construction camps, quarry sites, facility sites, access roads, and water wells that would be outside the nominal width of the construction right-of-way.

DOE determined that land disturbance would be 55 to 61 square kilometers (14,000 to 15,000 acres) for the Caliente rail alignment and 40 to 48 square kilometers (9,900 to 12,000 acres) for the Mina rail alignment. Lands that are currently relatively undisturbed would be extensively graded, which would result in topsoil loss and increased potential for erosion. However, DOE would implement best management practices to minimize erosion and sedimentation during construction activities. DOE assessed that impacts from soil erosion would be small.

Perlite, a locally important mineral, occurs in the area of the Caliente rail alignment Caliente and Eccles alternative segments, and other minerals, such as limestone, metallic commercial minerals, and geothermal resources, have been identified in some nearby mountains. Although no mineral resources would be removed, placement of the rail line could reduce the availability of perlite or limestone for mining. The Goldfield alternative segments would cross mining areas and could limit the boundaries for mining if mineral resources extended under the rail line.

Neither railroad construction nor operation would reduce the availability for mining of metallic minerals that have been identified in surrounding mountains. The Montezuma alternative segments would cross mining areas in the Goldfield Hills area, and could limit the boundaries for mining if mineral resources extended under the rail line.

Along the Caliente rail alignment, construction in the Caliente or Eccles alternative segment and Caliente common segment 1 would result in a small loss of up to 1.8 square kilometers (440 acres) of *prime farmland* soil. These prime farmland soils are found in isolated pockets and are unfarmed. In the Mina rail alignment, construction of Schurz alternative segment 1, 4, 5, or 6 would affect soils characterized as prime farmland directly adjacent to the banks of the Walker River. These areas are not farmed and DOE expects no change in their current agricultural land use. DOE expects that impacts to prime farmland soils would be small [up to 0.014 square kilometer (3.5 acres) would be lost]. There would be a potential for leaks and spills that could contaminate soils during railroad operations; however, DOE would implement best management practices and consider *mitigation* measures to reduce any impacts.

The Shared-Use Option would require the construction of additional rail sidings within the rail line construction right-of-way in areas of relatively flat terrain. DOE determined that implementation of the Shared-Use Option would increase the surface disturbance area by less than 0.1 percent for either the Caliente or Mina rail alignment, and would add no impacts to physical setting beyond the permanent alterations already described.

6.4.1.4 Paleontological Resources

Paleontology is a science that uses fossil remains to study life in past geological periods. Paleontological resources are recognized as a fragile and nonrenewable record of the history of life on Earth and a critical component of America's natural heritage and, once damaged, destroyed, or improperly collected, their scientific and educational value can be greatly reduced or lost forever. The region of influence for paleontological resources along both rail alignments is the rail line construction right-of-way and the footprints of railroad construction and operations support facilities.

DOE used the Bureau of Land Management system to classify paleontological resource areas according to their potential for containing vertebrate fossils, or noteworthy occurrences of invertebrate or plant fossils. This classification system became the basis to analyze the magnitude of potential impacts from construction in the region of influence of the Caliente and Mina rail alignments.

DOE determined that there are no known paleontological resources along any of the Caliente or Mina rail alignments or at the proposed locations of railroad construction and operations support facilities. Therefore, the Department does not anticipate any impacts to paleontological resources during the construction or operations phase along either alignment. However, if DOE uncovered previously unknown paleontological resources during construction activities, the Department would consult with the Bureau of Land Management to develop appropriate conservation measures.

Under the Shared-Use Option for either rail alignment, impacts to paleontological resources would be similar to those for the Proposed Action without shared use.

6.4.1.5 Surface-Water Resources

The region of influence for surface-water resources would be limited in most cases to the nominal width of construction right-of-way within the Caliente or Mina rail alignment. Railroad construction and operations along either rail alignment would potentially result in both direct and *indirect impacts* to surface-water resources. Many of these impacts are common impacts that would occur along the entire length of the alignment. *Direct impacts* would include temporary or permanent grading, dredging, rerouting, or filling of surface-water resources. Indirect impacts would include potential increases in surface flow and non-point source pollution resulting from runoff from areas where surface grades and characteristics would be changed.

DOE anticipates that during the construction phase of the Caliente or Mina rail alignment, channelization of natural drainage features would be required. Changes in drainage patterns could result in changes in erosion and sedimentation rates or locations. However, in all instances where the alignment would come close to or cross a surface-water feature, impacts would be substantially minimized by the implementation of engineering design standards and best management practices. The long-term (permanent) direct impacts to wetlands would be mitigated through onsite or offsite mitigation. DOE would develop a compensatory mitigation and monitoring plan for unavoidable impacts as part of its compliance with Section 404 of the *Clean Water Act*.

The Caliente alternative segment is adjacent to *wetlands* and some wetland fill would be unavoidable. DOE proposes to construct the Caliente alternative segment over the abandoned Union Pacific Railroad roadbed, in part to minimize filling wetlands. DOE would further avoid wetlands in the bottom of incised washes adjacent to the roadbed by shifting the roadbed away from the edge of the washes. New bridges would be constructed to span adjacent stream channels and avoid wetland areas. In addition, where the new rail roadbed crossed wetlands and other surface water features, DOE would avoid wetlands by increasing the slope and not constructing a permanent service road adjacent to the track through wetlands. The new rail roadbed would have a reduced footprint with a maximum width of about 17 meters (55 feet). Of the 0.096 square kilometer (23.8 acres) of wetlands delineated within the construction right-of-way, only 0.029 square kilometer (7.1 acres) would be filled to construct the rail line.

There are two options for siting the Staging Yard along the Caliente alternative segment. One option, the Indian Cove Staging Yard, would be constructed in a pasture located north of the City of Caliente. Construction of the Staging Yard in this area would require the wetlands to be filled above the level of the floodplain. It could also require an active drainage system and a channel around the eastern edge of the site to keep the area dry and in a stable condition. Approximately 0.19 square kilometer (47 acres) of wetlands would be filled for construction of the Staging Yard at Indian Cove near Caliente. These actions would require compliance with Section 404 of the Clean Water Act.

The second option (DOE's preferred option), the Upland site of the Staging Yard, is within and adjacent to an agricultural field in Meadow Valley. There is an isolated wetland immediately to the west of the Upland site, in a swale adjacent to the abandoned rail roadbed. DOE would avoid filling this wetland by constructing the staging yard to the west of the abandoned rail roadbed; therefore, no fill of wetlands or other waters of the United States would be required and there would be no impacts to wetlands from construction of the Staging Yard at the Upland site.

DOE identified two possible locations where ballast from quarry CA-8B could be loaded onto ballast trains, which would depend upon the location of the staging yard. If DOE were to select the Indian Cove Staging Yard, ballast would be loaded at that yard. If DOE were to select the Upland Staging Yard, it would construct a quarry siding immediately south of Beaver Dam Road and to the east of the mainline track. The total area of wetlands within the site is estimated to be 0.006 square kilometers (1.59 acres).

The Eccles alternative segment Interchange Yard would require portions of Clover Creek to be filled to elevate the site out of the floodplain. For a length of approximately 1,400 meters (4,600 feet) along the bed of this ephemeral creek (for construction of the interchange tracks), the fill would extend approximately 7.6 to 15 meters (25 to 50 feet) into the creek bed. For a length of approximately 900 meters (2,900 feet) on the east end and 600 meters (2,000 feet) on the west end of the interchange tracks (for construction of the interchange siding), the fill would extend approximately 8 meters (25 feet) into the creek. The total area that would be filled within the confines of Clover Creek would be approximately 0.033 to 0.042 square kilometer (8.2 to 11 acres), depending on the width of the fill.

Channelizing the creek bank and filling the creek bed could affect the velocity, sedimentation rates, and other hydraulic properties of the wash and could indirectly impact downstream riparian areas and associated wetlands, including the proposed Lower Meadow Valley Wash Area of Critical Environmental Concern. It could also impact riparian restoration efforts in Clover Creek required by the EPA.

Along the Mina rail alignment, there could be temporary impacts from disturbance of about 2,000 square meters (0.55 acre) of wetlands along Schurz alternative segments 1 and 4, and 3,000 square meters (0.73 acre) of wetlands along Schurz alternative segments 5 and 6 during construction of a bridge at the rail line crossing of the Walker River. Permanent fill or loss of wetlands would total about 20 square meters (0.005 acre) for Schurz alternative segments 1 and 4, or 28 square meters (0.007 acre) for emplacement of about 14 piers for Schurz alternative segments 5 and 6.

While some changes would be unavoidable, DOE would take steps to ensure the alterations to natural drainage, sedimentation, and erosion processes would not increase future flood damage, increase the impact of floods on human health and safety, or cause identifiable harm to the function and values of floodplains. The Department would implement best management practices, including erosion control measures such as the use of silt fences and flow-control devices to reduce flow velocities and minimize erosion.

6.4.1.6 Groundwater Resources

The generally dry climate characterizing the southern Nevada region is consistent with a lack of shallow *groundwater* underlying much of the length of the Caliente and Mina rail alignments. The region of influence for groundwater resources includes portions of the *aquifers* that would be affected by groundwater withdrawals DOE would make to obtain the water needed for railroad construction and operations. Groundwater resource features evaluated through impacts analysis include existing wells and nearby springs, seeps, and other surface-water-right locations (if present within the region of influence and potentially in hydraulic connection with proposed withdrawal well water-bearing zones). In a 1-mile (1.6-kilometer) region of influence surrounding the proposed Caliente rail alignment region of influence, groundwater withdrawals for domestic and irrigation purposes currently represent most of the groundwater use. In a 1-mile region of influence surrounding the Mina rail alignment region of influence, public supply-municipal, agricultural (stock watering), and mining and milling-related groundwater withdrawals currently represent most of the groundwater use.

To supply the approximately 7.5 billion cubic meters (6,100 acre-feet) of water needed during the construction phase along the Caliente rail alignment, DOE estimates that it would need to install approximately 150 to 176 new wells. To supply the approximately 7.4 billion cubic meters (5,950 acre-feet) of water needed during the construction phase along the Mina rail alignment, DOE estimates that it would need to install between approximately 77 and 110 new wells.

DOE analyses indicated that the effects of groundwater withdrawals from the proposed water-supply wells at the range of production rates that could be required to support a 4-year construction phase along either rail alignment would be localized in nature and extent, and hydrogeologic effects would be temporary. DOE determined that the short-term impacts caused by water withdrawals would be a series of localized drawdown cones of depression within the host aquifer surrounding each pumped well. DOE does not anticipate that proposed groundwater withdrawals would conflict with known regional or local aquifer management plans or the goals of governmental water authorities, and expects that the likelihood of impacts from groundwater withdrawals occurring to downgradient groundwater basins (or *hydrographic areas*) would tend to be low. DOE expects that impacts to ground subsidence or groundwater quality that could result from railroad construction and operations along either rail alignment would be small.

Groundwater withdrawals from hydrographic basin 227A, where the regions of influence for the railroad and repository overlap, would be approximately 333,000 cubic meters (270 acre-feet) during the first year of construction, 311,000 cubic meters (252 acre-feet) during the second year, 37,000 cubic meters (30 acre-feet) during the third year, and 25,000 cubic meters (20 acre-feet) during the final year of construction. Groundwater withdrawal rates for permanent water wells to support rail sidings and railroad operations facilities would be very low [less than 4 liters (1 gallon) per minute of the permanent water wells to approximately 26 liters (7 gallons) per minute]. Groundwater withdrawals from hydrographic basin 227A during operations of the railroad would be approximately 7,400 cubic meters (6 acre-feet) per year, and would commence about 1 year after repository construction began.

DOE anticipates that the impact to groundwater resources from contaminants that might be released by construction equipment during the construction phase or during railroad operations would be small because of generally deep groundwater beneath most of the Caliente and Mina rail alignments.

Railroad operations along the Mina and Caliente rail alignments would result in small potential impacts to groundwater resources. The Department would discontinue operating most of the wells needed following the railroad construction phase because there would not be a continued need for large-scale water withdrawals to support railroad operations. Additionally, groundwater withdrawal rates for those wells left in place to support railroad operations would be expected to be very low.

Overall, water demands for railroad construction and operations along the Caliente or the Mina rail alignment would represent a small portion of current water use amounts in their respective regions of influence. Existing groundwater uses within a 1-mile (1.6-kilometer) region of influence would likely continue to be dominated by domestic and irrigation withdrawals for the Caliente rail alignment, and by public-supply/municipal agricultural, and mining and milling withdrawals for the Mina rail alignment, with possibly increasing urban use from water transfers to the Las Vegas area (Caliente alignment).

Under the Shared-Use Option for either rail alignment, commercial-only facilities would require water for daily operation. The additional impacts to groundwater resources would be small, and overall would be similar to those described for the Proposed Action without shared use.

6.4.1.7 Biological Resources

DOE considered two areas of assessment in analyzing the *affected environment* for biological resources: a region of influence consisting of the nominal width of the construction right-of-way and a larger study area consisting of a 16-kilometer (10-mile)-wide area extending 8 kilometers (5 miles) on either side of the centerline of the rail alignment to ensure the identification of sensitive *habitat* areas and transient or migratory wildlife. The Caliente and Mina rail alignments are situated within the “cold” *Great Basin* Desert that covers most of central and northern Nevada and the “hot” Mojave Desert that covers most of southern Nevada and much of southeastern California. Although the two deserts are distinguished climatically, they are also distinguished by their predominant vegetation and vegetation communities.

For both the Caliente rail alignment and the Mina rail alignment, DOE determined that there would be some indirect adverse impacts due to the potential for the introduction and spread of noxious and invasive weed species during construction activities; however, the Department would minimize or avoid impacts through implementation of best management practices and Bureau of Land Management-prescribed methods. DOE concluded that there would be a small mostly short-term indirect impact to game species during railroad construction and operations along either rail alignment, due to temporary displacement causing pressure on other areas for habitat and forage. There could be small direct impacts due to a small loss of forage from the removal of vegetation to construct the proposed railroad. In addition, railroad operations could result in possible wildlife collisions with trains and disturbance from noise caused by passing trains. However, these impacts would not affect the viability of any game species' population.

DOE determined that federally listed species potentially present along the Caliente and Mina rail alignments could include the Mojave population of the desert tortoise, the southwestern willow flycatcher, the yellow-billed cuckoo, the Lahontan cutthroat trout, and the Ute ladies' tresses orchid. There would likely be small short-term indirect impacts to some Bureau of Land Management and State of Nevada special-status animal species because they might avoid the area of the rail alignment or be displaced during construction activities. Any potential direct impact would be due to habitat fragmentation and disturbance and possible injury or loss of individuals of a species from collision with trains. There could be indirect impacts on small mammals as a result of possible changes to predator-prey interactions due to the construction of towers and other structures that would provide new perch habitat for raptors and other predatory birds. DOE determined that potential impacts from noise disturbance to migratory birds would be small and short-term during construction and small from permanent habitat loss during operations. Potential direct impacts to the desert tortoise would be due to fragmentation of habitat and the possible crushing of occupied burrows during construction of common segment 6 and the Rail Equipment Maintenance Yard. Although these losses would be a small decrease in the number if individual tortoises in the vicinity of the railroad, long-term survival of this species would not be affected. For both the Caliente and Mina rail alignments, DOE determined that impacts to herd management areas and potential impacts to individual wild horses or burros would be small and would not significantly affect the management strategies utilized within the herd management areas.

DOE anticipates that for the Caliente rail alignment there would be short-term and long-term impacts to wetlands and riparian habitats from construction of the Caliente alternative segment, either of the potential Staging Yard locations (Indian Cove and Upland), and the Eccles alternative segment. Impacts from constructing the Caliente alternative segment would be mostly short-term and small, because the rail line would be constructed over an abandoned rail roadbed and limited to existing bridge crossings that would require modifications. The Eccles alternative segment would result in a small short-term impact to riparian habitat and would be limited to bridge construction over Meadow Valley Wash. Construction of the Indian Cove Staging Yard could result in a moderate impact in comparison with the Upland Option due to topographic constraints that could require possible draining and filling of the wetland. The proposed Eccles Interchange Yard could result in mostly small direct short-term impacts due to a small loss of riparian vegetation and small short-term indirect impacts with the potential for change in stream flow and increase in sedimentation. DOE determined there would be a moderate impact to wildlife habitat along Garden Valley alternative segments 1 and 3. Localized and minor loss of roosting and foraging habitat for the southwestern willow flycatcher and western yellow-billed cuckoo could occur from construction of the Caliente alternative segment; however, because these species do not nest along the alignment, impacts would be small and limited to transient individuals.

DOE determined that for the Mina rail alignment there would be direct short-term impacts to riparian vegetation from construction of Schurz alternative segment 1, 4, 5, or 6 due to bridge construction over the Walker River. There would be no long-term impacts on riparian vegetation along the Walker River as a result of constructing any of the Schurz alternative segments. There would be short-term moderate impacts to wildlife habitat at the potential Malpais Mesa quarry site. Construction of the Walker River Bridge for Schurz alternative segments 1, 4, 5, or 6 could result in a moderate short-term indirect impact on Lahontan cutthroat trout; however, DOE could mitigate any anticipated impact.

Under the Shared-Use Option, there would be more train traffic; therefore, DOE anticipates wildlife interactions with train traffic (collisions, change in movement patterns, altered behavior, and nest abandonment) would be slightly increased. Nevertheless, DOE anticipates that this slight increase in train traffic would result in small impacts to the wildlife communities. The existing rail alignment design could accommodate shared use with little additional construction (a few sidings), and the Department does not anticipate additional impacts from shared use above those discussed.

6.4.1.8 Cultural Resources

The region of influence for cultural resources includes the construction right-of-way (the area of potential direct and indirect impacts) and a 3.2-kilometer (2-mile)-wide area centered on the rail alignment (the area of potential indirect impacts).

Because of the length of the proposed rail line along the Caliente and Mina rail alignments, DOE is using a phased cultural resource identification and evaluation approach, described in 36 CFR 800.4(b)2, to identify specific cultural resources. Under this approach, DOE would defer final intensive field surveys (known as Class III inventories) of the actual construction right-of-way, as provided in the Programmatic Agreement between DOE, the Bureau of Land Management, the Surface Transportation Board, and the Nevada State Historic Preservation Office. The Programmatic Agreement states that an appropriate level of field investigation—including on-the-ground intensive surveys, evaluations of all recorded resources listed on the *National Register of Historic Places*, assessments of adverse effects, and applicable mitigation of identified impacts—be completed before any ground-disturbing construction activities that could affect a specific resource could begin.

Railroad construction and operations could lead to unavoidable changes in cultural landscapes, such as changes to ethnographic, rural historic, and historic viewscapes. Cultural landscapes along the Caliente rail alignment include historic-period Western Shoshone villages and surrounding use areas in the Oasis Valley, the Goldfield area, and Stone Cabin and Reveille Valleys; early ranching operations in Stone Cabin and Reveille Valleys; the historic Mormon settlement of Meadow Valley Wash; and the Goldfield, Clifford, and Reveille Mining Districts. Cultural landscapes along the Mina rail alignment include historic-period Northern Paiute use of the Walker River and Walker Lake areas, historic period Western Shoshone villages and surrounding use areas in the Oasis Valley and Goldfield areas, and historic mining in the Luning, Mina, and Goldfield districts.

DOE completed literature reviews and a Class II inventory (sample field surveys within the construction right-of-way) for 20 percent of each alternative segment and common segment along the Caliente and Mina rail alignments and has thereby identified potential areas of specific impacts. In addition, DOE conducted an intensive Class III inventory along a 12-kilometer (7.4-mile) corridor within the *Yucca*

Mountain site boundary, which resulted in the identification of seven sites and five isolates (isolated artifacts).

Based on preliminary information and the sample surveys conducted to date, the magnitude of impacts along both the Caliente and Mina rail alignments would range from small to moderate due to the extensive effort DOE would undertake to avoid or mitigate impacts to cultural resources in accordance with the regulatory framework and with the terms of the cultural resources Programmatic Agreement.

Impacts to cultural resources under the Shared-Use Option for either the Caliente or Mina rail alignment would be approximately the same as those under the Proposed Action without shared use. However, construction of any additional commercial-use sidings would have the potential to affect cultural resources.

6.4.1.9 American Indian Interests

Based on information provided by the Consolidated Group of Tribes and Organizations, American Indians are concerned that substantial and high adverse effects to a number of American Indian interests could be caused within and adjacent to the Caliente rail alignment region of influence, which also encompasses the southern segments of the Mina rail alignment. The Consolidated Group of Tribes and Organizations is a forum consisting of officially appointed tribal representatives from 17 tribes and organizations who are responsible for presenting their respective tribal concerns and perspectives to DOE. At the time of discussions with the Consolidated Group of Tribes and Organizations, the Mina rail alignment was not under consideration as an implementing alternative and the views of the Northern Paiute peoples who traditionally occupied lands north of Goldfield and Tonopah are not presented by this group. As part of any Proposed Action, the Department would continue to consult with American Indian tribes with regard to their interests and beliefs.

The proposed Mina rail alignment would pass through and directly affect the Walker River Paiute Reservation. In a letter dated April 29, 2007, the Walker River Paiute Tribal Council officially informed the Department of their withdrawal from the *environmental impact statement* process. The Tribal Council made the decision to withdraw based on information obtained during the Tribe’s involvement with the Rail Alignment EIS process and input from Tribal members. The Tribe determined that the impacts and risks associated with nuclear shipments through the reservation were too great and they reaffirmed a past objection to the transportation by any means of nuclear or radioactive material through the reservation.

American Indian views on construction and operation of a railroad along the Caliente rail alignment, as primarily expressed by the Consolidated Group of Tribes and Organizations, state that construction and operation of the proposed railroad would constitute an intrusion on the traditional lands of Southern Paiute, Western Shoshone, and Owens Valley Paiute and Shoshone people; would disturb cultural, biological, botanical, geological, and hydrological resources, including American Indian viewscapes, songscapes, storyscapes, and traditional cultural properties; would restrict the free access of American Indian people to their resources; and could cause substantial and high adverse effects to a number of American Indian interests within and adjacent to the region of influence. Within that forum of beliefs there would be an unavoidable impact to American Indian interests.

6.4.1.10 Socioeconomics

DOE assessed impacts to socioeconomic conditions in relation to population, housing, employment and income, and public service over the region of influence for the Caliente rail alignment in Lincoln, Esmeralda, Nye, and Clark counties, and over the region of influence for the Mina rail alignment in Churchill, Lyon, Mineral, Nye, Esmeralda, and Clark counties, the combined area of Washoe County and Carson City, and the Walker River Paiute Reservation.

The social and economic activities and changes associated with railroad construction along either rail alignment would include a brief elevation in project-related employment, increases in *real disposable income*, increases in state and local spending, increases in *Gross Regional Product*, population increases, slower rate of growth in the level of employment as railroad project activities moved from construction to operations, and possible small stresses on transportation including small traffic-delay impacts on road traffic at grade crossings. The percentage values of such changes would be low, as reported in Chapter 2, Table 2-3 of this Repository SEIS, and DOE has assessed such impacts to be generally small.

Changes associated with the railroad operations along either rail alignment would include increases in project-related employment (particularly associated with railroad facilities), slight population increases, possible small stresses on transportation, including small traffic-delay impacts on road traffic at grade crossings, some pressure on housing, and possible strains on public services (for example, schools, health care, and fire protection) in southern Nye County where the Cask Maintenance Facility, Rail Equipment Maintenance Yard, and possibly the Nevada Railroad Control Center and the National Transportation Operations Center would be located. The percentage values of such changes would be low, as shown in Chapter 2, Table 2-3. DOE has assessed such impacts to be generally small to moderate.

Under the Shared-Use Option for either rail alignment, there would be little increase in impacts beyond those described for the Proposed Action without shared use. Based on the lengths of track involved under the Shared-Use Option, the incremental impacts to traffic from constructing the additional sidings would be a small fraction of the overall impacts for rail line construction under the Proposed Action without shared use. Thus, impacts to the transportation *infrastructure* under the Shared-Use Option would be small. Traffic-delay impacts at highway-rail grade crossings from construction trains would be consistent with the delay impacts under the Proposed Action without shared use. These impacts would be small.

6.4.1.11 Occupational and Public Health and Safety

6.4.1.11.1 *Caliente and Mina Rail Corridors*

Nonradiological Impacts

DOE estimated nonradiological occupational health and safety impacts in relation to worker exposures to physical hazards and nonradioactive hazardous chemicals during the construction phase. DOE based these estimates on the number of hours worked and occupational incident rates for *total recordable cases*, *lost workday cases*, and fatalities.

Construction and operations workers could be exposed to physical hazards and to nonradiological hazardous chemicals related to operation and maintenance of construction equipment, rail line equipment, and facility equipment, including maintenance of casks and maintenance-of-way activities, which would include welding, metal degreasing, painting, and related activities. Occupational health and safety impacts could also result from worker exposure to fuels, lubricants, and other materials used in railroad construction, operation, and maintenance.

The recorded incident rates of these exposure hazards during construction work at the Yucca Mountain site have been small and are anticipated to be small for railroad construction and operations. Dust and soils hazards include potential occupational exposure to hazardous inhalable dust. However, occupational impacts associated with exposure to dust would be expected to be small. DOE would implement measures, such as processing and engineering controls, to reduce exposure to dust. Impacts to construction or operations workers from unexploded ordnance would be small due to implementation of inspection procedures and mitigation measures. Workers might also be exposed to biological hazards including infectious diseases (such as Hantavirus or West Nile Virus) and other biological hazards (such as venomous animals). The recorded incident rates of these biological hazards are small, and DOE would expect small impacts to construction or operations workers from these biological hazards.

DOE used both qualitative and *quantitative* components to estimate transportation accident incidents and potential fatalities resulting from vehicular and train accidents.

DOE estimated the following:

- During the construction phase, along both the Caliente rail alignment and the Mina rail alignment, there would be 6 vehicle-related fatalities.

- During the operations phase along the Caliente rail alignment, there would be 8 vehicle-related fatalities; along the Mina rail alignment, there would be 7 vehicle-related fatalities.

- During railroad construction and operations along the Caliente and Mina rail alignments, modeling indicates that there would be 16 rail-related accidents and approximately 1 rail-related fatality.

For the Shared-Use Option, DOE estimated the following:

- During the operations phase along the Caliente rail alignment, there would be 8 vehicle-related fatalities; along the Mina rail alignment, there would be 7 vehicle-related fatalities.

- During the operations phase along the Caliente rail alignment, there would be 26 rail-related accidents and 4 rail-related fatalities; along the Mina rail alignment, there would be 36 rail-related accidents and 7 rail-related fatalities.

- Nonradiological fatality impacts to workers from industrial hazards from railroad and facility construction and operations along the Caliente rail alignment would be approximately 3, and for the Mina rail alignment would be approximately 2.

Radiological Impacts

DOE estimated radiological impacts to workers and the public for incident-free transportation, the risk from transportation accidents, and the consequences of severe transportation accidents. The region of influence for radiological impacts to members of the public during incident-free transportation includes the area 0.8 kilometer (0.5 mile) on either side of the centerline of the rail alignments. The region of influence for occupational radiological impacts during incident-free operation includes the physical boundaries of railroad operations support facilities. For radiological accidents, the populations within the region of influence are based on the population within 80 kilometers (50 miles) on either side of the centerlines of the rail alignments.

DOE estimated the following:

- For workers, the radiological impacts were estimated to be 0.34 latent cancer fatality for the Caliente rail alignment and 0.35 latent cancer fatality for the Mina rail alignment.

- For workers at the Cask Maintenance Facility, the radiological impacts were estimated to be 0.43 latent cancer fatality. For workers at the Rail Equipment Maintenance Yard, the radiological impacts were estimated to be 0.0096 latent cancer fatality.

- For members of the public, the radiological impacts were estimated to be 1.4×10^{-4} latent cancer fatality for the Caliente rail alignment and 8.5×10^{-4} latent cancer fatality for the Mina rail alignment.

- For members of the public, the radiological impacts from the Cask Maintenance Facility were estimated to be 7.0×10^{-6} latent cancer fatality.

- The risk from transportation accidents was estimated to be 1.3×10^{-6} latent cancer fatality for the Caliente rail alignment and 7.7×10^{-6} latent cancer fatality for the Mina rail alignment.

- The consequences of the maximum reasonably foreseeable accident were estimated to be 0.0012 latent cancer fatality in rural areas and 0.46 latent cancer fatality in suburban areas along the Caliente rail alignment, and 0.0089 latent cancer fatality in rural areas and 1.2 latent cancer fatalities in suburban areas along the Mina rail alignment. The frequency of this severe accident ranged from 6×10^{-7} to 7×10^{-7} per year.

Sabotage

In response to the terrorist attacks of September 11, 2001, and to intelligence information that has been obtained since then, the United States Government has initiated nationwide measures to reduce the threat of sabotage. These measures include security enhancements intended to prevent terrorists from gaining control of commercial aircraft and additional measures imposed on foreign passenger carriers and domestic and foreign cargo carriers, as well as charter aircraft.

The Federal Government has also greatly improved the sharing of intelligence information and the coordination of response actions among federal, state, and local agencies. DOE has been an active participant in these efforts. In addition to its domestic efforts, DOE is a member of the International Working Group on Sabotage for Transport and Storage Casks, which is investigating the consequences of sabotage events and exploring opportunities to enhance the physical protection of casks.

The Department, as required by the *Nuclear Waste Policy Act*, would use transportation casks certified by the NRC. Spent nuclear fuel is protected by the robust metal structure of the transportation cask, and by cladding that surrounds the fuel pellets in each fuel rod of an assembly. Further, the fuel is in a solid form, which would tend to reduce dispersion of radioactive particulates beyond the immediate vicinity of the cask, even if a sabotage event were to result in a breach of the multiple layers of protection.

In addition, the NRC has promulgated rules (10 CFR 73.37) and interim compensatory measures (67 FR 63167, October 10, 2002) specifically to protect the public from harm that could result from sabotage of spent nuclear fuel casks. The Department has committed to following these rules and measures (see 69 FR 18557, April 8, 2004).

For the reasons stated above, DOE believes that under general credible threat conditions the probability of a sabotage event that would result in a major radiological release would be low. Nevertheless, because of the uncertainty inherent in the assessment of the likelihood of a sabotage event, DOE has evaluated events in which a military jet or commercial airliner would crash into a spent nuclear fuel cask or a modern weapon (a high-energy-density device) would penetrate a spent nuclear fuel cask.

In the Yucca Mountain FEIS (DIRS 155970-DOE 2002, Appendix J, Section J.3.3.1), DOE evaluated the ability of large aircraft parts to penetrate transportation casks and found that neither the engines nor shafts would penetrate a cask and cause a release of radiological materials if an aircraft were to crash into a spent nuclear fuel cask. Further analysis determined that if the impact and resultant fire caused a cask seal to fail, little radiation would escape and there would be less than 0.65 latent cancer fatality in the affected urban population. In the rural and suburban areas along the Caliente or Mina rail alignments, the impacts would be even lower. In the FEIS, DOE estimated the potential impacts of a sabotage event in which a high-energy-density device penetrates a rail cask. For the Rail Alignment EIS, DOE obtained more recent estimates of the fraction of spent nuclear fuel materials that would be released (release fractions) (DIRS 181279-Luna 2006, all). Based on the more recent information DOE estimated that there would be 0.0028 latent cancer fatality in rural areas and 1.1 latent cancer fatalities in suburban areas along the Caliente rail alignment, and 0.021 latent cancer fatality in rural areas and 2.8 latent cancer fatalities in suburban areas along the Mina rail alignment.

DOE also used both qualitative and quantitative components to estimate transportation accident incidents and potential fatalities resulting from vehicular and train accidents.

6.4.1.11.2 *Other Nevada Transportation Impacts*

In addition to the impacts from constructing, operating, and closing a rail line within Nevada, there would also be transportation-related impacts from truck shipments of spent nuclear fuel and high-level radioactive waste within Nevada. For these shipments, DOE estimated the following:

- The number of latent cancer fatalities to workers from radiological impacts during the operations period would be 0.057 (about 1 chance in 20).
- The number of latent cancer fatalities to the public from radiological impacts during the operations period would be 0.012 (about 1 chance in 80).
- The number of fatalities from exposure to vehicle emissions would be 0.0046 (about 1 chance in 200).
- The radiological risk from transportation accidents would be 1.9×10^{-6} latent cancer fatality (about 1 chance in 500,000).
- The number of nonradiological traffic fatalities would be 0.050 (1 chance in 20).

- The total number of radiological and nonradiological fatalities from truck shipments of spent nuclear fuel and high-level radioactive waste within Nevada would be 0.12 (about 1 chance in 8).

Within Nevada, there would also be transportation-related impacts from rail shipments from the Nevada border to the beginning of the Caliente or Mina rail corridors. These impacts are not included in the estimates of impacts for the Caliente and Mina rail corridors but are included in the national impacts presented in Section 6.3 of this Repository SEIS.

Table 6-15 lists the impacts for maximally exposed workers and members of the public from transporting spent nuclear fuel and high-level radioactive waste in Nevada for both rail and truck shipments. Among workers, escorts and inspectors would receive the highest estimated radiation doses, in large part because of their proximity to casks and the amount of time they would be exposed. The maximally exposed worker would receive an estimated radiation dose of 25 rem over as many as 50 years of repository operations, based on a 500-millirem-per-year administrative dose limit (DIRS 174942-BSC 2005, Section 4.9.3.3). The probability of a latent cancer fatality for this worker is 0.015 or about 1 chance in 70.

Table 6-15. Estimated radiation doses for maximally exposed workers and members of the public from Nevada transportation.[a]

Category	Dose (rem)	Probability of LCFs
Workers		
Escorts and inspectors	25[b]	0.015
Railyard crew member	4.8	0.0029
Truck inspector	11	0.0065
Worker at maintenance-of-way trackside facility	0.00088	0.00000053
Worker located at siding	0.00013 – 0.00051	0.000000077 – 0.00000030
Public		
Resident along rail route at 18 meters (60 feet)	0.0078	0.0000047
Other individuals near the rail route in Las Vegas[c]		
Individual at 15 meters (49 feet)	0.00075	0.00000045
Individual at 20 meters (66 feet)	0.00055	0.00000033
Individual at 30 meters (98 feet)	0.00035	0.00000021
Individual at 35 meters (110 feet)	0.00029	0.00000018
Individual at 40 meters (130 feet)	0.00024	0.00000015
Individual at 100 meters (330 feet)	0.000067	0.000000040
Individual at 160 meters (520 feet)	0.000029	0.000000017
Other individuals near the rail route in Reno (Reno trench)	0.0049	0.0000029
Individual along U.S. Highway 95 in Indian Springs	0.0011	0.00000064
Person in traffic jam	0.016	0.0000096
Person at service station	0.21	0.00013
Person near Staging Yard		
Caliente-Indian Cove	0.0000030	0.0000000018
Caliente-Upland	0.0027	0.0000016
Eccles-North	0.0000034	0.0000000021
Mina-Hawthorne	0.00018	0.00000011

a. Impacts are for the entire 50-year shipping period.
b. Based on a 500-millirem-per-year administrative dose limit.
c. Locations identified by the Nevada Agency for Nuclear Projects (DIRS 158452-Nevada Agency for Nuclear Projects 2002, p. 123).
LCF = Latent cancer fatality.

Members of the public would receive lower estimated radiation doses than workers from incident-free transportation because they would not be as close to the casks as workers and would not be exposed for as long as workers. The member of the public with the highest estimated individual radiation dose would be a service station attendant who refueled the trucks during shipments of spent nuclear fuel and high-level radioactive waste. Using assumptions that tend to overstate the risks, the same person would refuel about 600 trucks and receive an estimated radiation dose of 0.21 rem over as many as 50 years of shipments. Using these assumptions, the probability of a latent cancer fatality for this individual is 0.00013, or about 1 chance in 8,000.

The impacts of severe transportation accidents involving rail shipments of spent nuclear fuel and high-level radioactive waste within Nevada would be similar to the impacts estimated in Section 6.3.3.2 of this Repository SEIS and in Sections 4.2.10 and 4.3.10 of the Rail Alignment EIS. The impacts of severe transportation accidents involving truck shipments of spent nuclear fuel and high-level radioactive waste within Nevada would be less than those involving rail shipments. In addition, the impacts of transportation sabotage events involving truck and rail shipments of spent nuclear fuel and high-level radioactive waste would be similar to the impacts estimated in Section 6.3.4 of this Repository SEIS and in Sections 4.2.10 and 4.3.10 of the Rail Alignment EIS.

6.4.1.12 Noise and Vibration

DOE analyzed potential impacts from noise based on current *ambient* noise levels, noise modeling for future activities (proposed railroad construction and operations), and identification of changes in noise levels at noise-sensitive receptors (such as residences, schools, libraries, retirement communities, nursing homes) within the regions of influence. The region of influence for noise and vibration for construction and operations of the railroad along either the Caliente or the Mina rail alignment includes the construction right-of-way and extends out to variable distances along each rail alignment (depending on several factors, including the number of trains per day, ambient noise level, train speed, and number of railcars).

For operation of trains during the construction and operations phases, DOE analyzed noise impacts under established Surface Transportation Board criteria (a noise level of 65-dBA *day-night average sound level* or greater, with a 3-dBA or greater increase from the baseline). For noise impacts from construction activities, DOE used U.S. Department of Transportation, Federal Transit Administration, methods and construction noise guidelines. To evaluate potential vibration impacts from construction and operation activities, DOE used Federal Transit Administration building vibration damage and human annoyance criteria.

DOE determined that railroad construction and operations along the Caliente rail alignment would lead to an unavoidable increase in ambient noise from construction activities and passing trains. Noise from trains might be noticeable as new noise in residential areas near the rail line in Caliente and Goldfield. Because there is already a substantial amount of train activity in Caliente, additional train noise would be less noticeable than in other areas where there is currently no train activity and no train noise. For construction activities, noise levels in Caliente would be higher than Federal Transit Administration construction noise guidelines and would result in a temporary unavoidable impact. Train noise during the construction phase would cause 34 receptors to be adversely impacted. These would be temporary adverse impacts because of the temporary nature of the construction phase. During the operation phase, three receptors would be adversely impacted by train noise. For these receptors, DOE would consider mitigation, such as the development of a Quiet Zone, stationary warning horns, or building sound insulation treatments. A Quiet Zone refers to specific grade crossings that have sufficiently upgraded safety measures such that locomotive warning horns do not have to be sounded.

DOE determined that railroad construction and operations along the Mina rail alignment could lead to an unavoidable increase in ambient noise from passing trains in areas of Nevada that are mostly uninhabited. Noise from trains might be noticeable as new noise in residential areas near the rail line in Silver Springs, Silver Peak, Mina, and Goldfield. Because there is already some train activity in Silver Springs, additional train noise would be less noticeable there than in other areas where there is currently no train activity and no train noise. Construction of any of the Schurz alternative segments would eliminate future noise and vibration associated with operation of the existing Department of Defense Branchline through Schurz. However, there would be construction noise associated with removal of this existing rail line, although this noise would be temporary and no adverse impact would be expected.. For construction activities, noise levels along the Mina rail alignment would be lower than Federal Transit Administration construction noise guidelines. For train noise during the construction phase, there would be temporary adverse impacts at receptors in Silver Springs. For train noise during the operations phase, estimated noise levels at eight receptors in Silver Springs and one in Wabuska would be higher than impact criteria; therefore, there would be adverse impacts from noise associated with railroad operations at those locations. However, DOE would investigate mitigation methods for these nine locations. Mitigation methods could include building sound insulation, stationary warning horns, or the development of a Quiet Zone, which would allow the rail operator to reduce horn noise at specific crossings.

During the construction and operations phases along either the Caliente or Mina rail alignment, vibration levels would not exceed the Federal Transit Administration damage criteria for extremely fragile historic buildings. Therefore, DOE would expect no building damage due to vibration. In addition, train-generated vibration levels would be lower than Federal Transit Administration human annoyance criterion.

Under the Shared-Use Option for either rail alignment, increased rail traffic could result in noise impacts similar to the impacts described for the Caliente and Mina rail alignments without shared use. Increased operations would not affect vibration impacts because vibration is evaluated on a maximum-level basis only.

6.4.1.13 Aesthetic Resources

DOE considered the region of influence for aesthetic resources as the viewshed around all *common segments*, alternative segments, and facilities along the Caliente and Mina rail alignments. To ensure that seldom-seen views were included in this analysis, DOE used a conservative region of influence extending 40 kilometers (25 miles) on either side of the centerline of all common segments and alternative segments, and around facilities. Most of the lands that would be affected by the Proposed Action are Bureau of Land Management-administered public lands, including those on which the proposed railroad would be constructed. For this reason, DOE used Bureau of Land Management visual resource management classifications and contrast rating methodologies to evaluate aesthetic impacts to the surrounding viewshed. The Bureau of Land Management assigns visual resource management classes to lands under its jurisdiction, based on scenic quality and other factors, that range from Class I to Class IV, with Class I representing the highest visual values. Each class comes with specific visual resource management objectives that indicate the levels of project-related contrast that are acceptable. In this analysis, the primary basis for identifying potential adverse impacts to aesthetic resources was inconsistency with these Bureau of Land Management visual resource management objectives. The Department assessed the potential visual contrast between existing conditions and conditions expected during the project from key locations and compared these levels of contrast with the visual resource management objectives associated with the Bureau of Land Management classifications of the surrounding viewshed.

Along both the Caliente and the Mina rail alignments, DOE found that the contrast that would be caused by the rail line and support facilities would remain consistent with Bureau of Land Management visual resource management objectives during the operations phase, but could be inconsistent in certain locations during the construction phase. Along the Caliente rail alignment, a conveyor crossing of U.S. Highway 93 near the Caliente-Indian Cove or Caliente-Upland location of the Staging Yard, the northern portion of the Caliente-Indian Cove Staging Yard, and along some portions of Garden Valley alternative segments 1, 2, 3, and 8, construction would temporarily not meet Bureau of Land Management visual resource management objectives for the surrounding Class II or III lands.

Along the Mina rail alignment, DOE determined that construction of Schurz alternative segment 6 crossing of U.S. Highway 95 on the Walker River Paiute Reservation would temporarily not meet Bureau of Land Management objectives for Class III areas.

Overall, DOE anticipates that short-term visual impacts during the construction phase would range from small to large, and long-term impacts during the operations phase would range from small to large, without mitigation, and would be consistent with applicable Bureau of Land Management visual resource management objectives.

Impacts to aesthetic resources during the construction phase under the Shared-Use Option would generally be the same as those under the Proposed Action without shared use. Construction of additional sidings would create small impacts to the visual setting because of the short duration of construction. Impacts to aesthetic resources during the construction phase under the Shared-Use Option for both the Caliente and Mina rail alignments would be generally the same as those under the Proposed Action without shared use. Construction of additional sidings would create small impacts to the visual setting because of the short duration of construction.

6.4.1.14 Utilities, Energy, and Materials

The Caliente rail alignment region of influence for public water systems and wastewater transported offsite for treatment and *disposal* is Lincoln, Nye, and Esmeralda counties. The Mina rail alignment region of influence for public water systems and wastewater transported offsite for treatment and disposal is Lyon, Mineral, Esmeralda, and Nye counties, and the Walker River Paiute Reservation, the bulk of which lies in Mineral County with smaller portions in Churchill and Lyon counties. The region of influence for telecommunications and electricity is limited to the companies that service the aforementioned counties. The region of influence for fossil fuels is limited to regional suppliers within the State of Nevada. The region of influence for construction materials is defined by the distribution networks and suppliers of that material to the general project area.

DOE determined that the demands placed on utilities, energy, and materials from constructing and operating the proposed rail line along either alignment would be met by existing supply capacities;

therefore, potential impacts would be small. Utility interfaces would have the potential for short-term interruption of service, but would experience no permanent or long-term loss of service or prevention of future service area expansions. Most water for construction along either rail alignment would be supplied by new wells, although public water systems could be slightly affected by population increases attributable to construction employees. Wastewater treatment systems would not be directly affected by construction activities because dedicated treatment systems would be provided at construction camps; however, there could be small impacts to wastewater treatment systems due to population increases attributable to construction employees. There would be very small impacts to telecommunications systems because, during the construction phase, DOE would utilize a dedicated telecommunications system and rely little on existing telecommunications systems.

Peak electricity demand would be within the capacity of regional providers. The demand for fossil fuels during construction would be approximately 6.5 percent and 6 percent of statewide use for the Caliente and Mina rail alignments, respectively, and could be met by existing regional supply systems and suppliers. During the operations phase, the demand for fossil fuels for either rail alignment would be less than 0.25 percent of statewide use. The primary materials that would be consumed during the construction phase would be steel; concrete, principally for rail ties, bridges, and drainage structures; and rock for ballast and subballast. DOE determined that ballast requirements for construction could be met with output from planned quarries along the rail lines and that subballast would be obtained from the materials excavated during rail roadbed construction or from crushing rock in quarries. DOE determined that other construction material requirements for the Caliente rail alignment and for the Mina rail alignment would be a small fraction of current production rates within the respective regions of influence.

Under the Shared-Use Option for either rail alignment, the incremental demands on utilities, energy, and materials for construction of commercial sidings and support facilities would be sufficiently small that the anticipated impacts on these resources would be effectively the same as those for the Proposed Action without shared use. Therefore, potential impacts to local, regional, or national suppliers of such resources under the Shared-Use Option along either rail alignment would be small.

Fossil-fuel requirements for transporting general freight under the Shared-Use Option would depend on the volume and distance of shared-use traffic. DOE estimated that the incremental annual diesel consumption for commercial shared-use traffic would be 5.5 million liters (1.5 million gallons), a rate that is less than 0.3 percent of current annual diesel fuel use in Nevada. Most, if not all, of this fuel consumption would be offset by diesel fuel that would otherwise be used if the goods or materials were shipped by truck. Therefore, the impact to the capacities of national and regional fuel producers and distributors under the Shared-Use Option would be small.

6.4.1.15 Hazardous Materials and Wastes

For both the Caliente and Mina rail alignments, the region of influence for the use of hazardous materials and the generation of hazardous and nonhazardous wastes includes the nominal width of the rail line construction right-of-way and the locations of railroad construction and operations support facilities; for the disposal of *hazardous wastes*, it includes the entire continental United States (commercial hazardous waste disposal vendors could utilize facilities throughout the country); and for the disposal of *low-level radioactive wastes*, it includes DOE low-level waste disposal sites, sites in Agreement States, and NRC-licensed sites. The region of influence for the disposal of nonhazardous waste for the Caliente rail alignment includes the disposal facilities in Lincoln, Nye, Esmeralda, and Clark counties, and for the Mina rail alignment includes the disposal facilities in Mineral, Nye, Esmeralda, and Clark counties.

During railroad construction and operations, DOE would store and use hazardous materials such as oil, gasoline, diesel fuel, and solvents, primarily for the operation, maintenance, and cleaning of equipment and facilities, which would result in the generation of associated hazardous wastes. During the railroad construction and operations phases, the Department would implement an Environmental Management System and a Pollution Prevention/Waste Minimization Program, which would include an evaluation of methods to eliminate, reduce, or minimize the amounts of hazardous materials used and hazardous wastes generated. Each year, during the course of construction, approximately 20 tons of hazardous waste would be generated, and a total of 82 tons over the entire construction phase. Ample disposal capacity is available for the disposal of hazardous waste during both the construction and operations phases. DOE would implement appropriate planning measures for the storage and handling of hazardous materials and comply with applicable regulations.

DOE would dispose of nonrecyclable or nonreusable waste in permitted landfills. During construction it is likely that, if utilized, some of the larger landfills would not see an appreciable change in the amount of waste received; however, some of the smaller landfills, if utilized, might see a substantial, although manageable, change in daily receipt of solid, industrial, and special wastes.

Construction of the proposed railroad along the Caliente rail alignment would raise the disposal rate of nonhazardous waste to landfills in the region of influence by about 0.15 percent. DOE anticipates that impacts to local landfills from the disposal of solid and industrial and special wastes would be small (for the relatively large Apex Landfill) to moderate (for the smaller landfills such as Goldfield Class I).

DOE estimates that railroad construction along the Mina rail alignment could generate three times the amount of industrial and special waste as would railroad construction along the Caliente rail alignment. This is because of wastes from dismantling the Department of Defense Branchline through the town of Schurz. However, to the extent practicable, these wastes would be recycled to minimize waste volumes. Construction of the proposed railroad along the Mina rail alignment would raise the disposal rate of nonhazardous waste to landfills in the region of influence by about 0.34 percent. DOE anticipates that impacts to local landfills from the disposal of solid and industrial and special wastes would be small (for the relatively large Apex Landfill) to moderate (for the smaller landfills such as Goldfield Class I).

During railroad operations along either the Caliente or Mina rail alignment, the generation of wastes would be substantially less than during the construction phase. DOE anticipates railroad operations along either alignment would produce similar amounts of wastes. Therefore, impacts to landfills during operations would be small because ample disposal capacity would be available for either rail alignment.

Activities at the Cask Maintenance Facility would generate from 3,200 to 7,900 cubic meters (113,000 to 280,000 cubic feet) of Class A low-level radioactive waste throughout the railroad operations phase. Site-generated, low-level radioactive waste would be controlled and disposed of in a DOE low-level waste disposal site, an Agreement State site, or in an NRC-licensed site subject to the completion of the appropriate review pursuant to the National Environmental Policy Act. Disposal in an Agreement State site or in an NRC-licensed site would be in accordance with applicable provisions of 10 CFR Part 20. DOE low-level radioactive waste disposal sites such as the Nevada Test Site, and commercial low-level radioactive waste disposal sites such as Energy Solutions Barnwell Operations in Barnwell, South

Carolina; U.S. Ecology in Richland, Washington; and Energy Solutions Clive Operations in Clive, Utah, all currently have ample capacity to accept these wastes. Therefore, impacts to low-level radioactive waste disposal facilities would be small. For comparison, the total amount of waste estimated to be generated throughout the operations phase accounts for only about 6 percent of the low-level waste disposed of in 2005 at commercial low-level waste facilities nationwide (DIRS 182320-NRC 2007, all). No low-level radioactive waste is anticipated to be generated during construction activities; therefore, no impacts to disposal facilities would occur.

Under the Shared-Use Option for either rail alignment, waste characteristics, generation rates, and disposal requirements would increase only slightly; therefore, any additional adverse impacts associated with the Shared-Use Option would be small.

6.4.1.16 Environmental Justice

The region of influence for environmental justice encompasses the regions of influence for all other resource areas because impacts in other resource areas could result in environmental justice impacts.

DOE performed the analysis of potential environmental justice impacts in accordance with Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations*, Council on Environmental Quality guidance (DIRS 103162-CEQ 1997, all), and NRC policy. DOE followed the Council on Environmental Quality guidance to use the annual statistical poverty thresholds from the U.S. Bureau of the Census to identify low-income populations, and followed NRC's 2004 policy to identify low-income and minority populations. The policy states, in part:

> "Under current NRC [Nuclear Regulatory Commission] staff guidance, a minority or low-income community is identified by comparing the percentage of the minority or low-income population in the impacted area to the percentage of the minority or low-income population in the County (or Parish) and the State. If the percentage in the impacted area significantly exceeds that of the State or the County percentage for either the minority or low-income population then EJ [environmental justice] will be considered in greater detail. 'Significantly' is defined by staff guidance to be 20 percentage points. Alternatively, if either the minority or low-income population percentage in the impacted area exceeds 50 percent, EJ matters are considered in greater detail."

Following this policy, DOE identified low-income communities as those affected areas (by census block groups) where the percentage of people characterized as below the poverty threshold exceeded 31 percent, which is 20 percent above the state average of 11 percent of people below the poverty threshold.

Because the percentage of minorities in Nevada is approximately 34 percent (DIRS 173533-Bureau of Census 2005, all), adding 20 percentage points would provide a threshold of 54 percent to identify minority communities. Instead, DOE identified minority communities as those affected areas (by census blocks) where the minority population exceeded 50 percent.

DOE determined whether there would be minority or low-income populations in the Caliente or Mina rail alignment regions of influence for environmental justice, and assessed whether any high and adverse impacts could fall disproportionately on minority or low-income populations. DOE also considered whether minority or low-income populations would be affected by an alternative in different ways than the general population, such as through unique exposure pathways or rates of exposure, special sensitivities, or different uses of natural resources.

For the Caliente rail alignment, the Department determined that railroad construction and operations would not result in disproportionately high and adverse impacts to minority or low-income populations. For the Mina rail alignment DOE determined that the Schurz population center and the Walker River Census County Division, which includes the Walker River Paiute Reservation, are the only locations where the minority populations exceed the threshold of 50 percent, and the Walker River Census County Division to be the only location where the low-income population exceeds the threshold of 31 percent. Because there would be no high and adverse impacts in these areas, constructing and operating the proposed railroad along the Mina rail alignment would not result in disproportionately high and adverse impacts to minority or low-income populations.

Similarly, the Department determined that under the Shared-Use Option for either rail alignment, there would be not disproportionately high and adverse impacts to minority or low-income populations.

6.4.1.17 Comparison of Proposed Action and Alternatives

Council on Environmental Quality implementing regulations (40 CFR Parts 1500 through 1508) for NEPA state that agencies should provide a comparison of the environmental impacts of the proposal and the alternatives to sharply define the issues and provide a clear basis for choice. The comparison referred to in this section is based on the information and analyses presented in the Rail Alignment EIS.

In Chapter 2 of this Repository SEIS, Table 2-3 highlights the differences in potential impacts under the Proposed Action for the Caliente and Mina Implementing Alternatives. The table lists the range of potential impacts under the Proposed Action for the Caliente and Mina Implementing Alternatives considering the largest and smallest potential impacts of the different alternative segments.

Potential impacts under the Shared-Use Option would be generally the same as impacts under the Proposed Action without shared use, unless noted otherwise in Table 2-3. Potential commercial sidings and facilities that could be constructed under the Shared-Use Option would likely be constructed within the operations right-of-way to the extent practicable; therefore, the impacts of their construction are included within those impacts presented for the Proposed Action. More detailed discussion of impacts resulting from the Shared-Use Option can be found in Chapter 4 of the Rail Alignment EIS.

Table 2-3 illustrates that the Mina Implementing Alternative would be environmentally preferable when compared with the Caliente Implementing Alternative. In general, the Mina Implementing Alternative would have fewer private land conflicts, less surface disturbance, smaller impacts to wetlands, and smaller impacts to air quality than the Caliente Implementing Alternative. However, the Mina Implementing Alternative remains the nonpreferred alternative due to the objection of the Walker River Paiute Tribe to the transportation of spent nuclear fuel and high-level radioactive waste through its Reservation.

6.4.2 TRANSPORTATION IMPACTS FROM REPOSITORY ACTIVITIES

DOE would transport construction materials, repository components, and consumables to the repository on trucks on Nevada highways, and on trains along the Caliente or Mina rail corridor. Shipments of construction materials would include 190,000 metric tons (210,000 tons) of cement; 280,000 metric tons (310,000 tons) of steel; and 670 metric tons (740 tons) of copper. Shipments of repository components would include 11,200 empty waste packages, 11,200 emplacement pallets, 11,500 drip shields, 2,500 *aging overpacks*, and about 1,000 TAD canisters. About 6,500 additional empty TAD canisters would be shipped directly to the generator sites. The impacts of shipping these 6,500 empty TAD canisters to the generator sites are included in Section 6.2.1. Most of the consumables would be fuel oil; about 8,100 railroad tank cars of fuel oil would be shipped to the repository during the operations period. In total, there would be about 29,000 railcar shipments of construction materials, repository components, and consumables to the repository. These shipments would account for 47 to 57 million railcar kilometers (29 to 35 million railcar miles) of round-trip travel in Nevada. Shipments of repository components would account for about 90 to 100 million railcar kilometers (56 to 62 million railcar miles) of round-trip travel on the national level. DOE would ship waste materials from repository activities off the site. This waste would include nonhazardous *solid waste* and hazardous, mixed, and low-level radioactive wastes. Workers would commute to the repository; DOE would provide bus service from Clark and Nye counties for these workers. In addition, the analysis assumed that 80 percent of the workers would live in Clark County and 20 percent would live in Nye County. During the construction, operations, *monitoring*, and *closure* periods, these workers would account for about 1.9 billion vehicle kilometers (1.2 billion vehicle miles) of round-trip travel from Nye and Clark counties in Nevada.

Table 6-16 lists the impacts from the transportation of these materials and from worker commutes. DOE estimated that there would be about 13 vehicle emission fatalities and 44 to 46 traffic fatalities. Pahrump, the largest city in Nye County, is closer to the repository than Las Vegas. If the workers lived in Pahrump, the impacts would be less because the commuting distance would be less.

Table 6-16. Impacts from transportation of material and people.

Category	Latent cancer fatalities	Vehicle emission fatalities	Traffic fatalities
Caliente rail corridor			
Construction materials, repository components, consumables, and waste materials	0.15	0.96	8.4
Commuting workers	0	12	36
Total	0.15	13	44
Mina rail corridor			
Construction materials, repository components, consumables, and waste materials	0.15	0.92	11
Commuting workers	0	12	35
Total	0.15	13	46

Notes: Includes impacts from the construction and operation of the Caliente and Mina rail corridors for the Shared-Use Option. Values are rounded to two significant figures; therefore, totals might differ from sums.

Evaluation of these transportation activities resulted in impacts that were greater than the impacts presented in the Yucca Mountain FEIS. The primary reasons for the increase were extrapolating impacts to 2067 instead of 2035, increasing the number of construction workers required to build the Nevada rail line, increasing the repository operations period from 24 years to up to 50 years, increasing rail shipments to account for the Shared-Use Option for the Caliente and Mina rail corridors, and including workers who work in Las Vegas in the estimates of vehicle emission and traffic fatalities.

6.4.3 IMPACTS TO REGIONAL TRAFFIC

DOE has used Transportation Research Board's *Highway Capacity Manual 2000* (DIRS 176524-TRB 2001, p. all) to characterize roadway performance in terms of level of service, which consists of a qualitative ranking of traffic conditions users experience. There are six levels of service that characterize the performance of roadways; level of service A represents the best operating conditions (that is, free flow) and level of service F represents the worst (DIRS 176524-TRB 2001, p. 2-3). The determination of the level of service of a roadway is based on factors that affect how users perceive the quality of service they receive on a roadway, such as speed, travel time, freedom to maneuver, traffic interruptions, and comfort.

In the area of the intersection of Nevada State Route 373 and U.S. Highway 95 near Gate 510 to the Nevada Test Site, the existing level of service is B, which represents almost free flow (DIRS 185463-Facanha 2008, all). During the construction and operations analytical periods, traffic would increase in this area with workers who commuted by bus and automobile to the repository and other facilities such as the Cask Maintenance Facility and Rail Equipment Maintenance Yard, transport of construction materials such as steel and concrete by truck for repository-related facilities, transport of fuel oil and gasoline by truck, shipments of spent nuclear fuel to the repository by truck, and truck shipments of repository-generated waste for offsite disposal. The primary effect would be that from commuting workers (DIRS 185463-Facanha 2008, all). DOE estimated about two-thirds of workers would commute by bus and one-third by automobile.

As a result of this traffic increase, the level of service at the intersection of Nevada State Route 373 and U.S. Highway 95 near Gate 510 would drop from level of service B to level of service D, which indicates high-density traffic but still stable conditions (DIRS 185463-Facanha 2008, all). Even if the share of workers that would commute by automobile were to increase to 80 percent, the level of service for that traffic increase would still be D. If U.S. Highway 95 was widened to four lanes, the level of service would improve to A if two-thirds of the workers commuted by bus, and the level of service would remain at B if 80 percent of workers commuted by automobile.

REFERENCES

181282	AAR 2006	AAR (Association of American Railroads) 2006. *Railroad Facts 2006 Edition.* Washington, D.C.: Association of American Railroads. TIC: 259612.
185281	AEC 1972	AEC (U.S. Atomic Energy Commission) 1972. *Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants.* Oak Ridge, Tennessee: U.S. Atomic Energy Commission. ACC: MOL.20080313.0081.
180220	Bendixen and Facanha 2007	Bendixen, L. and Facanha, C. 2007. "Rail Accident Rate Calculation Methodology." Technical memo from L. Bendixen (ICF International) and C. Facanha (ICF International), to M. West (Potomac-Hudson Engineering), March 30, 2007. ACC: MOL.20070412.0014.

181343	Bjorkman et al. 2007	Bjorkman, G.; Chuang, T-J.; Einziger, R.; Malik, S.; Malliakos, A.; Mitchell, J.; Navarro, C.; Ryder, C.; Shaukat, S.; Ulses, A.; and Zigh, G. 2007. *A Pilot Probabilistic Risk Assessment Of a Dry Cask Storage System at a Nuclear Power Plant.* NUREG-1864. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20070913.0518.
179131	BLS 2006	BLS (Bureau of Labor Statistics) 2006. "Table 1. Incidence Rates of Nonfatal Occupational Injuries and Illnesses by Industry and by Case Types, 2005." *Occupational Injuries and Illnesses (Annual).* Washington, D.C.: U.S. Department of Labor, Bureau of Labor Statistics. Accessed February 13, 2007. ACC: MOL.20070220.0267. URL: http://stats.bls.gov/news.release/osh.toc.htm
179129	BLS 2007	BLS (Bureau of Labor Statistics) 2007. "All Charts, Census of Fatal Occupational Injuries, 2005." *Census of Fatal Occupational Injuries (CFOI) - Current and Revised Data.* Washington, D.C.: U.S. Department of Labor, Bureau of Labor Statistics. Accessed February 12, 2007. ACC: MOL.20070220.0266. URL: http://stats.bls.gov/iif/oshcfoi1.htm
161120	BSC 2002	BSC (Bechtel SAIC Company) 2002. *Subsurface Shielding Source Term Specification Calculation.* 000-00C-WER0-00100-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20021216.0076; ENG.20050815.0022.
169987	BSC 2004	BSC (Bechtel SAIC Company) 2004. *CSNF Waste Form Degradation: Summary Abstraction.* ANL-EBS-MD-000015 REV 02. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20040908.0001; DOC.20050620.0004.
174942	BSC 2005	BSC (Bechtel SAIC Company) 2005. *Project Design Criteria Document.* 000-3DR-MGR0-00100-000 REV 005. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20050826.0001.
180185	BSC 2007	BSC (Bechtel SAIC Company) 2007. *Characteristics for the Representative Commercial Spent Fuel Assembly for Preclosure Normal Operations.* 000-PSA-MGR0-00700-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070521.0008.
181377	BSC 2007	BSC (Bechtel SAIC Company) 2007. *Calculation of Transportation Data for SEIS Analyses.* 000-00C-G000-01300-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070523.0036.

184907	BSC 2008	BSC (Bechtel SAIC Company) 2008. *Recommended Values for HLW Glass for Consistent Usage on the Yucca Mountain Project*. 000-00A-MGR0-00200-000-00C. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080122.0020.
173533	Bureau of Census 2005	Bureau of Census 2005. "Nevada QuickFacts, Clark County, Nevada." (Washington, D.C.) Bureau of Census. Accessed April 7, 2005. ACC: MOL.20050505.0098. URL: http://quickfacts.census.gov/qfd/states/32/32003.html
156368	Bureau of Indian Affairs 2000	Bureau of Indian Affairs 2000. "Indian Lands and Native Entities in the United States (IND3)." Lakewood, Colorado: U.S. Department of Interior, Bureau of Indian Affairs. Accessed September 19, 2001. ACC: MOL.20011112.0016. URL: http://data.gdsc.bia.gov/data.htm
103162	CEQ 1997	CEQ (Council on Environmental Quality) 1997. *Considering Cumulative Effects Under the National Environmental Policy Act.* Washington, D.C.: Council on Environmental Quality. TIC: 243482.
104794	CRWMS M&O 1994	CRWMS M&O 1994. *Health and Safety Impacts Analysis for the Multi-Purpose Canister System and Alternatives.* A00000000-01717-0200-00006 REV 02. Vienna, Virginia: CRWMS M&O. ACC: MOV.19950217.0043.
156764	DOE 1999	DOE (U.S. Department of Energy) 1999. *Radiological Control,* DOE-STD-1098-99. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20011210.0187.
155970	DOE 2002	DOE (U.S. Department of Energy) 2002. *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*. DOE/EIS-0250F. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20020524.0314; MOL.20020524.0315; MOL.20020524.0316; MOL.20020524.0317; MOL.20020524.0318; MOL.20020524.0319; MOL.20020524.0320.
172283	DOE 2002	DOE (U.S. Department of Energy) 2002. *Recommendations for Analyzing Accidents under the National Environmental Policy Act.* Washington, D.C.: U.S. Department of Energy, Office of NEPA Policy and Compliance. ACC: MOL.20041122.0199.
169354	DOE 2004	DOE (U.S. Department of Energy) 2004. *Source Term Estimates for DOE Spent Nuclear Fuels.* DOE/SNF/REP-078, Rev. 1. Three volumes. Idaho Falls, Idaho: U.S. Department of Energy, Idaho Operations Office. ACC: MOL.20040524.0451.

178579	DOE 2004	DOE (U.S. Department of Energy) 2004. *Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements.* Second Edition. Washington, D.C.: U.S. Department of Energy, Office of NEPA Policy and Compliance. ACC: MOL.20070111.0019.
178016	DOT 2005	DOT (U.S. Department of Transportation) 2005. *Railroad Safety Statistics 2004 Annual Report.* Washington, D.C.: U.S. Department of Transportation, Federal Railroad Administration. ACC: MOL.20061031.0151.
181280	DOT 2006	DOT (U.S. Department of Transportation) 2006. *Freight in America.* Washington, D.C.: U.S. Department of Transportation, Research and Innovative Technology Administration. ACC: MOL.20070712.0049.
107684	Eckerman and Ryman 1993	Eckerman, K.F. and Ryman, J.C. 1993. *External Exposure to Radionuclides in Air, Water, and Soil, Exposure-to-Dose Coefficients for General Application, Based on the 1987 Federal Radiation Protection Guidance*. EPA 402-R-93-081. Federal Guidance Report No. 12. Washington, D.C.: U.S. Environmental Protection Agency, Office of Radiation and Indoor Air. TIC: 225472.
101069	Eckerman et al. 1988	Eckerman, K.F.; Wolbarst, A.B.; and Richardson, A.C.B. 1988. *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*. EPA 520/1-88-020. Federal Guidance Report No. 11. Washington, D.C.: U.S. Environmental Protection Agency. ACC: MOL.20010726.0072.
185461	Edwards 2008	Edwards, S. 2008. RE: SNF Shipment Data. Email from S. Edwards to J. Rivers, May 6, 2008. ACC: MOL.20080514.0314.
153733	EPA 2000	EPA (U.S. Environmental Protection Agency) 2000. *Cancer Risk Coefficients for Environmental Exposure to Radionuclides.* EPA 402-C-99-001. Federal Guidance Report No. 13. CD Supplement. Washington, D.C.: U.S. Environmental Protection Agency. TIC: 249372.
175544	EPA 2002	EPA (U.S. Environmental Protection Agency) 2002. *Federal Guidance Report 13, CD Supplement, Cancer Risk Coefficients for Environmental Exposure to Radionuclides, EPA.* EPA-402-C-99-001, Rev. 1. Washington, D.C.: U.S. Environmental Protection Agency. ACC: MOL.20051013.0016.

185248	EPA 2007	EPA (U.S. Environmental Protection Agency) 2007. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005*. Washington, D.C.: U.S. Environmental Protection Agency, Office of Atmospheric Programs. ACC: MOL.20080331.0109.
185330	EPRI 2005	EPRI (Electric Power Research Institute) 2005. *Assessment of Incident-Free Transport Risk for Transport of Spent Nuclear Fuel to Yucca Mountain Using RADTRAN 5.5.* EPRI 1011821. Technical Update 1. Palo Alto, California: Electric Power Research Institute. TIC: 260103.
185463	Facanha 2008	Facanha, C. 2008. "Question regarding traffic analysis." Email from C. Facanha to S. Maheras, April 29, 2008, with attachment. ACC: MOL.20080514.0318.
182082	FMCSA 2007	FMCSA (Federal Motor Carrier Safety Administration) 2007. *Large Truck Crash Facts 2005*. FMCSA-RI-07-046. Washington, D.C.: U.S. Department of Transportation, Federal Motor Carrier Safety Administration. ACC: MOL.20070726.0013.
185098	Gehner 2008	Gehner, P. 2008. "Location for the Maintenance of Way (MOW) Combined Facility for Caliente Rail Corridor." Technical memo from P. Gehner (BSC) to M. West (PHE), February 15, 2008, with attachment. ACC: ENG.20080221.0020.
182833	Golan 2005	Golan, P. 2005. "Letter Informing Stakeholders of Policy Adopted by the Department to Use Dedicated Trains for its Shipment of Spent Nuclear Fuel and High-Level Radioactive Waste to the Yucca Mountain Repository." Letter from P. Golan to Stakeholder, July 18, 2005, with attachment. ACC: HQO.20051003.0001.
185236	Hill et al. 1993	Hill, C.V.; Loud, G.C.; and Heitzman, A.C. 1993. "Marginal Overweight Operating Scenario for DOE's Initiative I Highway Casks." *High Level Radioactive Waste Management, Proceedings of the Fourth Annual International Conference, Las Vegas, Nevada, April 26-30, 1993. 1,* 286-292. La Grange Park, Illinois: American Nuclear Society. TIC: 208542.
101075	ICRP 1977	ICRP (International Commission on Radiological Protection) 1977. *Recommendations of the International Commission on Radiological Protection.* Volume 1, No. 3 of *Annals of the ICRP*. ICRP Publication 26. Reprinted 1982. New York, New York: Pergamon Press. TIC: 221568.

101836	ICRP 1991	ICRP (International Commission on Radiological Protection) 1991. "1990 Recommendations of the International Commission on Radiological Protection." Volume 21, No. 1-3 of *Annals of the ICRP*. ICRP Publication 60. New York, New York: Pergamon Press. TIC: 235864.
152446	ICRP 1996	ICRP (International Commission on Radiological Protection) 1996. *Age-Dependent Doses to Members of the Public from Intake of Radionuclides: Part 5 Compilation of Ingestion and Inhalation Dose Coefficients*. Volume 26, No. 1 of Annals of the ICRP. Smith, H., ed. ICRP Publication 72. New York, New York: Pergamon Press. TIC: 235870.
172935	ICRP 2001	ICRP (International Commission on Radiological Protection) 2001. *The ICRP Database of Dose Coefficients: Workers and Members of the Public.* ICRP Publication 72. New York, New York: Elsevier. TIC: 255638.
182836	ICRP 2007	ICRP (International Commission on Radiological Protection) 2007. *Draft Recommendations of the International Commission on Radiological Protection.* New York, New York: Pergamon. ACC: MOL.20070918.0101; MOL.20071003.0192.
157144	Jason Technologies 2001	Jason Technologies. 2001. *Transportation Health and Safety Calculation/Analysis Documentation in Support of the Final EIS for Yucca Mountain Repository*. CAL-HSS-ND-000003. Las Vegas, Nevada: Jason Technologies. ACC: MOL.20020209.0097.
181276	Johnson and Michelhaugh 2003	Johnson, P.E. and Michelhaugh, R.D. 2003. *Transportation Routing Analysis Geographic Information System (TRAGIS) User's Manual.* ORNL/NTRC-006, Rev. 0. Oak Ridge, Tennessee: Oak Ridge National Laboratory. ACC: MOL.20070712.0024.
104780	Johnson et al. 1993	Johnson, P.E.; Joy, D.S.; Clarke, D.B.; and Jacobi, J.M. 1993. *HIGHWAY 3.1—An Enhanced Highway Routing Model: Program Description, Methodology, and Revised User's Manual.* ORNL/TM-12124. D00000000-02268-2003-20012 REV 1. Oak Ridge, Tennessee: Oak Ridge National Laboratory. ACC: MOV.19960711.0024.
104781	Johnson et al. 1993	Johnson, P.E.; Joy, D.S.; Clarke, D.B.; and Jacobi, J.M. 1993. *INTERLINE 5.0—An Expanded Railroad Routing Model: Program Description, Methodology, and Revised User's Manual.* ORNL/TM-12090. D00000000-02268-2002-20015 REV 1. Oak Ridge, Tennessee: Oak Ridge National Laboratory. ACC: MOV.19960711.0014.

104782	Kelderhouse 1999	Kelderhouse, S. 1999. "LWT, HH and Rail Transportation Graphics." E-mail from S. Kelderhouse to R. Best (CRWMS M&O), April 27, 1999, with attachment. ACC: MOL.19990526.0027.
181756	Lamb et al. 2001	Lamb, M.; Resnikoff, M.; and Moore, R. 2001. *Worst Case Credible Nuclear Transportation Accidents: Analysis for Urban and Rural Nevada.* New York, New York: Radioactive Waste Management Associates. TIC: 259574.
181892	Lamb et al. 2002	Lamb, M., Hintermann, B., Resnikoff, M. 2002. *Potential Consequences of a Successful Sabotage Attack on a Spent Fuel Shipping Container: An Analysis of the Yucca Mountain EIS Treatment of Sabotage*. New York, New York: Radioactive Waste Management Associates. TIC: 259556.
174559	Lawrence 2002	Lawrence, A. 2002. "Radiation Risk Estimation from *Total Effective Dose Equivalents* (TEDEs)." Memorandum from A. Lawrence (DOE) to distribution, August 9, 2002, with attachments. ACC: MOL.20050815.0190.
181279	Luna 2006	Luna, R.E. 2006. "Release Fractions from Multi-Element Spent Fuel Casks Resulting from HEDD Attack." *WM'06 Conference, February 26-March 2, 2006, Tucson, AZ.* Tucson, Arizona: WM Symposia. TIC: 259643.
104918	Luna et al. 1999	Luna, R.E.; Neuhauser, K.S.; and Vigil, M.G. 1999. *Projected Source Terms for Potential Sabotage Events Related to Spent Fuel Shipments.* SAND99-0963. Albuquerque, New Mexico: Sandia National Laboratories. ACC: MOL.19990609.0160.
181250	National Research Council 2006	National Research Council. 2006. *Health Risks from Exposure to Low Levels of Ionizing Radiation, BEIR VII Phase 2.* Washington, D.C.: National Academies Press. TIC: 257529.
150898	Neuhauser and Kanipe 2000	Neuhauser, K.S. and Kanipe, F.L. 2000. *RADTRAN 5, User Guide.* SAND2000-1257. Albuquerque, New Mexico: Sandia National Laboratories. TIC: 249356.
155430	Neuhauser et al. 2000	Neuhauser, K.S.; Kanipe, F.L.; and Weiner, R.F. 2000. *RADTRAN 5, Technical Manual.* SAND2000-1256. Albuquerque, New Mexico: Sandia National Laboratories. ACC: MOL.20010724.0159.

158452	Nevada Agency for Nuclear Projects	Nevada Agency for Nuclear Projects 2002. "A Mountain of Trouble: A Nation at Risk, Report on Impacts of the Proposed Yucca Mountain High-Level Nuclear Waste Program." Volume 1. Carson City, Nevada: State of Nevada, Nuclear Waste Project Office. Accessed May 23, 2002. TIC: 252580. URL: http://www.state.nv.us/nucwaste/yucca/impactreport.pdf
148184	NRC 1998	NRC (U.S. Nuclear Regulatory Commission) 1998. "NRC Issues Certificate to General Atomics for Transportation Cask for Spent Nuclear Fuel." Washington, D.C.: U.S. Nuclear Regulatory Commission. Accessed March 16, 1999. ACC: MOL.20010725.0130. http://www.nrc.gov/OPA/gmo/nrarcv/nr98/98-197.htm
181757	NRC 2002	NRC (U.S. Nuclear Regulatory Commission) 2002. "NRC Inspection Report 50-312/2002-03; 72-11/2002-02." Letter from D.D. Chamberlain (NRC) to J. Shetler (Sacramento Municipal Utility District), September 18, 2002, with enclosures. ACC: MOL.20070712.0079.
182320	NRC 2007	NRC (U.S. Nuclear Regulatory Commission) 2007. "Low-Level Waste Disposal Statistics." Washington, D.C.: U.S. Nuclear Regulatory Commission. Accessed August 7, 2007. ACC: MOL.20070809.0006. URL: http://www.nrc.gov/waste/llw-disposal/statistics.html
103455	Saricks and Tompkins 1999	Saricks, C.L. and Tompkins, M.M. 1999. *State-Level Accident Rates of Surface Freight Transportation: A Reexamination.* ANL/ESD/TM-150. Argonne, Illinois: Argonne National Laboratory. TIC: 243751.
101747	Schneider et al. 1987	Schneider, K.J.; Ross, W.A.; Smith, R.I.; Daling, P.M.; Grinde, R.B.; Hostick, C.J.; Peterson, R.W.; Stiles, D.L.; Weakley, S.A.; and Young, J.R. 1987. *Analysis of Radiation Doses from Operation of Postulated Commercial Spent Fuel Transportation Systems, Main Report.* DOE-CH/TPO-001. Argonne, Illinois: U.S. Department of Energy, Chicago Operations Office. ACC: MOL.20010727.0163.
181758	Spitzberg 2004	Spitzberg, D.B. 2004. "NRC Inspection Report 050-00397/04-007; 072-00035/04-001." Letter from D.B. Spitzberg (NRC) to J.V. Parrish (Energy Northwest), April 23, 2004, with enclosure. ACC: MOL.20070712.0080.

181759	Spitzberg 2005	Spitzberg, D.B. 2005. "NRC Inspection Report 50-528/05-10; 50-529/05-10; 50-530/05-10; 72-44/05-01." Letter from D.B. Spitzberg (NRC) to G.R. Overbeck (Arizona Public Service Company), April 6, 2005, with enclosure. ACC: MOL.20070712.0082.
181760	Spitzberg 2005	Spitzberg, D.B. 2005. "NRC Inspection Report 050-00313/05-013; 050-00368/05-013; 072-00013/04-002." Letter from D. Spitzberg (NRC) to J.S. Forbes (Arkansas Nuclear One), March 31, 2005, with enclosure. ACC: MOL.20070712.0081.
156311	Tiller 1996	Tiller, V.E.V., ed. 1996. *Tiller's Guide to Indian Country, Economic Profiles of American Indian Reservations.* Albuquerque, New Mexico: BowArrow Publishing. TIC: 251237.
103470	Timbisha Shoshone Tribe n.d.	Timbisha Shoshone Tribe n.d. "The Timbisha Shoshone Tribal Homeland, A Draft Secretarial Report to Congress to Establish a Permanent Tribal Land Base and Related Cooperative Activities." Death Valley National Park, California: Timbisha Shoshone Tribe. Accessed June 12, 2000. ACC: MOL.20010727.0168. URL: http://www.nps.gov/deva/Timbisha_toc.html
176524	TRB 2001	TRB (Transportation Research Board) 2001. *Highway Capacity Manual 2000*. HCM2000. Washington, D.C.: National Research Council, Transportation Research Board. TIC: 258170.
181755	UMTRI 2003	UMTRI (University of Michigan, Transportation Research Institute) 2003. *Evaluation of the Motor Carrier Management Information System Crash File, Phase One.* UMTRI 2003-6. Ann Arbor, Michigan: University of Michigan, Transportation Research Institute, Center for National Truck Statistics. ACC: MOL.20070712.0083.
101483	Yuan et al. 1995	Yuan, Y.C.; Chen, S.Y.; Biwer, B.M.; and LePoire, D.J. 1995. *RISKIND - A Computer Program for Calculating Radiological Consequences and Health Risks from Transportation of Spent Nuclear Fuel*. ANL/EAD-1. Argonne, Illinois: Argonne National Laboratory. ACC: HQV.19930517.0008.

7

Environmental Impacts of the No-Action Alternative

TABLE OF CONTENTS

LIST OF TABLES

7. ENVIRONMENTAL IMPACTS OF THE NO-ACTION ALTERNATIVE

This chapter describes potential *impacts* for the *No-Action Alternative* that the U.S. Department of Energy (DOE or the Department) described in the *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F; DIRS 155970-DOE 2002, all) (Yucca Mountain FEIS) and Chapter 2 of this *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F-S1) (Repository SEIS). The purpose of the No-Action *Alternative* is to provide a basis for comparison with the impacts of the *Proposed Action*. Under the No-Action Alternative, DOE would terminate activities at Yucca Mountain and undertake site reclamation to mitigate significant adverse environmental impacts. Commercial utilities and DOE would continue to store and manage *spent nuclear fuel* and *high-level radioactive waste* at 76 sites in the United States in a manner that protected public health and safety and the environment. This *Repository* SEIS updates the health and safety impacts of the No-Action Alternative in the Yucca Mountain FEIS to reflect updated *radiation* dosimetry and *latent cancer fatality* conversion factors. This Repository SEIS incorporates the more detailed discussion of the analysis and environmental impacts associated with the No-Action Alternative to the Proposed Action by reference to Chapter 7 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 7-1 to 7-59).

7.1 Changes to the Analysis of the No-Action Alternative

DOE has performed an assessment of the analytical areas it evaluated for the No-Action Alternative in the Yucca Mountain FEIS to determine the areas that warranted updates. Throughout this Repository SEIS, DOE has used two updated analytical parameters in the determination of radiological health impacts: (1) radiation dosimetry and (2) latent cancer fatality conversion factors. To provide a basis of comparison with the Proposed Action, DOE has updated the radiological health impacts from the No-Action Alternative in the Yucca Mountain FEIS to reflect the changes in these parameters. The following sections provide the background on these changes.

7.1.1 RADIATION DOSIMETRY

Radioactive material released to the environment could affect persons who come in contact with it. Mechanisms for transport of radioactive material include air, water, soil, and food. The various ways an individual or population can come into contact with radioactive material are known as *pathways*. An individual can come into contact with radioactive material directly through the external and inhalation pathways or indirectly through the ingestion pathway. For this Repository SEIS, DOE evaluated five pathways for *exposure* to radioactive material:

- Inhalation,
- Ingestion,
- Inhalation of previously deposited material resuspended from the ground (*resuspension*),
- External exposure to material deposited on the ground (*groundshine*), and
- External exposure to material in the air (*immersion* or *cloudshine*).

The factors that DOE used to convert estimates of *radionuclide* intake (by inhalation or ingestion) or exposure (by groundshine or immersion) to a radiation *dose* are called dose coefficients. For this Repository SEIS, DOE used the International Commission on Radiological Protection inhalation and ingestion dose coefficients from *The ICRP Database of Dose Coefficients: Workers and Members of the Public* (DIRS 172935-ICRP 2001, all) and the groundshine and immersion dose coefficients from *Federal Guidance Report 13, CD Supplement, Cancer Risk Coefficients for Environmental Exposure to Radionuclides, EPA* (DIRS 175544-EPA 2002, all) to estimate radiation doses. The Department based its use of these dose coefficients on, and incorporated them from, the recommendations of the International Commission on Radiological Protection (DIRS 101836-ICRP 1991, all; DIRS 152446-ICRP 1996, all; respectively). Some dose coefficients have increased and some have decreased. Therefore, changes in radiation doses as a result of changes in dose coefficients are not uniform.

7.1.2 LATENT CANCER FATALITY CONVERSION FACTORS

Current DOE guidance recommends that the Department base estimates of latent cancer fatalities on received radiation dose and on dose-to-health-effect conversion factors recommended by the Interagency Steering Committee on Radiation Standards. For this Repository SEIS, DOE used the updated guidance for workers and members of the public. The latent cancer fatality conversion factor is 0.0006 fatality per *person-rem* (DIRS 174559-Lawrence 2002, p. 2).

7.2 Summary of No-Action Alternative Impacts

Under the No-Action Alternative, *decommissioning* and reclamation would begin as soon as practicable and could take several years to complete. Decommissioning and reclamation would include removal or shutdown of existing surface and *subsurface facilities* and restoration of disturbed lands. Short-term impacts from site reclamation at Yucca Mountain would be small. Table 7-1 summarizes the estimated local short-term impacts by resource area.

DOE recognizes that the future course Congress, DOE, and the commercial utilities would take if the U.S. Nuclear Regulatory Commission (NRC) did not license the *Yucca Mountain Repository* is uncertain. DOE further recognizes that it and the nuclear utilities could pursue a number of possibilities that include the continued storage of spent nuclear fuel and high-level radioactive waste at each generator site in expanded onsite storage facilities, storage of these materials at one or more centralized locations, study and selection of another location for a deep *geologic repository* (Chapter 1 of the Yucca Mountain FEIS identified the alternative sites DOE previously selected for technical study as potential *geologic* repository locations), development of new technologies, or reconsideration of alternatives to geologic *disposal*. Other documents have analyzed the environmental considerations of these possibilities in other contexts to varying degrees. Table 7-1 of the Yucca Mountain FEIS described studies related to centralized or regionalized interim storage that included alternatives in DOE *National Environmental Policy Act* documents, and summarized the relevant considerations. As mentioned below, some of these documents have been updated.

The proposed Private Fuel Storage facility on the reservation of the Skull Valley Band of Goshute Indians in Tooele County, Utah, is an example of the difficulty in predicting sustainable alternatives to storage and disposal of spent nuclear fuel. The NRC licensed this facility on February 21, 2006 (DIRS 181683-Ruland 2006, all). However, the construction of the facility has not begun due to a failure to lease the site or obtain the necessary right-of-way access across federally managed land. Both the Bureau of Indian

Table 7-1. Potential No-Action Alternative short-term impacts in the Yucca Mountain vicinity.

Resource area	Potential environmental impacts
Land use and ownership	DOE would require no new land to support decommissioning and reclamation; it would restore disturbed land to its approximate preconstruction condition.
Air quality	Dismantling and removal of existing structures, recontouring, and revegetation would generate fugitive dust that would be below the regulatory limits.
Hydrology (surface water)	Recontouring of terrain to restore the natural drainage and manage potential surface-water contaminant sources would minimize surface-water impacts.
Hydrology (groundwater)	DOE would use a small amount of groundwater during decommissioning and reclamation.
Biological resources and soils	Reclamation would result in the restoration of 1.4 square kilometers (350 acres) of habitat. Site reclamation would include soil stabilization and revegetation of disturbed areas. Some animal species could take advantage of abandoned tunnels for shelter. Decommissioning and reclamation could produce adverse impacts to the threatened desert tortoise.
Cultural resources	Leaving roads in place after decommissioning could have an adverse impact on cultural resources by increasing public access to the site. Preserving the integrity of important archeological sites and resources important to American Indians could be difficult.
Socioeconomics	The No-Action Alternative would result in the loss of approximately 4,700 jobs (1,800-person workforce for decommissioning and reclamation, 1,400-person engineering and technical personnel in locations other than the repository site, and 1,500 indirect jobs) in the socioeconomic region of influence. Nye County collects most of the federal monies associated with the repository project. The No-Action Alternative would result in the loss of payments in lieu of taxes to Nye County.
Occupational and public health and safety	During decommissioning and reclamation, workers and members of the public would be exposed to naturally occurring nonradioactive and radioactive materials. Doses to worker population could be as high as 150 person-rem as a result of radioactive radon decay, which would result in an estimated 0.09 latent cancer fatality. Annual radiation dose to the offsite population would be less than 2 person-rem, which would result in an estimated 0.001 latent cancer fatality.
Accidents	Accident impacts would be limited to those from traffic and typical industrial hazards encountered during construction or excavation activities. These were estimated at 94 total recordable cases and 45 lost workday cases.
Noise	Noise levels would be no greater than the current baseline noise environment at the Yucca Mountain site.
Aesthetics	Site decommissioning and reclamation would improve the scenic value of the site, which DOE would return to a state as close as possible to its predisturbance state.
Utilities, energy, materials, and site services	Decommissioning would consume electricity, diesel fuel, and gasoline. The No-Action Alternative would not adversely affect the utility, energy, or material resources of the region.
Waste management	Decommissioning would generate some waste that would require disposal in existing Nevada Test Site landfills. DOE would minimize waste by salvaging most equipment and many materials.

Table 7-1. Potential No-Action Alternative short-term impacts in the Yucca Mountain vicinity (continued).

Resource area	Potential environmental impacts
Traffic and transportation	Less than 0.15 traffic fatality would be likely during decommissioning and reclamation.
Environmental justice	Disproportionately high and adverse impacts to minority or low-income populations would be unlikely because there is no reason to believe they would be any more likely to be affected by job loss.

DOE = U.S. Department of Energy.

Affairs and the Bureau of Land Management have disapproved construction and operation of the facility (DIRS 181684-Cason 2006, p. 29; DIRS 181685-Calvert 2006, p. 1).

In light of these types of uncertainties and DOE's conclusion that no action would not result in predictable actions by others, the Yucca Mountain FEIS considered the range of possibilities by focusing the analysis of the No-Action Alternative on the potential impacts of two scenarios.

In No-Action Scenario 1, DOE would continue to manage its spent nuclear fuel and high-level radioactive waste in above- or below-ground dry-storage facilities at DOE sites around the country. Commercial utilities would continue to manage their spent nuclear fuel at current locations. The commercial and DOE sites would remain under *institutional control*; that is, they would be maintained to ensure the protection of workers and the public in accordance with current federal regulations. The storage facilities would be replaced every 100 years. They would undergo one major repair during the first 100 years because this scenario assumes that the design of the first storage facilities at a site would include a facility life of less than 100 years. The facility replacement period of 100 years represents the assumed useful lifetime of the structures. Replacement facilities would be on land adjacent to the existing facilities.

In No-Action Scenario 2, spent nuclear fuel and high-level radioactive waste would remain in *dry storage* at commercial and DOE sites and would be under institutional control for approximately 100 years (the same as Scenario 1). Beyond that time, the scenario assumed no institutional control. Therefore, after about 100 years and up to 10,000 years, the analysis assumed that the spent nuclear fuel and high-level radioactive waste storage facilities at commercial and DOE sites would begin to deteriorate and would eventually release radioactive materials to the environment.

Table 7-2 summarizes potential No-Action Alternative impacts at commercial and DOE sites for both scenarios from 100 to 10,000 years. From a *qualitative* standpoint, the long-term health impacts of the No-Action Alternative scenarios can be estimated for a longer period (that is, 1 million years). Because the scope of the Scenario 1 impacts (with institutional controls) is related to rebuilding the storage installations every 100 years, the estimate of the Scenario 1 impacts over 1 million years would be a time-step function of the 10,000-year value. In other words, the annual impacts would be the same or less (due to radioactive *decay*), but the integrated impacts over the million-year period would be approximately 100 times those of the 10,000-year impacts in Table 7-2.

The scope of health impacts over 1 million years for Scenario 2 is more speculative. The No-Action Alternative evaluation of the 10,000-year period in the Yucca Mountain FEIS showed that the original storage facility and containment vessels of the spent nuclear fuel and high-level radioactive waste would be compromised and dissolution of these materials would cause radionuclides to enter the accessible

Table 7-2. Potential No-Action Alternative impacts at commercial and DOE sites.

Resource area	Short-term impacts (100 years)	Long-term impacts (100 to 10,000 years) Scenario 1	Scenario 2
Land use and ownership	Small; storage would continue at existing sites.	Small; storage would continue at existing sites.	Large; potential contamination of 0.04 to 0.4 km^2 (10 to 100 acres) surrounding each commercial and DOE site.
Air quality	Small; releases and exposures well below regulatory limits.	Small; releases and exposures well below regulatory limits.	Small; degraded facilities would preclude large atmospheric releases.
Hydrology			
Groundwater	Small; use would be small in comparison with other site use.	Small; use would be small in comparison with other site use.	Large; potential for radiological contamination of groundwater around the commercial and DOE sites.
Surface water	Small; minor changes to runoff and infiltration rates.	Small; minor changes to runoff and infiltration rates.	Large; potential for radiological releases and contamination of drainage basins downstream of commercial and DOE sites (concentrations potentially exceeding current regulatory limits).
Biological resources and soils	Small; storage would continue at existing sites.	Small; storage would continue at existing sites.	Large; potential adverse impacts at each of the sites from subsurface contamination of 0.04 to 0.4 km^2 (10 to 100 acres).
Cultural resources	Small; storage would continue at existing sites; limited potential of disturbing sites.	Small; storage would continue at existing sites; limited potential of disturbing sites.	Small; no construction or operation activities; no impacts.
Socioeconomics	Small; population and employment changes would be small compared with totals in the regions.	Small; population and employment changes would be small compared with totals in the regions.	No workers; therefore, no impacts.
Occupational and public health and safety			
Public – Radiological MEI (probability of an LCF)	0.0000052[a]	0.0000016[a]	(b)
Public – Population (LCFs)	0.49[a]	3.1[a]	1,000[c]
Public – Nonradiological (fatalities due to emissions)	Small; exposures well below regulatory limits or guidelines.	Small; exposures well below regulatory limits or guidelines.	Moderate to large; substantial increases in releases of hazardous substances and exposures to the public.
Workers – Radiological (LCFs)	24[a]	15[a]	No workers; therefore, no impacts.

Table 7-2. Potential No-Action Alternative impacts at commercial and DOE sites (continued).

Resource area	Short-term impacts (100 years)	Long-term impacts (100 to 10,000 years)	
		Scenario 1	Scenario 2
Occupational and public health and safety (continued)			
Workers – Nonradiological fatalities (includes commuting traffic fatalities)	9	1,080	No workers; therefore, no impacts.
Accidents			
Public – Radiological MEI (probability of an LCF)	None.	None.	Not applicable.
Public – Population (LCFs)[d]	None.	None.	4 to 16[e]
Workers	Large; for some unlikely accident scenarios workers probably would be severely injured or killed; however, DOE or NRC would manage facilities safely during continued storage operations.	Large; for some unlikely accident scenarios workers would probably be severely injured or killed.	No workers; therefore, no impacts.
Noise	Small; transient and not excessive, less than 85 dBA.	Small; transient and not excessive, less than 85 dBA.	No activities, therefore, no noise.
Aesthetics	Small; storage would continue at existing sites; expansion as needed.	Small; storage would continue at existing sites; expansion as needed.	Small; aesthetic value would decrease as facilities degraded.
Utilities, energy, materials, and site services	Small; materials and energy use would be small compared with total site use.	Small; materials and energy use would be small compared with total site use.	No use of materials or energy; therefore, no impacts.
Waste management	Small; waste generated and materials used would be small compared with total site generation and use.	Small; waste generated and materials used would be small compared with total site generation and use.	No generation of waste or use of hazardous materials; therefore, no impacts.
Environmental justice	Small; no disproportionately high and adverse impacts to minority or low-income populations.	Small; no disproportionately high and adverse impacts to minority or low-income populations.	Large; potential for disproportionately high and adverse impacts to minority or low-income populations.

Table 7-2. Potential No-Action Alternative impacts at commercial and DOE sites (continued).

Source: DIRS 155970-DOE 2002, pp. 2-79 to 2-82.

a. Updated using a conversion factor of 0.0006 LCF per person-rem; no change to external dose coefficients.

b. With no effective institutional controls, the MEI could receive a fatal dose of radiation within a few weeks to months. Death could be caused by acute direct radiation exposure.

c. Updated using a conversion factor of 0.0006 LCF per person-rem and ingestion dose coefficients that overall are about 25 percent of the coefficients used in the Yucca Mountain FEIS.

d. Downstream exposed population of approximately 3.9 billion over 10,000 years.

e. Updated using a conversion factor of 0.0006 LCF per person-rem and inhalation dose coefficients that are approximately the same as coefficients used in the Yucca Mountain FEIS.

dBA = A-weighted decibel.
DOE = U.S. Department of Energy.
km^2 = square kilometer.
LCF = Latent cancer fatality.
MEI = Maximally exposed individual.
NRC = U.S. Nuclear Regulatory Commission.

environment. The Scenario 2 health impacts in Table 7-2 indicate the catastrophic impacts that this scenario could cause. Beyond 10,000 years, the unchecked deterioration and dissolution of the materials would continue and increase impacts even further. The increasing uncertainty (for example, actual locations of radiological materials, climate changes, and degree of institutional control) over this extended period, however, does not provide a meaningful basis for *quantitative* impact analyses because of the limitless number of scenarios that could occur.

7.3 Cumulative Impacts for the No-Action Alternative

DOE analyzed *cumulative impacts* of the continued storage of all spent nuclear fuel and high-level radioactive waste (Inventory Module 1, as discussed in detail in Chapter 8 of this Repository SEIS) at the commercial and DOE facilities for the No-Action Alternative in the Yucca Mountain FEIS. This section summarizes and incorporates by reference Section 7.3 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 7-43 to 7-54).

The Yucca Mountain FEIS demonstrated that the impacts of continued storage of spent nuclear fuel and high-level radioactive waste would be directly proportional to the increased amount of *commercial spent nuclear fuel* in Inventory Module 1. In the FEIS, the amount of commercial spent nuclear fuel in Inventory Module 1 was approximately 70 percent higher than that in the Proposed Action. The resultant impacts of continued storage of these materials were approximately 1.7 times the impacts from storage of the *Proposed Action inventory*. By applying this linear relationship to the updated Inventory Module 1, the impacts of continued storage of the 130,000 *metric tons of heavy metal* of commercial spent nuclear fuel would be approximately twice that of the Proposed Action (Chapter 8 of this Repository SEIS contains more details). Table 7-3 lists estimates of the potential health impacts of the continued storage

Table 7-3. Potential No-Action Alternative health impacts from continued storage of Inventory Module 1 at commercial and DOE sites.

Resource area	Short-term impacts (100 years)	Long-term impacts (100 to 10,000 years) Scenario 1	Long-term impacts (100 to 10,000 years) Scenario 2
Occupational and public health and safety			
Public – Radiological MEI (probability of an LCF)	0.00001	0.000003	(a)
Public – Population (LCFs)[b]	1	6	2,000
Public – Nonradiological (fatalities due to emissions)	Small; exposures well below regulatory limits or guidelines.	Small; exposures well below regulatory limits or guidelines.	Moderate to large; substantial increases in releases of hazardous substances in the spent nuclear fuel and high-level radioactive waste and exposures to the public.
Workers – Radiological (LCFs)	48	30	No workers; therefore, no impacts.
Workers – Nonradiological fatalities (includes commuting traffic fatalities)	18	2,200	No workers; therefore, no impacts.

a. With no effective institutional controls, the MEI could receive a fatal dose of radiation within a few weeks to months. Cause of death would be acute direct radiation exposure.
b. Downstream exposed population of approximately 3.9 billion over 10,000 years.
DOE = U.S. Department of Energy. MEI = Maximally exposed individual.
LCF = Latent cancer fatality.

of Inventory Module 1 based on this linear relationship. The long-term impacts in Table 7-3 are estimates of the impacts that could occur within 10,000 years. As discussed in Section 7.2, the impacts of continued storage for 1 million years would be higher.

Chapter 8 of this Repository SEIS also evaluates the effects that the Global Nuclear Energy Partnership (GNEP) Program could have on the inventories evaluated for Module 1 (Section 8.1.2.4.1). The premise of the analysis is that approximately half of the commercial spent nuclear fuel in Module 1 could be recycled using one of the available technologies addressed in the upcoming GNEP Programmatic EIS. The effect that this potential recycling would have on the No-Action Alternative of Module 1 would be to lessen the overall impacts as compared to the continued storage of all of the commercial spent nuclear fuel. This would be due to the smaller volume of commercial high-level radioactive waste resulting from the recycling of the spent nuclear fuel. The impacts presented in Table 7-3 would be representative of the impacts of storage of Module 1 regardless of whether recycling technologies were implemented in the future.

REFERENCES

181685	Calvert 2006	Calvert, C. 2006. *Record of Decision Addressing Right-of-Way Applications U 76985 and U 76986 to Transport Spent Nuclear Fuel to the Reservation of the Skull Valley Band of Goshute Indians.* Washington, D.C.: U.S. Department of Interior, Bureau of Land Management. ACC: MOL.20070712.0055.
181684	Cason 2006	Cason, J.E. 2006. *Record of Decision for the Construction and Operation of an Independent Spent Fuel Storage Installation (ISFSI) on the Reservation of the Skull Valley Band of Goshute Indians (Band) in Tooele County, Utah.* Washington, D.C.: U.S. Department of Interior, Bureau of Indian Affairs. ACC: MOL.20070712.0053.
155970	DOE 2002	DOE (U.S. Department of Energy) 2002. *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada.* DOE/EIS-0250F. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20020524.0314; MOL.20020524.0315; MOL.20020524.0316; MOL.20020524.0317; MOL.20020524.0318; MOL.20020524.0319; MOL.20020524.0320.
175544	EPA 2002	EPA (U.S. Environmental Protection Agency) 2002. *Federal Guidance Report 13, CD Supplement, Cancer Risk Coefficients for Environmental Exposure to Radionuclides, EPA.* EPA-402-C-99-001, Rev. 1. Washington, D.C.: U.S. Environmental Protection Agency. ACC: MOL.20051013.0016.

101836	ICRP 1991	ICRP (International Commission on Radiological Protection) 1991. "1990 Recommendations of the International Commission on Radiological Protection." Volume 21, *No. 1-3 of Annals of the ICRP*. ICRP Publication 60. New York, New York: Pergamon Press. TIC: 235864.
152446	ICRP 1996	ICRP (International Commission on Radiological Protection) 1996. "Age-Dependent Doses to Members of the Public from Intake of Radionuclides: Part 5 Compilation of Ingestion and Inhalation Dose Coefficients." Volume 26, *No. 1 of Annals of the ICRP*. Smith, H., ed. ICRP Publication 72. New York, New York: Pergamon Press. TIC: 235870.
172935	ICRP 2001	ICRP (International Commission on Radiological Protection) 2001. "The ICRP Database of Dose Coefficients: Workers and Members of the Public." *ICRP Publication 72*. New York, New York: Elsevier. TIC: 255638.
174559	Lawrence 2002	Lawrence, A. 2002. "Radiation Risk Estimation from Total Effective Dose Equivalents (TEDEs)." Memorandum from A. Lawrence (DOE) to distribution. August 9, 2002, with attachments. ACC: MOL.20050815.0190.
181683	Ruland 2006	Ruland, W. H. 2006. "Issuance of Materials License No. SNM-2513 for the Private Fuel Storage Facility (TAC No. L23821)." Letter from W.H. Ruland, NRC, to J.D. Parkyn, Private Fuel Storage, L.L.C., February 21, 1006, with attachments. ACC: MOL.20070712.0078.

8

Cumulative Impacts

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

8. CUMULATIVE IMPACTS

This chapter describes potential *cumulative impacts* for the *Proposed Action* of this *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F-S1) (*Repository* SEIS). An evaluation of cumulative impacts is necessary to understand the environmental implications of implementing the Proposed Action and is essential to the development of appropriate *mitigation* measures and the monitoring of their effectiveness.

In preparing this chapter, the U.S. Department of Energy (DOE or the Department) followed the Council on Environmental Quality regulations handbook *Considering Cumulative Effects Under the National Environmental Policy Act* (DIRS 103162-CEQ 1997, all) that implements the procedural provisions of the *National Environmental Policy Act of 1969* (NEPA; 42 U.S.C. 4321 et seq.). The Council on Environmental Quality regulations define a cumulative impact as "the *impact* on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions" (40 CFR 1508.7). The term "reasonably foreseeable" refers to future actions for which there is a reasonable expectation that the action could occur, such as a proposed action under analysis, a project that has already started, or a future action that has obligated funding. Thus, DOE identified actions that could have effects that coincided in time and space with the effects from the proposed repository and associated transportation activities. The Department based its identification of the relevant actions on reviews of resource, policy, development, and land use plans from agencies at all levels of government and from private organizations; other *environmental impact statements*; and environmental assessments. In addition to the assessment of potential cumulative impacts and consistent with Council on Environmental Quality regulations [40 CFR 1502.16(c) and 1506.2], this cumulative impacts analysis considered potential conflicts with plans issued by various government entities to the extent practicable and to the extent they provided relevant information. Past, present, and reasonably foreseeable future actions could contribute incrementally to the overall cumulative impacts.

This chapter summarizes, incorporates by reference, and updates the information in Chapter 8 of the *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F; DIRS 155970-DOE 2002, all) (Yucca Mountain FEIS). DOE has organized this chapter as follows:

- Section 8.1 presents past, present, and reasonably foreseeable future federal, non-federal, and private actions. This includes a detailed analysis of nuclear materials that need to be disposed of in addition to those evaluated for the Proposed Action. It describes and evaluates these waste quantities, referred to as Inventory Modules 1 and 2, for which DOE acknowledges the need for legislative action by Congress before these wastes could be disposed of at Yucca Mountain.

- Section 8.2 presents cumulative *preclosure* impacts in the proposed *Yucca Mountain Repository* region that could occur during the *construction*, *operations*, *monitoring*, and *closure* of the repository. DOE organized this section by resource area, which corresponds to Chapter 4 of this Repository SEIS. The analysis included only the resource areas with potential cumulative impacts.

- Section 8.3 discusses the results from the postclosure cumulative impact analysis DOE conducted for Inventory Modules 1 and 2, the Nevada Test Site, and the Beatty low-level radioactive waste *disposal* and hazardous waste treatment, storage, and disposal facilities.

- Section 8.4 presents cumulative transportation impacts for national and Nevada transportation.

- Section 8.5 describes potential cumulative impacts from the manufacturing of the repository components that would be necessary to emplace Inventory Module 1 or 2.

- Section 8.6 presents a summary table of cumulative impacts. In addition, this section presents a perspective on the cumulative impacts of these actions from the viewpoint of Nye County, Nevada, which is a cooperating agency on this Repository SEIS.

8.1 Past, Present, and Reasonably Foreseeable Future Actions

This section identifies past, present, and reasonably foreseeable future actions with impacts that could combine with impacts of the Proposed Action for this Repository SEIS.

8.1.1 PAST AND PRESENT ACTIONS

The description of existing environmental conditions in Chapter 3 includes the impacts of most past and present actions on the environment that the Proposed Action would affect. This includes *site characterization* activities at Yucca Mountain. Therefore, the Chapter 4, 5, and 6 analyses of potential environmental impacts of the Proposed Action generally encompass the impacts of past and present actions because the baseline for these analyses is the *affected environment* described in Chapter 3. Table 8-1 lists two past actions that the Chapter 3 environmental baseline does not address but that DOE identified for inclusion in the cumulative impact analysis. The table also lists information on the potential areas with cumulative impact from these two actions.

Table 8-1. Past and present actions that could result in potential cumulative impacts with the Proposed Action.

Past and present action and description	Potential cumulative impact areas			
	Preclosure	Postclosure	Transportation	Manufacturing
Nevada Test Site				
Nuclear weapons testing, waste management	Air quality and public health and safety	Air quality, groundwater, and public health and safety	Occupational and public radiological health and safety	None
Beatty Waste Disposal Area				
Low-level radioactive and hazardous waste disposal	None	Groundwater and public health and safety	Occupational and public radiological health and safety	None

In addition to the specific actions in Table 8-1, the cumulative impacts for national transportation consider the occupational and public radiological health impacts of other past, present, and reasonably foreseeable future *shipments* of *radioactive* material.

8.1.2 REASONABLY FORESEEABLE FUTURE ACTIONS

This section describes the reasonably foreseeable future actions that the cumulative impacts analysis considered. These actions could result in impacts in the repository *region of influence*. Section 8.4 discusses potential effects to national and Nevada transportation. Table 8-2 summarizes the reasonably foreseeable future actions that could result in potential cumulative impacts with the Proposed Action.

Table 8-2. Reasonably foreseeable future actions that could result in potential cumulative impacts.

Name/description	Change from the Yucca Mountain FEIS to the Repository SEIS
Inventory Module 1 Disposal of all SNF and HLW	Increase in projected inventory
Inventory Module 2 Disposal of Inventory Module 1, as well as GTCC and SPAR wastes	Increase in projected inventory
Nevada Test and Training Range	Additional actions.
Nevada Test Site	Additional actions.
DOE	
Programmatic Environmental Impact Statement for the Global Nuclear Energy Partnership	New action.
Environmental Impact Statement for the Disposal of Greater-Than-Class-C Low-Level Radioactive Waste	New action.
Draft Complex Transformation Supplemental Programmatic EIS (DIRS 185273 -DOE 2007, all) – analyzes potential environmental impacts from the continued transformation of the U.S. nuclear weapons complex.	New action.
DOE and BLM have issued the Draft *Programmatic Environmental Impact Statement Designation of Energy Corridors on Federal Land in 11 Western States* (DIRS 185274-DOE 2007, all), which analyzes the potential designation of energy corridors on federal land in western states.	New action.
DOE and BLM have issued a notice of intent to Prepare a Programmatic Environmental Impact Statement to Evaluate Solar Energy Development, Develop and Implement Agency-Specific Programs, Conduct Public Scoping Meetings, Amend relevant Agency Land Use Plans, and Provide Notice of Proposed Planning Criteria (73 FR 30908, May 29, 2008)	New action.
Nye County	
Yucca Mountain Project Gateway Area Concept Plan for the Yucca Mountain Project entrance (DIRS 182345-Giampaoli 2007, all)	New action.
Desert Space and Science Museum Construction of a science museum (DIRS 182345-Giampaoli 2007, all)	Nye County has decreased acreage for the project since completion of the Yucca Mountain FEIS.
BLM has received 11 right-of-way permit applications for solar energy facilities in Nye County. The applications are in varying stages of review (DIRS 185368-BLM 2008, all)	New action.
BLM has received applications for eight wind energy projects in Nye County. The applications are in varying stages of review.(DIRS 185367-BLM 2008, all)	New action.

Table 8-2. Reasonably foreseeable future actions that could result in potential cumulative impacts (continued).

Name/description	Change from the Yucca Mountain FEIS to the Repository SEIS
U.S. Department of Justice published *Final Environmental Impact Statement for the Proposed Contractor Detention Facility, Las Vegas, Nevada Area* (DIRS 185475-DOJ 2008, all)	New action.

BLM = Bureau of Land Management.
DOE = U.S. Department of Energy.
EIS = Environmental impact statement.
GTCC = Greater-Than-Class-C
HLW = High-level radioactive waste.
NRC = U.S. Nuclear Regulatory Commission.
SNF = Spent nuclear fuel.
SPAR = Special-Performance-Assessment-Required.

8.1.2.1 Inventory Modules 1 and 2

Under the Proposed Action, DOE would emplace as much as 70,000 *metric tons of heavy metal* (MTHM) of *spent nuclear fuel* and *high-level radioactive waste* in the proposed repository. Of the 70,000 MTHM, approximately 63,000 MTHM would be *commercial spent nuclear fuel* and commercial high-level radioactive waste. The remaining 7,000 MTHM would consist of DOE materials (spent nuclear fuel and high-level radioactive waste).

As in the Yucca Mountain FEIS, DOE analyzed the *emplacement* of Inventory Modules 1 and 2 as a reasonably foreseeable action. Under Module 1, DOE would emplace all of the projected spent nuclear fuel and high-level radioactive waste. Under Module 2, DOE would emplace all of Inventory Module 1 plus other radioactive materials that could require disposal in a monitored *geologic repository* (commercial *Greater-Than-Class-C waste* and DOE *Special-Performance-Assessment-Required waste*). This Repository SEIS updates, as necessary, the estimated inventories of these modules. As stated in the Yucca Mountain FEIS, DOE acknowledges the need for legislative action by Congress before these actions could occur. DOE also acknowledges that prior to disposal of spent nuclear fuel and high-level radioactive waste in excess of 70,000 MTHM, appropriate regulatory authorizations would be obtained from the NRC, including any necessary amendments to DOE's license for the operation of the Yucca Mountain Repository.

As a result of developments involving the *Programmatic Environmental Impact Statement for the Global Nuclear Energy Partnership* (GNEP Programmatic EIS), which DOE is preparing, the Department has modified the analysis of Inventory Modules 1 and 2 from the evaluated in the Draft Repository SEIS. Section 8.2.4.1 contains details about the GNEP Draft Programmatic EIS.

Some of the GNEP programmatic alternatives involve the recycling of commercial spent nuclear fuel. Rather than disposing of the Module 1 or Module 2 inventory of commercial spent nuclear fuel at Yucca Mountain (as was analyzed in the Draft Repository SEIS), the commercial spent nuclear fuel in excess of the Proposed Action could be recycled using one of the technologies DOE is analyzing in the upcoming GNEP Programmatic EIS. In this case, the high-level radioactive waste that resulted from this recycling activity would require geologic disposal rather than the spent nuclear fuel.

In this Repository SEIS, Inventory Module 1 would include all commercial spent nuclear fuel (about 130,000 MTHM) projected to be generated by existing U.S. reactors (assuming a 60-year operating life) (DIRS 182343-BSC 2006, all), all *DOE spent nuclear fuel* (about 2,500 MTHM) (DIRS 155970-DOE

2002, all), and all high-level radioactive waste (approximately 36,000 *canisters*) (DIRS 182702-Koutsandreas 2007, all). This inventory has not changed from the Draft Repository SEIS.

Inventory Module 2 has changed from the Draft Repository SEIS and would include the Module 1 inventory plus about 36,000 cubic meters of Greater-Than-Class-C or Greater-Than-Class-C-like low-level radioactive wastes (DIRS 185296-Joyce 2008, all). This increase (from about 6,000 cubic meters) results primarily from a revised estimate of Greater-Than-Class-C-like wastes that could be generated as a result of the project-specific alternative of the Advanced Fuel Cycle Facility proposed to be analyzed in the GNEP Programmatic EIS. The Department is proposing the Advanced Fuel Cycle Facility as a project-specific alternative, rather than programmatic alternative, that could be pursed by the Department independent of its decision on the programmatic alternatives. DOE assumes that if the Greater-Than-Class-C wastes were packaged in *transportation, aging, and disposal (TAD) canisters* prior to disposal, it would require approximately 12,000 TAD canisters.

To evaluate the potential effects of GNEP on the impacts of the repository, this Repository SEIS evaluates two disposal cases (A and B) for Inventory Modules 1 and 2. Case A represents the inventory modules without recycle. This is what DOE evaluated in the Draft Repository SEIS. Case B represents the inventory modules assuming the use of one of the recycling technologies through the implementation of one of the GNEP programmatic alternatives (that is, a thermal reactor recycle alternative) that assumes commercial spent nuclear fuel recycling. As such, under Case B the Department would dispose of 63,000 MTHM of commercial spent nuclear fuel as spent nuclear fuel, as in the Proposed Action for this SEIS; the balance of the commercial spent nuclear fuel inventory (67,000 MTHM) would be recycled and the resultant commercial high-level radioactive waste form would be transported to Yucca Mountain and disposed of in engineered waste packages. DOE presents a quantitative evaluation of the environmental impacts of this inventory scenario in Module 1 Case B.

The inventory for Module 1 Case B includes the commercial high-level radioactive waste potentially resulting from the recycling of approximately 67,000 MTHM of commercial spent nuclear fuel. The resultant volume of these commercial wastes would depend on the treatment technology. For instance, the West Valley Demonstration Project vitrified the high-level radioactive waste resulting from the reprocessing of commercial spent nuclear fuel from 1966 to 1972. The canisters of high-level radioactive waste resulting from this reprocessing contain an equivalent of 2.3 MTHM per canister (DIRS 155970-DOE 2002, Appendix A, p. A-36). Under the thermal reactor recycle programmatic GNEP alternative, the processes could generate high-level radioactive waste that had the volumetric characteristics of approximately 5.0 MTHM per canister. Assuming these two surrogate processes would define the range of canisters requiring disposal, the expected number of canisters would range from 13,400 to 29,000. This analysis assumed these commercial high-level radioactive waste canisters would have the same radiological characteristics as the existing commercial high-level radioactive waste canisters from West Valley, which are described in the Yucca Mountain FEIS (DIRS 155970-DOE 2002, Appendix A, Section A.2.3).

The recycling of commercial spent nuclear fuel through implementation of the thermal reactor recycle alternative could also generate an additional Greater-Than-Class-C waste stream (DIRS 185502-Schwartz 2008, all). The preliminary estimate of the volume of the Greater-Than-Class-C waste generated as a result of recycling 67,000 MTHM of commercial spent nuclear fuel could be approximately 140,000 cubic meters. If the same packaging configuration assumptions from the preliminary estimate for Case A were applied to Greater-Than-Class-C wastes in Case B (that is, if DOE assumed that all of the Greater-

Than-Class-C wastes would be placed in TAD canisters prior to shipment to and disposal at the repository), then the Greater-Than-Class-C waste in Case B of Module 2 would require more than 55,000 additional waste packages. This increase in waste packages would be high enough to make it highly uncertain that DOE would dispose of these materials in the Yucca Mountain Repository in this configuration. Rather, DOE would investigate other alternatives such as volume reduction, alternative waste package designs, or additional pretreatment considerations before making any decisions on disposal of this material. Because the disposal of this volume of Greater-Than-Class-C wastes in the Yucca Mountain Repository in the assumed configurations would be highly uncertain, DOE does not provide a quantitative evaluation of the environmental impacts of Module 2 Case B.

Table 8-2a lists the projected inventories of each waste type for each of the inventory modules.

Table 8-2a. Waste types and amounts considered for the inventory modules.

Inventory Module/Case	CSNF (MTHM)	DHLW (canisters)	DSNF (MTHM)	CHLW (canisters)	GTCC-EIS (cubic meters)	GTCC-GNEP (cubic meters)
Module 1A	130,000	36,000	2,500	0	0	0
Module 1B	63,000	36,000	2,500	13,400 – 29,000	0	0
Module 2A	130,000	36,000	2,500	0	36,000	0
Module 2B	63,000	36,000	2,500	13,400–29,000	36,000	140,000

Number of DHLW canisters includes about 280 canisters of commercial HLW canisters from West Valley Demonstration Project.
CHLW = Commercial high-level radioactive waste
CSNF = Commercial spent nuclear fuel.
DHLW = Defense high-level radioactive waste.
DSNF = DOE spent nuclear fuel.
GTCC-EIS = Greater-Than-Class-C Environmental Impact Statement.
GTCC-GNEP = Greater-Than-Class-C resulting from the Global Nuclear Energy Partnership programmatic alternatives.
MTHM = Metric tons of heavy metal.

This Repository SEIS examines the potential impacts of disposal of Case A of the inventory modules by evaluating the following factors:

- The commercial spent nuclear fuel inventory in Case A of the inventory modules (130,000 MTHM) is approximately twice that of the Repository SEIS Proposed Action amount (63,000 MTHM).
- The Yucca Mountain FEIS established an analytical relationship between the impacts in each environmental resource area for the Proposed Action and those of Inventory Module 1. This relationship, which was based on detailed analyses, did not always result in a linear increase in relation to the higher amount of materials.
- The Yucca Mountain FEIS Module 1 commercial spent nuclear fuel inventory (105,000 MTHM) is about 67 percent higher than that of the FEIS Proposed Action amount (63,000 MTHM).
- The Greater-than-Class-C or Greater-than-Class-C-like low-level radioactive wastes that DOE plans to analyze in the Greater-than-Class-C EIS, which are included in Module 2, would require an estimated 12,000 TAD canisters for transportation and disposal (DIRS 185296-Joyce 2008, all).

This Repository SEIS considers the following factors for the evaluation of Module 1, Case B:

- The disposal of 67,000 MTHM of commercial spent nuclear fuel would require approximately 7,000 waste packages. A range of 2,700 to 5,800 waste packages would be required to dispose of the commercial high-level radioactive waste resulting from recycling 67,000 MTHM of commercial spent nuclear fuel, a reduction of 17 to 61 percent of the required number of waste packages. This analysis assumed there would be five canisters of commercial high-level radioactive waste per waste package.

- With the reduction in the number of waste packages, the number of rail shipments would decrease proportionately. Consistent with DOE's other transportation analyses there would be five canisters of commercial high-level radioactive waste per rail transportation cask.

Chapters 4, 5, and 6 of this Repository SEIS present the environmental impacts for the Proposed Action.

8.1.2.2 Nevada Test and Training Range

The U.S. Air Force operates the Nevada Test and Training Range (formerly known as the Nellis Air Force Range) in south-central Nevada (Figure 8-1), a national test and training facility for military equipment and personnel that consists of approximately 12,000 square kilometers (3 million acres). In *Renewal of the Nellis Air Force Range Land Withdrawal: Legislative Environmental Impact Statement* (DIRS 103472-USAF 1999, all), the Air Force addressed potential environmental impacts of extending the land withdrawal to continue use of the Nevada Test and Training Range lands for military use. In 2005, the Air Force designated the Indian Springs Air Force Auxiliary Airfield as Creech Air Force Base and expanded its mission and *infrastructure* to play a major role in the war on terrorism. The base is home to two key military operations: the MQ-1 unmanned aerial vehicle and the Unmanned Aerial Vehicle Battle laboratory. The 1,590-square-kilometer (390,000-acre) Bureau of Land Management-administered National Wild Horse Range is within the boundary of the Nevada Test and Training Range. More than 3,200 square kilometers (800,000 acres) of the Test and Training Range comprise the Desert National Wildlife Refuge. The Air Force and the U.S. Fish and Wildlife Service jointly manage this area. In 2004, the Bureau of Land Management prepared a resource management plan for about 8,900 square kilometers (2.2 million acres) of withdrawn public lands on the Test and Training Range (DIRS 178102-BLM 2004, all). The plan guides the management of the affected Range natural resources 20 years into the future (2024). The decisions, directions, allocations, and guidelines in the plan are based on the primary use of the withdrawn area for military training and testing purposes. Environmental assessments are periodically completed for new or changing activities at the Range. Table 8-3 is a summary of Nevada Test and Training Range environmental assessments identified since the completion of the Yucca Mountain FEIS.

8.1.2.3 Nevada Test Site

The Nevada Test Site was established in 1951 as the nation's proving ground for developing and testing nuclear weapons (Figure 8-1). The site is on land administratively held by the Bureau of Land Management, but the Test Site land was withdrawn for use by the U.S. Atomic Energy Commission and its successors (including DOE). At present, the National Nuclear Security Administration manages the site, which consists of about 3,200 square kilometers (800,000 acres) of land.

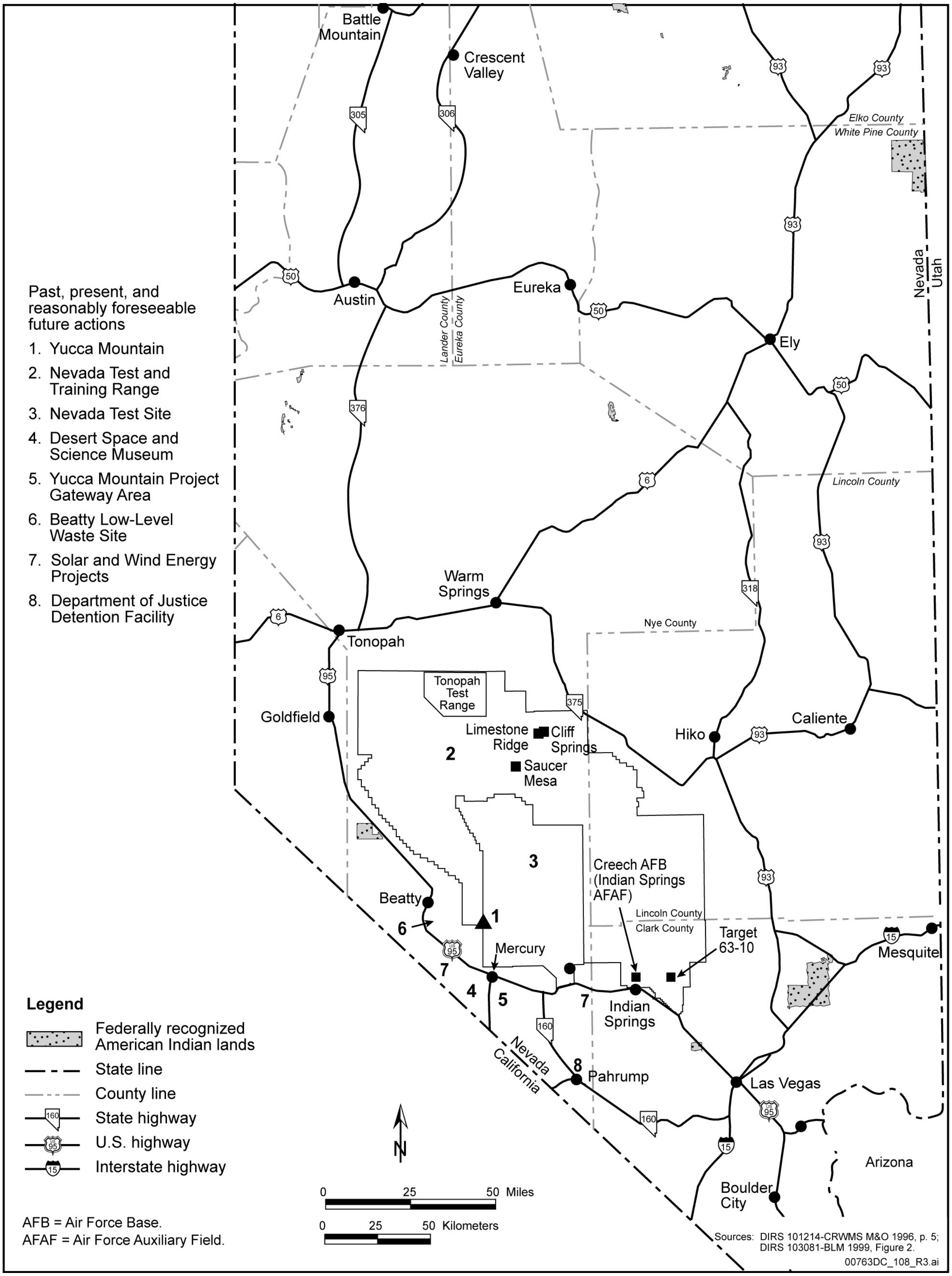


Figure 8-1. Locations of past, present, and reasonably foreseeable future actions.

Table 8-3. Environmental assessments identified since completion of the Yucca Mountain FEIS for the Nevada Test and Training Range.

Title	Description
Final Environmental Assessment for Increased Depleted Uranium Use on Target 63-10, Nevada Test and Training Range (DIRS 181607-USAF 2006, all)	The proposed action was to increase the use of depleted uranium ammunition at the Nevada Test and Training Range to meet ongoing test and training requirements for A-10 aircraft. The Air Force was to increase the number of depleted uranium rounds authorized to be fired on Target 63-10 from 7,900 to 19,000 annually. The environmental assessment evaluated five resource areas—air quality, soil and water resources, health and safety, hazardous and radioactive materials and waste, and biological resources—in detail to identify potential environmental impacts. The Air Force issued a Finding of No Significant Impact.
Final Environmental Assessment for Predator Force Structure Changes at Indian Springs Air Force Auxiliary Field, Nevada (DIRS 172314-USAF 2003, all)	The proposed action included changes to personnel assignments, upgrades to existing facilities, construction of new facilities, and extension of a runway by 120 meters (400 feet). The Air Force completed facilities for the Predator unmanned aerial vehicles in 2006. The Air Force issued a Finding of No Significant Impact.
Expeditionary Readiness Training Course Expansion, Final Environmental Assessment, Creech AFB (DIRS 182838-USAF 2006, all)	Environmental assessment to increase the number of Security Forces personnel trained at the Regional Training Center at Silver Flag Alpha and Creech AFB, Nevada, from an existing 2,520 to 6,000 students per year. The Air Force issued a Finding of No Significant Impact.
Wing Infrastructure Development Outlook, Final Environmental Assessment, Nellis AFB (DIRS 182839-USAF 2005, all)	The proposed action consists of 630 Wing Infrastructure and Development Outlook projects in 11 categories as classified under 32 CFR Part 989, *Air Force EIAP*. A total of 18 new construction and demolition projects are proposed for Creech Air Force Base. On the Nevada Test and Training Range, the proposed action would implement four new construction projects at four locations. At Tonopah Test Range, three new construction projects are planned along with the demolition of 10 buildings. The Air Force issued a Finding of No Significant Impact.
Draft Range 74 Target Complexes Environmental Assessment Nevada Test and Training Range, Nevada (DIRS 185372-USAF 2007, all)	The proposed action is to construct and operate three target complexes in mountainous terrain in Range 74 of the Nevada Test and Training Range at Saucer Mesa, Limestone Ridge, and Cliff Springs. The Saucer Mesa target array would employ both large-scale live and inert munitions; the Limestone Ridge sites would employ large-scale inert munitions; both target sites would employ small-scale live munitions. The Cliff Springs target complex would be laser and simulated attack targets and no munitions would be used. The Air Force issued a Finding of No Significant Impact.
A Final Base Realignment and Closure Environmental Assessment for Realignment of Nellis Air Force Base (DIRS 181492-USAF 2007, all)	The proposed action would affect the Nevada Test and Training Range by adding 1,400 F-16 sorties flown from Nellis Air Force Base. Although they would not cause total annual sortie operations to exceed the current maximum of 300,000 at the Nevada Test and Training Range, the environmental assessment evaluated noise, air quality, socioeconomics and infrastructure, water and soil resources, biological resources, cultural resources, and hazardous materials and waste. The Air Force issued a Finding of No Significant Impact.

AFB = Air Force Base.

A number of defense-related material and management activities, waste management, environmental restoration, and non-defense research and development are conducted at the site. DOE activities at the Nevada Test Site include stockpile stewardship and management (helping ensure the U.S. nuclear weapon stockpile is safe, secure, and reliable), materials disposition (removal of nuclear materials in a safe and timely manner), and nuclear emergency response. Between 1951 and 1992, the Federal Government conducted just over 900 nuclear tests at the site. The *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DIRS 101811-DOE 1996, all) described existing and projected future actions at the Test Site. That EIS was followed by *Supplement Analysis for the Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DIRS 162638-DOE 2002, all). Table 8-4 is a summary of the Nevada Test Site environmental assessments identified since the issuance of the Yucca Mountain FEIS. A new *Draft Supplement Analysis for the Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DIRS 185437-DOE 2008, all) has been developed and, based on this analysis, the National Nuclear Security Administration presents a preliminary conclusion that no additional NEPA documentation is required including:

- No substantial changes have occurred with respect to the proposals included in the Nevada Test Site EIS and selected for implementation in DOE Records of Decision.

- Screening analyses for the following resource areas showed no significant new circumstances or information relevant to environmental concerns: land use, infrastructure, socioeconomics, geology and soils, hydrology, biological resources, air quality, noise, visual resources, cultural resources, public radiological impacts from normal operations, worker radiological and occupational health and safety, waste management (portions), transportation (portions), and environmental justice.

Table 8-4. Environmental assessments identified since completion of the Yucca Mountain FEIS for the Nevada Test Site.

Title	Description
Environmental Assessment for Relocation of Technical Area 18 capabilities and materials from the Los Alamos National Laboratory to the Nevada Test Site (DIRS 162639-DOE 2002, all)	DOE completed relocation of Technical Area 18 operational capabilities and materials from the Los Alamos National Laboratory to the Nevada Test Site in November 2005. Relocation included the transport of about 2.4 metric tons (2.6 tons) of special nuclear material and approximately 10 metric tons (11 tons) of natural and depleted uranium and thorium, as well as support equipment, some of which would have radioactive contamination, associated with the operations. A Finding of No Significant Impact was issued.
Environmental Assessment for Defense Logistics Agency transfer of waste to DOE and Finding of No Significant Impact (DIRS 172280-DLA 2003, all) (DIRS 172281-DOD 2003, all)	The Defense Logistics Agency of the U.S. Department of Defense issued an environmental assessment of its proposal to transfer thorium nitrate from the Defense National Stockpile Center to DOE for disposal as a low-level radioactive waste at the Nevada Test Site. The Agency issued a Finding of No Significant Impact in November 2003 (DIRS 172281-DOD 2003, all). The Defense Logistics Agency made eight shipments of low-level thorium waste [about 310 cubic meters (10,900 cubic feet)] in 2004 (DIRS 182346-DOE 2005, all).

DOE = U.S. Department of Energy.

More detailed analyses were performed and identified no significant new circumstances or information relevant to environmental concerns for the following resource areas: public worker impacts from radiological and chemical accidents, low-level and mixed low-level radioactive waste management, and transportation (portions).

8.1.2.4 U.S. Department of Energy

DOE is completing several environment impact statements for proposals that can be considered reasonably foreseeable future actions.

8.1.2.4.1 *Programmatic Environmental Impact Statement for the Global Nuclear Energy Partnership*

DOE is preparing a GNEP Programmatic EIS. GNEP is a domestic and international program designed to support expansion of nuclear energy production while advancing nonproliferation goals and reducing the impacts of spent nuclear fuel disposal.

The GNEP Programmatic PEIS will evaluate the impacts of domestic programmatic alternatives that would reduce the volume, thermal output, and radiotoxicity of spent nuclear fuel and wastes requiring geologic disposal in the future. Within these programmatic alternatives, the Programmatic EIS will evaluate a range of potential growth scenarios for nuclear power generation through approximately 2060 to 2070 that range from the status quo of the current generation capability (approximately 100 gigawatts) to an annual growth of approximately 2.5 percent (400 gigawatts after a period of approximately 55 to 60 years). It also will evaluate a project-specific alternative to pursue the potential implementation of an Advanced Fuel Cycle Facility to conduct research, development, and demonstration at one or more of five DOE sites in the continental United States (DIRS 185502-Schwartz 2008, all).

The programmatic alternatives in the GNEP Programmatic EIS vary by reactor type, fuel type, and whether they would incorporate recycling of commercial spent nuclear fuel to recover usable materials for reuse in other reactor fuels. The alternatives include a no-action alternative that assumes continued use of light-water reactors without recycling spent nuclear fuel. All of the programmatic alternatives assume that the current licensed reactors would be replaced by similar or different reactor types, depending on the alternative.

Depending on the specific programmatic alternative analyzed, the resultant radiological materials that required geologic disposal could range from only high-level radioactive waste from recycling spent nuclear fuel, to only spent nuclear fuel (at varying mass projections depending on the reactor type alternative and the nuclear power growth scenario). The estimates of spent nuclear fuel vary widely among the alternatives. For the alternatives with repeated recycle of usable materials, no spent nuclear fuel would require geologic disposal (DIRS 185502-Schwartz 2008, all).

There are many uncertainties associated with the implementation of any programmatic alternative and many factors (such as market forces, research and development, regulatory issues, and public policy) could impact the successful implementation of any alternative. Because of these factors, it is not possible to predict with confidence when, and to what extent, any of the programmatic action alternatives would be implemented. In any event, transition to any new fuel cycle could take many decades to complete.

The United States presently uses a “once-through” fuel cycle in which a nuclear utility uses nuclear fuel in a reactor only once, and then utility places the spent nuclear fuel in storage while awaiting disposal. GNEP would not diminish in any way the need for the nuclear waste disposal program at Yucca Mountain, because any fuel-recycling scenario would produce high-level radioactive waste and/or spent nuclear fuel that would require disposal, and none of the spent nuclear fuel recycling scenarios would treat existing inventories of DOE high-level radioactive waste that require disposal at the Repository.

DOE anticipates that by about 2020 the commercial utilities will have produced about 86,000 MTHM of spent nuclear fuel, which exceeds DOE's disposal limit of 63,000 MTHM of commercial spent nuclear fuel for the Yucca Mountain Repository. If DOE decided in a GNEP Record of Decision to proceed with its proposal to recycle spent nuclear fuel, the necessary facilities would not begin operations until 2020 or later. Given the current uncertainties associated with the timelines, potential capacities, technological developments, need of, and the private industry support for, the facilities evaluated in the GNEP programmatic alternatives, the Department believes there would be no change in the spent nuclear fuel and high-level radioactive waste inventory analyzed under the Proposed Action of this Repository SEIS [that is, 63,000 MTHM of commercial spent nuclear fuel, which could include about 280 canisters of commercial high-level radioactive waste from the West Valley Demonstration Project, and 7,000 MTHM of DOE spent nuclear fuel (about 3,200 canisters) and high-level radioactive waste (about 9,300 canisters)].

As discussed in Section 8.1.2.1, in light of the developments in the preparation of the GNEP Programmatic EIS DOE has modified its analysis of the inventory modules in this Repository SEIS.

8.1.2.4.2 *Disposal of Greater-Than-Class-C Low-Level Radioactive Waste Environmental Impact Statement*

DOE is preparing the *Disposal of Greater-Than-Class-C Low-Level Radioactive Waste Environmental Impact Statement* (DOE/EIS-0375) (72 FR 40135, July 23, 2007). This EIS will address the disposal of wastes with concentrations greater than Class C, as defined in U.S. Nuclear Regulatory Commission (NRC) regulations at 10 CFR Part 61, and DOE low-level radioactive waste and *transuranic waste* having characteristics similar to Greater-Than-Class-C waste and that otherwise do not have a path to disposal. DOE proposes to evaluate alternatives for Greater-Than-Class-C low-level waste and Greater-Than-Class-C-like waste (also referred to as Special-Performance-Assessment-Required waste; Section 8.1.2.1) disposal in a geologic repository, in intermediate depth *boreholes*, and in enhanced near-surface facilities. Candidate locations for these disposal facilities are the Idaho National Laboratory, the Los Alamos National Laboratory and Waste Isolation Pilot Plant in New Mexico, the Nevada Test Site and the proposed Yucca Mountain Repository, the Savannah River Site in South Carolina, the Oak Ridge Reservation in Tennessee, and the Hanford Site in Washington. DOE will also evaluate disposal at generic commercial facilities in *arid* and humid locations. This Repository SEIS evaluates the potential cumulative impacts of disposal of these wastes at Yucca Mountain as a reasonably foreseeable action, which is referred to as Inventory Module 2.

8.1.2.4.3 *Complex Transformation Supplemental Programmatic EIS*

In December 2007, the National Nuclear Security Administration and DOE published *Draft Complex Transformation Supplemental Programmatic Environmental Impact Statement* (formerly known as the Complex 2030 Supplemental Programmatic EIS) (DIRS 185273-DOE 2007, all). This supplemental programmatic EIS analyzes the potential environmental impacts of reasonable alternatives to continue transformation of the U.S. nuclear weapons complex under the National Nuclear Security Administration's vision of a smaller, more responsive, efficient, and secure complex. As part of the proposed action, activities could take place at Los Alamos National Laboratory in New Mexico, the

Nevada Test Site, the Pantex Plant in Texas, the Y-12 National Security Complex in Tennessee, the Savannah River Site in South Carolina, White Sands Missile Range, and Lawrence Livermore National Laboratory.

8.1.2.4.4 *Programmatic EIS To Designate Energy Corridors on Federal Land*

To identify appropriate right-of-way *corridors* throughout the western United States, including Nevada, DOE and the Bureau of Land Management are co-lead agencies and have issued *Draft Programmatic Environmental Impact Statement, Designation of Energy Corridors on Federal Land in the 11 Western States*, which analyzes the potential designation of energy corridors on federal land in western states (DIRS 185274-DOE 2007, all). The proposed action is to designate corridors for oil, gas, and hydrogen pipelines and electricity transmission and distribution facilities. The states are Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. Based on information and analyses developed, DOE and the Bureau of Land Management, as well as the federal cooperating agencies (U.S. Forest Service and U.S. Department of Defense), might amend their relevant land use plans. The energy corridors in the Draft Programmatic EIS near the Nevada Test Site and Yucca Mountain Repository follow existing, designated energy corridors.

8.1.2.4.5 *Notice of Intent To Prepare an EIS To Evaluate Solar Energy Development*

DOE and the Bureau of Land Management have issued a Notice of Intent in response to the following mandates: Executive Order 13212, *Actions to Expedite Energy-Related Projects* and Title II, Section 211 of the *Energy Policy Act of 2005* (73 FR 30908, May 29. 2008). DOE and the Bureau have identified utility-scale solar energy development as a potentially critical component in meeting these mandates. DOE and the Bureau are considering the development and implementation of agency-specific programs related to solar energy development in six western states (Arizona, California, Colorado, New Mexico, Nevada, and Utah). DOE proposes to develop a solar energy program of environmental policies and mitigation strategies that would apply to the deployment of DOE-supported solar energy projects on Bureau-administered lands or other federal, state, tribal, or private lands. The Bureau would establish its own environmental policies and mitigation strategies to use when making decisions on whether to issue rights-of-way for utility-scale solar energy development projects on public lands administered by the Bureau. Until details for specific utility-scale solar energy development projects are available, the possibility of cumulative impacts, if any, with the Yucca Mountain Project is unknown.

8.1.2.5 Nye County

Nye County is proposing several projects that can be considered as reasonably foreseeable future actions.

8.1.2.5.1 *Yucca Mountain Project Gateway Area Concept Plan*

Nye County has completed a Yucca Mountain Project Gateway Area Concept Plan with proposed land use designations for the area around the entrance to the proposed repository site (DIRS 182345-Giampaoli 2007, all). This report presents Nye County's proposed multiphase land use plan for the portion of the town of Amargosa Valley that is adjacent to and near the site entrance area. Nye County proposed this plan to ensure that land development occurs in an orderly manner and to increase opportunities for industrial and commercial development consistent with the repository program. Nye County views this plan as a starting point for development of the infrastructure, institutional capacity, and facilities to offset the potential impacts associated with the repository while also benefiting the repository program. The county developed the plan to use and manage existing initiatives while expanding and improving the area. It states the purposes of the plan as follows:

- Describe key objectives and methods to manage the expected impacts of repository-related activities, which would include growth in neighboring towns,
- Review existing conditions and identify necessary planning and infrastructure improvements,
- Review financial options for land and utility development, and
- Present a land use concept to ensure orderly and compatible development for the area around the repository site entrance.

Nye County plans to nominate Crater Flat lands for disposal of the land (transfer of land) in the Bureau of Land Management Resource Management Plan amendment process.

8.1.2.5.2 *Desert Space and Science Museum*

The Yucca Mountain FEIS evaluated the proposed museum that the Nevada Science and Technology Center, LLC, would construct and operate under lease from Nye County. Nye County would construct infrastructure and oversee development of industrial, commercial, recreational, and public purpose facilities on the adjacent 1.4 square kilometers (350 acres). The U.S. Fish and Wildlife Service issued a notice of availability for the “Nye County Habitat Conservation Plan for Lands Conveyed at Lathrop Wells, NV” (67 FR 39737, June 10, 2002), which includes the proposed museum and the adjacent development. In total, 3.3 square kilometers (820 acres) of land would transfer from the Bureau of Land Management to Nye County, of which the county would develop 0.4 square kilometer (99 acres) for the proposed facilities and manage the remaining area for natural resource values and desert tortoise *habitat* (DIRS 182804-Maher 2006, all). The U.S. Fish and Wildlife Service has made a preliminary determination that approval of the Habitat Conservation Plan qualifies as a categorical exclusion under NEPA.

8.1.2.5.3 *U.S. Highway 95 Technology Corridor*

Nye County has outlined a strategy for a Technology Corridor along U.S. Highway 95 (DIRS 182841-Gamble 2007, all). The corridor extends from Indian Springs in Clark County in the south to Tonopah in the north, passing through the Pahrump Valley, Mercury (entrance to the Nevada Test Site), Amargosa Valley, Beatty, and Goldfield. Nye County would like to increase industrial space to accommodate new high-technology businesses by completing the Amargosa Valley Science and Technology Park at Lathrop Wells, assisting Beatty to adaptively reuse the Barrick Bullfrog site for new industry, and encouraging Pahrump to facilitate a business park for the Pahrump Valley. Nye County’s goals for the Technology Corridor are to change economic diversity of the region’s industries, transform the regional economy to one more closely associated with national trends, and increase the presence of green energy industry in the region.

As part of its Technology Corridor, a major goal of Nye County is to pursue development of renewable energy along the U.S. Highway 95 corridor (DIRS 182841-Gamble 2007, Goal 1-7, p. C-1). Wide expanses and sunny climate offer abundant opportunity to employ solar energy options to spread energy demand and lower operating costs for households and businesses. Nevada has created an incentive for power utilities to invest in alternative energy. To increase renewable energy research and development activities, Nye County plans to work cooperatively with (1) the DOE National Laboratory for Renewable Energy to provide contracts to regional providers, (2) private industry to attract investment to promote renewable energy projects, and (3) installation providers to recruit and provide skill training through Great Basin College to local workers (DIRS 182841-Gamble 2007, Section 3.3.10, p. 31).

The Bureau of Land Management has received right-of-way permit applications for solar energy facilities in Nye County. The applications are in varying stages of review by the Bureau. The following are descriptions of the eight solar energy applications the Bureau's Las Vegas Field Office is evaluating:

- Solar Millennium LLC applied in November 2007 for a right-of-way permit for about 3.4 square kilometers (840 acres) of Bureau of Land Management land in Amargosa Valley in the Anvil Farm Road area. The applicant is proposing to build and operate a 150- to 350-megawatt solar parabolic trough electric power plant (DIRS 185368-Seley 2008, all).

- Solar Millennium LLC applied in November 2007 for a right-of-way permit for about 17 square kilometers (4,100 acres) of Bureau of Land Management land in Amargosa Valley in the Amargosa Farm Road area. The applicant is proposing to build and operate a 150- to 350-megawatt solar parabolic trough electric power plant (DIRS 185368-Seley 2008, all).

- Solar Investments LLC applied in March 2007 for a right-of-way permit for about 89 square kilometers (22,000 acres) of Bureau of Land Management land northwest of the Big Dune Area of Critical Environmental Concern and abutting U.S. Highway 95. The applicant is proposing to construct and operate a 1,000-megawatt solar thermal energy facility in the Big Dune area of Nye County (DIRS 185368-Seley 2008, all).

- Solar Investments LLC applied in February 2007 for a right-of-way permit for about 53 square kilometers (13,000 acres) of Bureau of Land Management land east of the Big Dune Area of Critical Environmental Concern and abutting U.S. Highway 95. The applicant is proposing to construct and operate a 1,000-megawatt solar thermal energy facility in Amargosa (DIRS 185368-Seley 2008, all).

- Solar Investments LLC applied in March 2007 for a right-of-way permit for about 53 square kilometers (13,000 acres) of Bureau of Land Management land south of the Beatty Airfield, near the Town of Beatty. The applicant is proposing to construct and operate a 1,000-megawatt solar thermal energy facility (DIRS 185368-Seley 2008, all).

- Pacific Solar Investments, Inc., applied in December 2007 for two right-of-way permits, one for about 30 square kilometers (7,500 acres), and one for about 31 square kilometers (7,700 acres), for Bureau of Land Management land in the Amargosa Desert adjacent to the Big Dune Area of Critical Environmental Concern and south of U.S. Highway 95. The applicant is proposing to construct and operate 500-megawatt parabolic trough plants, known as the proposed Amargosa South and North Plants (DIRS 185368-Seley 2008).

- Ausra NV 1 LLC applied in March 2008 for a right-of-way permit for about 28 square kilometers (7,000 acres) of Bureau of Land Management land near the Ash Meadows Wildlife Refuge in the Johnnie Amargosa area. The applicant is proposing to construct and operate a compact linear Fresno reflector power plant, where the first phase would be 400-megawatts and the second phase would be 200 megawatts (DIRS 185368-Seley 2008, all).

The Bureau of Land Management Battle Mountain Field Office is evaluating:

- Solar Millennium LLC applied in November 2007 for a right-of-way permit for about 10 square kilometers (2,500 acres) of Bureau of Land Management land just west of the Beatty Airport, near the Town of Beatty. The applicant is proposing to build and operate a 150- to 350-megawatt solar parabolic trough electric power plant (DIRS 185368-Seley 2008, all).

The Bureau of Land Management has also received an application for a wind energy site testing a project area in Nye County.

- Greenwing Pacific Energy Corporation applied in August 2007 for a right-of-way permit for about 30 square kilometers (7,400 acres) of Bureau of Land Management land west of the Town of Beatty and abutting Nevada State Route 374 (DIRS 185367- BLM 2008, all).

8.1.2.5.4 *U.S. Department of Justice Detention Facility*

The U.S. Department of Justice Office of the Federal Detention Trustee and the U.S. Marshals Service determined that there is a need to house federal detainees at a facility near Las Vegas. In March 2008, the Department of Justice published the *Final Environmental Impact Statement for the Proposed Contractor Detention Facility, Las Vegas, Nevada Area* (DIRS 185475-DOJ 2008, all). The EIS preferred alternative identified is a 120-acre site in Pahrump, about 80 kilometers (50 miles) from the repository site. Development of the proposed facility would take about 12 to 15 months and would employ 200 to 250 people upon operation. Operation of the proposed detention facility is anticipated to result in approximately 40 to 50 contractor employees relocating to Nye County, and the remainder of the new contractor employees are expected to be current residents of Clark County who would continue to reside in Clark County within commuting distance of the selected site.

8.2 Cumulative Preclosure Impacts in the Proposed Yucca Mountain Repository Region

This section describes preclosure cumulative impacts during the construction, operations, monitoring, and closure analytical periods of the proposed repository in the regions of influence for the resources the repository could affect and updates information from Chapter 8 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 8-1 to 8-116).

DOE has organized the analysis of cumulative impacts by resource area. As necessary, the discussion of each resource area includes cumulative impacts: from Inventory Module 1 or 2; from other federal, non-federal, and private actions; and from the combination of Inventory Modules 1 and 2 and other federal, non-federal, and private actions.

8.2.1 LAND USE AND OWNERSHIP

Impacts to the ownership, management, and use of the *analyzed land withdrawal area* described in Chapter 4, Section 4.1.1 of this Repository SEIS would not change due to Inventory Module 1 or 2. The amount of land necessary for surface facilities would increase somewhat for Module 1 or 2 because of the larger area for excavated rock storage and additional ventilation *shafts* for the larger repository. Table 8-4a lists the estimated increases in excavation above that estimated for the Proposed Action. The differences in excavation for the various inventory modules and cases are based primarily on the number of waste packages, but take into account the shorter length of the waste packages that would contain high-level radioactive waste in comparison with those that would contain TAD canisters. This increased land disturbance would have no substantial cumulative land use or ownership impact.

Table 8-4a. Increased excavated rock storage area for the inventory modules

Inventory Module/Case	Increase in waste packages[a]	Increased length of excavation [km (miles)]	Excavated rock storage area increase (percentage)	Total excavated rock storage [km^2 (acres)]
Module 1A	14,700	73 (45)	110	1.7 (420)
Module 1B	10,400 – 13,500	41 – 54 (26 – 33)	61 – 79	1.3 – 1.5 (320 – 360)
Module 2A	26,700	150 (91)	220	2.6 (630)

a. Estimated number of waste packages in the Proposed Action would be 11,200.
km = kilometers.
km^2 = square kilometers.

To identify and quantify cumulative impacts for land use, DOE evaluated actions that had occurred or could occur within an 84-kilometer (52-mile) radius of the repository. The only *quantitative* change in land use impacts from other federal, non-federal, and private actions from the Yucca Mountain FEIS would be a decrease in land disturbance for the Desert Space and Science Museum from 1.8 square kilometers (440 acres) to 0.40 square kilometer (100 acres). Changes in impacts from the continued use of the Nevada Test Site and the Nevada Test and Training Range would be unlikely. The Bureau of Land Management has designated land in the town of Amargosa Valley adjacent to the repository site entrance for disposal, indicating that the land has limited public use. The Nye County Yucca Mountain Project Gateway Area Concept Plan presents a land use concept to ensure orderly and compatible development of an approximately 23-square-kilometer (9-square-mile)-area around the repository site entrance (DIRS 182345-Giampaoli 2007, all). The county proposed this plan to ensure that land development would occur in an orderly manner and increase the opportunities for industrial and commercial development consistent with the repository program. Nye County views this plan as a starting point for development of the infrastructure, institutional capacity, and facilities to support the Yucca Mountain Repository.

The Bureau of Land Management has received several permit applications for solar and wind energy projects in Nye County near the repository. Locations and amount of proposed acreage are discussed in Section 8.1.2.5.3. A major goal of Nye County is to pursue development of renewable energy and these uses would permit orderly development of the area. No additional land use or ownership impacts are available at this time.

The U.S. Department of Justice proposes a 120-acre site in Pahrump, about 80 kilometers (50 miles) from the repository site. Because of the compact, self-contained nature of the proposed facility, it would not have a significant effect on local land use patterns or land uses in the area of the selected site and is not expected to contribute to cumulative impacts.

8.2.2 AIR QUALITY

The cumulative preclosure nonradiological impacts to *air quality* would essentially be the same as those for the Proposed Action in Chapter 4, Section 4.1.2 of this Repository SEIS. In summary, construction, operations, monitoring, and closure of the proposed repository would have small impacts on regional air quality for Inventory Module 1 or 2.

The activities that produced releases of *criteria pollutants* (*nitrogen dioxide, sulfur dioxide, carbon monoxide,* and *particulate matter*) and carbon dioxide would be roughly the same for Inventory Module 1 or 2 as those described for the Proposed Action (Section 4.1.2). One change would be the increased land disturbance and particulate matter generated for the larger area for the excavated rock storage pile and additional ventilation shafts from the larger *subsurface* repository. DOE would monitor the excavated rock storage pile, ventilation shafts, and other areas to ensure compliance with applicable air quality standards throughout the construction, operations, monitoring, and closure periods. Carbon dioxide output would be related to fossil-fuel demand, which would be the same annually for Inventory Modules 1 or 2 as that for the Proposed Action but would last for a longer period.

8.2.2.1 Construction

The repository construction period for Inventory Module 1 or 2 would produce the same levels of all pollutants and cristobalite because the amount of surface or subsurface construction during this 5-year period would be constant. The additional excavation necessary for Module 1 or 2 would occur during the operations period. The land disturbance outside the analyzed land withdrawal area and near the boundary of the *land withdrawal area* would not change. The air concentrations would still be less than the applicable regulatory limits, as reported in Chapter 4, Section 4.1.2.1.

8.2.2.2 Operations and Monitoring

The operations period for Inventory Module 1 or 2 would produce the same levels of gaseous pollutants but slightly higher concentrations of particulate matter and cristobalite. During the operations period, the excavated rock storage pile for Inventory Module 1 or 2 would contain between two and three times the amount of excavated rock as that for the Proposed Action. This could increase the amount of particulate matter with an aerodynamic diameter of 10 micrometers or less (PM_{10}) released to the air and increase the PM_{10} concentration. However, due to the distance between the excavated rock storage pile and the boundary of the analyzed land withdrawal area, the PM_{10} concentration from the rock pile would still be significantly less than the regulatory limit. The cristobalite concentration would be less than 0.05 percent of the regulatory limit. The amount of land disturbed by ventilation shafts would increase.

As shown in Chapter 4, Section 4.1.2.2, all pollutant concentrations would be less than the applicable regulatory limits for the Proposed Action during the operations period. Because the development of the emplacement *drifts* for Module 1 or 2 would take additional time in comparison with that for the Proposed Action, these releases of criteria pollutants would occur over a longer period than those for the Proposed Action.

During the subsequent monitoring and maintenance activities, the concentrations would decrease considerably and would be the same as those reported in Chapter 4, Section 4.1.2.3.

8.2.2.3 Closure

Closure of the proposed repository for Inventory Module 1 or 2 could produce comparable, but slightly higher, concentrations of gaseous pollutants, particulate matter, and cristobalite than those estimated for the Proposed Action. The concentrations would be much less than the applicable regulatory limits. With Inventory Module 1 or 2, the amount of backfill necessary would be larger than that for the Proposed Action, and the size of the excavated rock storage pile to reclaim would be larger. The duration of the closure period for Inventory Module 1 or 2 would be longer than that of the Proposed Action, which could result in minor changes in the air concentrations between the Proposed Action and Inventory Module 1 or 2.

As in the Yucca Mountain FEIS, other reasonably foreseeable actions would be unlikely to have cumulative impacts with the repository or Modules 1 or 2 because they would be sufficiently far away that plumes would have limited potential for overlap. Further, the responsible agencies would take measures for each action to minimize regional air quality impacts. Repository activities would have no effect on air quality in the Las Vegas Valley air basin, which is a *nonattainment area* for carbon monoxide and PM_{10}, because the basin is approximately 120 kilometers (75 miles) southeast of the proposed repository site. Section 8.2.7.2 evaluates radiological air quality cumulative impacts.

8.2.3 HYDROLOGY

The cumulative preclosure potential impacts to surface waters and *groundwater* from Inventory Module 1 or 2 and other federal, non-federal, or private actions would be similar to those described in Section 8.2.3 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 8-39 to 8-43), which this section incorporates by reference and summarizes.

8.2.3.1 Inventory Module 1 or 2

8.2.3.1.1 *Surface Water*

Potential surface-water impacts from Inventory Module 1 or 2 would be relatively minor and would include the following:

- Introduction and movement of *contaminants*,
- Changes to runoff or infiltration rates, and
- Alterations of natural drainage.

Introduction and Movement of Contaminants

Inventory Module 1 or 2 would result in essentially no change in the potential for soil *contamination* during the construction, operations, monitoring, and closure periods. Neither the types of contaminants nor the operations that could involve spills or releases would change, but the operations would last longer. Similarly, there would be no change in the threat of flooding to cause contaminant releases.

Changes to Runoff or Infiltration Rates

Inventory Module 1 or 2 would require the disturbance of additional land, primarily as a result of the need for more area for the excavated rock storage pile and the need to construct additional ventilation shafts for the subsurface area. The additional land disturbance would be small (less than 20 percent) in comparison with the total 9 square kilometers (2,200 acres) that the Proposed Action without Inventory Module 1 or 2 would disturb. This increase in disturbed land would be a relatively small portion of the natural drainage areas and would make little difference in the amount of water that soaked into the ground or reached the intermittently flowing drainage channels, particularly because most of the additional land disturbance (for the excavated rock storage pile) would be in areas where stormwater *detention ponds* would control runoff. Disturbed areas not covered by structures would slowly return to conditions similar to those of the surrounding undisturbed ground.

Alterations of Natural Drainage

No additional actions or land disturbances from Inventory Module 1 or 2 would involve a potential to alter noteworthy natural drainage channels in the area beyond those the Proposed Action alters. The excavated rock storage pile and its increased size for Module 1 or 2 would be in an area already altered and controlled through the installation of collection ditches and stormwater detention ponds. Potential impacts to *floodplains* would be the same as those described for the Proposed Action (Chapter 4, Section 4.1.3.1.4). Construction could involve the placement of structures, facilities, or roadways in or over drainage channels or their associated floodplains (or flood zones) and could affect the 100- and 500-year floodplains of *Fortymile Wash*, Busted Butte Wash (also known as Dune Wash), Drill Hole Wash, and Midway Valley Wash (also known as Sever Wash) at Yucca Mountain.

8.2.3.1.2 *Groundwater*

Potential groundwater impacts from Inventory Module 1 or 2 would relate to the following:

- The potential for a change in infiltration rates that could increase the amount of water in the *unsaturated zone* and adversely affect the performance of waste containment in the repository or decrease the amount of recharge to the *aquifer*,
- The potential for contaminants to migrate to the unsaturated or saturated groundwater zones during the active life of the repository, and
- The potential for water demands for the repository to deplete groundwater resources to an extent that could affect downgradient groundwater use or users.

Changes to Infiltration and Aquifer Recharge

Under Inventory Module 1 or 2, DOE anticipates changes due to infiltration and recharge rates in three areas—an increase in the size of the excavated rock storage pile, an increase in the number of ventilation shaft operations areas, and an extended scope for subsurface activities. The following paragraphs discuss these items.

Additional land disturbance would result from the continued growth of the excavated rock storage pile. Although the rock pile could have different infiltration rates than undisturbed ground, it probably would not be a recharge location because of the extended depth of unconsolidated material, and it probably would not cause a large change in the amount of water that would otherwise reach recharge areas such as drainage channels.

Increased land disturbance would result from the additional ventilation shaft operation areas and the access roads that DOE would need for the increased size of the repository footprint. These areas of disturbance would be primarily on steeper terrain, uphill from the *portal* areas, where unconsolidated material is probably thin and where disturbances could expose *fractured* bedrock and increase infiltration rates. However, road material or equipment pads would cap much of the disturbed area, and the amount of disturbed land would be small in comparison to the surrounding undisturbed area.

Underground activities and their associated potential to increase recharge due to their use of water would be basically the same as those described for the Proposed Action, except that emplacement drift construction could take up to twice as long to complete in comparison to the Proposed Action. As described for the Proposed Action, the quantities of water in the subsurface that ventilation or pumping did not remove to the surface, and thus were available for recharge, would be small.

Potential for Contaminant Migration to Groundwater Zones

Neither Inventory Module 1 nor 2 would involve additional actions likely to increase the potential for contaminant releases to the environment, although actions, in general, would last longer.

Potential to Deplete Groundwater Resources

Anticipated annual water demand for Inventory Module 1 or 2 would be the same as or very similar to that for the Proposed Action, but the operations period, when both emplacement and subsurface development were occurring, could last two to three times as long. DOE based the repository water demand estimates described in Chapter 4, Section 4.1.3.2 on a maximum design throughput of the surface facilities of about 3,000 MTHM per year of spent nuclear fuel and high-level radioactive waste. Because Inventory Module 1 or 2 would roughly double the amount of materials the facilities handled, it would take about twice as long and the associated water demand, already based on a maximum operational rate, would stay the same. The extended duration of this period (when subsurface development and emplacement were both ongoing) would result in a significant increase in the total water demand for the action, but the annual demand would be unlikely to change in any appreciable amount. As described in Section 4.1.3.2, water demand during this period would probably range from 270,000 to 300,000 cubic meters (220 to 240 acre-feet) per year. A notable change in water demand would be unlikely during the construction period or during the 5 years immediately after the construction period when some building on the surface would still be under way, the subsurface area would still be under construction, and emplacement would be ongoing.

As noted in Chapter 4, Section 4.1.3.2 for the repository portion of the Proposed Action, water demand for the monitoring and closure periods would probably remain unchanged from those identified in the Yucca Mountain FEIS. As in the operations period, closure would take longer with the Module 1 or 2 inventory, but annual demand rates during closure would probably be the same or very similar.

Potential impacts to water resources under Inventory Module 1 or 2 would be very similar to those under the Proposed Action because the annual water demand would change little, and the best understanding of the groundwater resource is that it replenishes on an annual basis as gauged by the perennial yield of the groundwater basin. Under Module 1 or 2, the highest annual water demand would be below estimates of perennial yield for the Jackass Flats *hydrographic area*; this would include the lowest estimated value of perennial yield [720,000 cubic meters (580 acre-feet)] for the western two-thirds of this hydrographic area (Chapter 3, Section 3.1.4.2.2). Chapter 2, Section 2.3 contains more information on regional groundwater use and demand for the combined repository and rail actions.

8.2.3.2 Cumulative Impacts from Inventory Module 1 or 2 and Other Federal, Non-Federal, and Private Actions

As in the Yucca Mountain FEIS, other reasonably foreseeable actions would be unlikely to have cumulative impacts for the repository or Modules 1 or 2. Potential impacts to groundwater from the Proposed Action, including both repository and rail actions as described in Chapter 2, Section 2.3, and from Inventory Module 1 or 2 would be small and limited to the immediate vicinity of land disturbances from the action. The exceptions to this could be the potential impact from water demands on groundwater resources and potential impacts from contaminants in groundwater. With these exceptions, other federal, non-federal, or private action effects would have to occur in the same region of influence to be cumulative with those from the Proposed Action or Inventory Module 1 or 2; no currently identified actions meet this criterion. With respect to impacts from groundwater contamination, there would be very limited potential for the Proposed Action to cause such impacts during the preclosure period. Rather, this is considered a postclosure concern and is addressed in Section 8.3.

The remainder of this discussion addresses potential impacts to groundwater resources from water demand. The discussion of impacts to groundwater resources in Chapter 4, Section 4.1.3.2 includes ongoing water demands from Area 25 of the Nevada Test Site. Area 25 is the proposed location of the primary repository surface facilities. It is also the location of wells J-12, J-13, and the C-wells complex, which would provide water for the Proposed Action and for ongoing Nevada Test Site activities in this area. During the 7-year period from 2000 to 2006, the average Test Site water withdrawal from the *Jackass Flats* hydrographic area for the Area 25 activities has been about 83,000 cubic meters (67 acre-feet) per year (DIRS 181232-Fitzpatrick-Maul 2007, all). In a 2002 analysis, DOE indicated there were no planned expansions of existing operations on the Test Site that would affect water use, but that future programs could involve additional water use (DIRS 162638-DOE 2002, pp. 4-18 and 4-19). DOE assumed that this recent use represents a reasonable estimate of Nevada Test Site water demand, at least in the near term (5 to 10 years). However, it is recognized that the Test Site demand could increase at some time in the more distant future, but water demand for the Proposed Action would decrease over time.

Water demand from rail and repository actions in the Jackass Flats hydrographic area, as described in Chapter 2, Section 2.3, is based on the assumption that rail construction actions, as well as infrastructure improvements, primarily would be scheduled for the 2 years before the start of repository construction. Under this same scenario, and for the combined construction period, water demand for rail and repository activities under Inventory Module 1 or 2 combined with the baseline demands from Nevada Test Site activities would remain below the lowest value of perennial yield estimated for the western two-thirds of the hydrographic area. Estimated water demand for the peak year (which includes the demand for Nevada Test Site activities in Area 25 and for the remaining rail activities that would occur in the Jackass Flat hydrographic area) would be approximately 670,000 cubic meters (540 acre-feet) in comparison with the lowest estimate of perennial yield of 720,000 cubic meters (580 acre-feet) for the western two-thirds of the hydrographic area. Several other years during this combined construction period would have water demands quite similar to the peak year, ranging from 620,000 to 650,000 cubic meters (500 to 530 acre-feet). None of the water demand estimates would approach the high estimate of perennial yield for the entire Jackass Flats hydrographic basin, which is 4.9 million cubic meters (4,000 acre-feet) (Chapter 3, Section 3.1.4.2.2). Potential impacts to groundwater resources from this combined demand would be no different than those described in Chapter 2, Section 2.3 and in more detail in Chapter 4, Section 4.1.3.2; that is, some decline in the water level could be likely near the production wells, and water elevation decreases at the town of Amargosa Valley would probably be no more than 0.4 to 1.1 meter (1.2 to 3.6 feet) (Section 4.1.3.2.6). The reduction in underflow from the Jackass Flats hydrographic area to the *Amargosa Desert* hydrographic area would be less than the quantity of water actually withdrawn from the upgradient area because there would probably be minor changes in groundwater flow patterns as the water level adjusted to the withdrawals. Groundwater flow models predict that the reduction in underflow to the Amargosa Desert would be no higher than 160,000 to 180,000 cubic meters (130 to 150 acre-feet) per year, even with the assumption of a long-term groundwater withdrawal rate of 530,000 cubic meters (430 acre-feet) per year (Section 4.1.3.2).

A new *Draft Supplement Analysis for the Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DIRS 185437–DOE 2008, all) has a preliminary description of water demand estimates as being lower than those estimated in the *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DIRS 101811-DOE 1996, all). A conservative approach would be to look at the estimates in the *Supplement Analysis for the Nevada Test Site FEIS* (DIRS 162638-DOE 2002, pp. 4-18 and 4-19), which identified potential future projects that, if implemented, could involve additional Nevada Test Site water use. The Atlas Facility in Area 6 of the Nevada Test Site could require water primarily for dust suppression during construction. Its operating use of 400 cubic meters (0.32 acre-foot) per year would be minor and would not present a cumulative effect. The Advanced Accelerator applications project would use the most water of the potential projects and would be in either Area 22 or Area 25 of the Nevada Test Site (DIRS 162638-DOE 2002, p. 3-8). This project could require an estimated 4.9 million cubic meters (4,000 acre-feet) for construction and system initialization and about 490,000 to 980,000 cubic meters (400 to 790 acre-feet) per year thereafter. If DOE implemented this project, particularly in Area 25, its water demand could be significant and cumulative with the Proposed Action, although the Supplement Analysis indicated that its water demand would be sustainable by existing groundwater resources (DIRS 162638-DOE 2002, p. 4-19).

Tables 8-3 and 8-4 list documents generated since completion of the Yucca Mountain FEIS that address other proposed actions at the Nevada Test and Training Range and the Nevada Test Site. DOE considered the actions described in these documents as reasonably foreseeable future actions and used the information therein to determine if there would be cumulative impacts when considered with those of the repository action. None of these documents addressed water demand estimates or associated concerns. Based on the document reviews, DOE judged the proposed actions to either have little potential to involve significant water demands or they were proposed for areas outside the Alkali Flat-Furnace Creek groundwater basin, or both. Groundwater moves between the various basins in the Death Valley regional groundwater flow system, but how much the outside basins contribute to the Alkali Flat-Furnace Creek basin is a matter of speculation. Similarly, DOE believes it would be speculative to attempt to gauge the degree to which outside groundwater withdrawals would be cumulative with those inside.

Cumulative demands on the Jackass Flats hydrographic area could have long-term impacts on water availability in the downgradient aquifers beneath the Amargosa Desert. The groundwaters in these areas are hydraulically linked, but even in these adjacent areas the exact nature and extent of the link is a matter of study and some speculation. However, the amount of water being withdrawn in the Amargosa Desert [averaging about 16 million cubic meters (13,000 acre-feet) per year between 2000 and 2004 (Chapter 3, Section 3.1.4.2.1)] is much greater than the quantities being considered for withdrawal from Jackass Flats. If water pumped from Jackass Flats affected levels in the Amargosa Desert, the impacts would be small in comparison with those caused by local pumping in that area (both are in the Alkali Flat-Furnace Creek groundwater basin).

The Nye County Yucca Mountain Project Gateway Area Concept Plan is a land use concept to ensure orderly and compatible development for the area around the repository site entrance (DIRS 182345-

Giampaoli 2007, all). Development could affect available water; Nye County proposed this plan to ensure that development occurred in an orderly manner consistent with the proposed repository land use.

8.2.4 BIOLOGICAL RESOURCES

The cumulative preclosure impacts to biological resources would be similar to those for the Proposed Action in Chapter 4, Section 4.1.4, of this Repository SEIS. Those impacts would occur primarily as a result of site clearing, placement of material in the excavated rock storage pile, habitat loss, and loss of individuals of some animal species during site clearing and from vehicle traffic. Inventory Module 1 or 2 would require disturbance of biological resources in a larger area [as shown in Table 8-4a: 1.3 to 2.6 square kilometers (310 to 630 acres)] than that disturbed under the Proposed Action, primarily because the excavated rock storage pile would be larger.

The Nye County Yucca Mountain Project Gateway Area Concept Plan (DIRS 182345-Giampaoli 2007, all) anticipates potential effects on some species of plants, fish, and wildlife resources. Because this is only a plan, specific impacts cannot be determined.

8.2.5 CULTURAL RESOURCES

The cumulative preclosure impacts to cultural resources could increase slightly from those reported for the Proposed Action (Chapter 4, Section 4.1.5) due to the increase in land disturbance associated with Inventory Module 1 or 2. The emplacement of either module would require small additional disturbances to land in areas surveyed during site characterization activities and an increase in the time of operation. Because repository construction, operations, monitoring, and closure would be federal actions, DOE would identify and evaluate cultural resources, as required by Section 106 of the *National Historic Preservation Act*, and would take appropriate measures to avoid or mitigate adverse impacts to such resources. As a consequence, archaeological information from artifact retrieval during land disturbance would contribute additional cultural resources information to the regional database for understanding past human occupation and use of the land.

The Nye County Yucca Mountain Project Gateway Area Concept Plan (DIRS 182345-Giampaoli 2007, all) is for managing development of the area south of the analyzed land withdrawal area. If implemented, this plan could have impacts on cultural resources; however, there are no currently identified specific actions that would have a noticeable cumulative impact on these resources. To the extent the development involves federal actions, it could be subject to compliance with Section 106 of the *National Historic Preservation Act.*

8.2.6 SOCIOECONOMICS

The cumulative preclosure impacts to socioeconomics would be similar to those in Chapter 4, Section 4.1.6 for the Proposed Action. The increased inventory associated with the modules would not result in a larger number of employees, but would result in a longer duration of the operations period. The annual socioeconomic impacts would occur for a longer period.

Additional cumulative impacts from other reasonably foreseeable federal, non-federal, or private actions could probably be from actions at the Nevada Test Site, as discussed in the Yucca Mountain FEIS. Nye County acknowledges there could be potential impacts to the socioeconomics of the region in the Yucca

Mountain Project Gateway Area Concept Plan (DIRS 182345-Giampaoli 2007, all). This plan, as stipulated earlier, is for management of the development of the area south of the analyzed land withdrawal area and it has no currently identified specific actions that would have a noticeable cumulative impact on socioeconomics. Also, the Department of Justice has proposed a detention facility in *Final Environmental Impact Statement for the Proposed Contractor Detention Facility, Las Vegas, Nevada Area* (DIRS 185475-DOJ 2008, all), with a preferred alternative site in Pahrump, Nevada, employing 200 to 250 personnel upon completion. Operation of the proposed detention facility is anticipated to result in approximately 40 to 50 contractor employees relocating to Nye County, and the remainder of the new contractor employees are expected to be current residents of Clark County who would continue to reside in Clark County within commuting distance of the selected site.

Information on jobs associated with the construction or operation of proposed solar and wind energy facilities are not available.

8.2.7 OCCUPATIONAL AND PUBLIC HEALTH AND SAFETY

8.2.7.1 Industrial Hazards

The preclosure cumulative impacts to nonradiological occupational health and safety would increase proportionately (from that presented for the Proposed Action in Chapter 4, Section 4.1.7.1) with the number of full-time equivalent worker years on the project. This effect on impacts during the operations period is attributable to a linear relationship to the total number of processed waste packages. Table 8-4b lists the total numbers of waste packages DOE would handle during the operations period for each inventory module and disposal case. As presented in Section 4.1.7.1, half of the estimated impacts for the Proposed Action would occur during the operations period. Therefore, the total estimated impacts from industrial hazards could increase by the percentage shown in Table 8-4b over the impacts in Section 4.1.7.1. The estimated values are shown in the last three columns of Table 8-4b.

Table 8-4b. Estimated industrial hazard impacts for the inventory modules.

Inventory Module/Case	Total number of waste packages[a]	Percentage increase waste package handling operations over Proposed Action	Total project period increase of industrial hazard impacts (percent)[b]	Total recordable cases	Lost workday cases	Fatalities
Module 1A	25,900	130	65	2,970	1,320	1.52
Module 1B	21,600 – 24,700	93 – 120	60	2,880	1,280	1.47
Module 2A	37,900	240	120	3,960	1,760	2.02

a. Estimated number of waste packages in the Proposed Action would be 11,200.
b. Percent increase from the values in Table 4-22.

Nye County Public Safety Report (DIRS 182710-NWRPO 2007, all) addresses Nye County’s concerns and provides recommendations on public safety issues. Nye County recommends a comprehensive and integrated approach for public safety services with DOE, including fire, emergency, medical, and law enforcement services.

8.2.7.2 Radiological Impacts

This section discusses preclosure radiological health and safety impacts to workers and members of the public from construction, operations, monitoring, and closure activities at the *Yucca Mountain site* for Inventory Module 1A, 1B, or 2A. Appendix D, Section D.3 contains the approach and methods DOE used to estimate radiological health and safety impacts and detailed radiological impact results for the Proposed Action, which are presented in Chapter 4, Section 4.1.7.

The radiological characteristics of the spent nuclear fuel and defense high-level radioactive waste for Inventory Module 1 or 2 would be the same as those for the Proposed Action. However, there would be more material to emplace, as listed in Table 8-2a. DOE assumed the commercial high-level radioactive waste in Module 1B would exhibit the same radiological characteristics as the commercial high-level radioactive waste from the West Valley Demonstration Project, which is defined in the Yucca Mountain FEIS (DIRS 155970-DOE 2002, Appendix A, Section A.2.3)

The estimated volume of Greater-than-Class-C and Greater-than-Class-C-like low-level radioactive wastes in Module 2A has increased from that analyzed in the Draft Repository SEIS for Module 2. The estimated volume of 36,000 cubic meters includes projected Greater-than-Class-C-like wastes that could be generated as a result of the proposed Advanced Fuel Cycle Facility, which is a project-specific alternative in the GNEP Draft Programmatic EIS (DIRS 185296-Joyce 2008, all). For this analysis, the radiological constituents of the Greater-than-Class-C or Greater-than-Class-C-like wastes would be similar to those described in Appendix A of the Yucca Mountain FEIS.

The primary parameters that would affect the magnitude of worker health and safety impacts between the Proposed Action and the inventory module would be the number of waste package handling operations, which would also affect the size of the excavated repository. For the public, the principal changes in parameters that would affect the magnitude of the health impact estimates would be the length of the various periods and the rate at which air containing radon-222 would exhaust from the repository. The exhaust rate of the repository ventilation system would affect the worker exposures from manmade radionuclides and radon-222 concentrations and the quantity of *radionuclides* released to the environment. Appendix D, Section D.3.1, discusses potential releases of radon-222 and manmade radionuclides during the project periods for the Proposed Action. The amount of radon released from the larger repository required for the inventory modules would increase linearly with the ratio of excavated volume to that required for the Proposed Action. This ratio is roughly linear to the increased number of waste packages. Therefore, doses to workers and the public as a result of radon release to the atmosphere would increase by the factors presented in the third column of Table 8-4b.

For comparison, Table 8-5 lists the radiological impacts to workers for each repository analytical period and for the entire project duration for the Proposed Action. Tables 8-5a, 8-5b, and 8-5c list the radiological impacts to workers for each repository analytical period and for the entire project duration for Inventory Modules 1A, 1B, and 2A, respectively.

The estimated radiological impacts would include potential *doses* and radiological health impacts to *involved workers*, *noninvolved workers*, and the total for all workers. Radiological health impacts for maximally exposed individuals would be the increase in the *probability* of a *latent cancer fatality* from the *radiation* dose received. Radiological health impacts for populations would be the estimated number of latent cancer fatalities that resulted from the collective radiation dose received. The estimated number

Table 8-5. Estimated radiation doses and radiological health impacts to workers for each analytical period and the entire project duration—Proposed Action.

Worker group and impact category	Construction	Operations	Monitoring	Closure	Entire project
Proposed Action					
Maximally exposed worker					
Dose (rem)					
Involved	0.49	30	13	1.6	30
Noninvolved	0.052	0.25	0.21	0.028	0.25
Probability of latent cancer fatality					
Involved	0.00029	0.018	0.0078	0.00097	0.018
Noninvolved	0.000031	0.00015	0.00012	0.000017	0.00015
Worker population					
Collective dose (person-rem)					
Involved	33	4,200	890	400	5,500
Noninvolved	4.7	190	26	18	240
Nevada Test Site noninvolved	0.12	9.2	8.9	1.2	19
Total	38	4,400	930	420	5,800
Number of latent cancer fatalities					
Involved	0.02	2.5	0.54	0.24	3.3
Noninvolved	0.0028	0.12	0.016	0.011	0.14
Nevada Test Site noninvolved	0.000074	0.0055	0.0053	0.00073	0.012
Total	0.023	2.6	0.56	0.25	3.5

Table 8-5a. Estimated radiation doses and radiological health impacts to workers for each analytical period and the entire project duration—Module 1A.

Worker group and impact category	Construction	Operations	Monitoring	Closure	Entire project
Inventory Module 1A					
Maximally exposed worker					
Dose (rem)					
Involved	0.49	30	13	1.6	30
Noninvolved	0.052	0.25	0.21	0.028	0.25
Probability of latent cancer fatality					
Involved	0.00029	0.018	0.0078	0.00097	0.018
Noninvolved	0.000031	0.00015	0.00012	0.000017	0.00015
Worker population					
Collective dose (person-rem)					
Involved	33	9,700	2,100	920	13,000
Noninvolved	4.7	440	60	42	550
Nevada Test Site noninvolved	0.12	21	21	2.8	44
Total	38	10,000	2,200	970	13,000
Number of latent cancer fatalities					
Involved	0.020	5.8	1.2	0.55	7.6
Noninvolved	0.0028	0.28	0.037	0.025	0.34
Nevada Test Site noninvolved	0.000074	0.013	0.012	0.0017	0.027
Total	0.023	6.0	1.3	0.58	7.9

of latent cancer fatalities for repository workers during the construction, operations, monitoring, and closure periods for Module 1A could be about 7.9 fatalities. Impacts for Module 1B would be lower due to the decrease in the number of waste packages. The estimated number of latent cancer fatalities for repository workers during the construction, operations, monitoring, and closure periods for Module 2A

Table 8-5b. Estimated radiation doses and radiological health impacts to workers for each analytical period and the entire project duration—Module 1B.

Worker group and impact category	Construction	Operations	Monitoring	Closure	Entire project
Inventory Module 1B					
Maximally exposed worker					
Dose (rem)					
Involved	0.49	30	13	1.6	30
Noninvolved	0.052	0.25	0.21	0.028	0.25
Probability of latent cancer fatality					
Involved	0.00029	0.018	0.0078	0.00097	0.018
Noninvolved	0.000031	0.00015	0.00012	0.000017	0.00015
Worker population					
Collective dose (person-rem)					
Involved	33	9,300	2,000	880	12,000
Noninvolved	4.7	420	58	40	520
Nevada Test Site noninvolved	0.12	20	20	2.7	43
Total	38	9700	2,100	930	13,000
Number of latent cancer fatalities					
Involved	0.020	5.5	1.2	0.53	7.3
Noninvolved	0.0028	0.27	0.035	0.024	0.33
Nevada Test Site noninvolved	0.000074	0.012	0.012	0.0016	0.026
Total	0.023	5.8	1.2	0.55	7.6

Table 8-5c. Estimated radiation doses and radiological health impacts to workers for each analytical period and the entire project duration—Module 2A.

Worker group and impact category	Construction	Operations	Monitoring	Closure	Entire project
Inventory Module 2A					
Maximally exposed worker					
Dose (rem)					
Involved	0.49	30	13	1.6	30
Noninvolved	0.052	0.25	0.21	0.028	0.25
Probability of latent cancer fatality					
Involved	0.00029	0.018	0.0078	0.00097	0.018
Noninvolved	0.000031	0.00015	0.00012	0.000017	0.00015
Worker population					
Collective dose (person-rem)					
Involved	33	14,000	3,000	1,400	19,000
Noninvolved	4.7	640	88	61	800
Nevada Test Site noninvolved	0.12	31	30	4.1	65
Total	38	15,000	3,100	1,400	20,000
Number of latent cancer fatalities					
Involved	0.020	8.50	1.8	0.81	11
Noninvolved	0.0028	0.41	0.054	0.037	0.50
Nevada Test Site noninvolved	0.000074	0.019	0.018	0.0025	0.039
Total	0.023	8.8	1.9	0.85	12

would be about 12 fatalities. Most of the total worker radiation dose would be from the receipt and handling of spent nuclear fuel during the operations period. Radiation *exposure* from inhalation of radon-222 and its *decay* products from radiation that emanated from the subsurface would be contributors to the total dose. DOE identified no other activities in the area that could cause cumulative radiological impacts to repository workers.

For comparison, Table 8-6 lists the estimates of radiological impacts to the public for each repository activity period and the entire project duration for the Proposed Action. Tables 8-6a, 8-6b, and 8-6c list the radiological impacts to the public for each repository analytical period and for the entire project duration for Inventory Modules 1A, 1B, and 2A, respectively. They list estimated radiation doses and health effects for the offsite maximally exposed individual and the potentially exposed population.

Table 8-6. Estimated radiation doses and radiological health impacts to the public for each analytical period and entire project—Proposed Action.

Dose and health impact	Construction	Operations	Monitoring	Closure	Entire project
Proposed Action					
Maximally exposed individual					
Dose (millirem)					
Maximum annual	1.4	7.6	7.5	7.5	7.6
Total	4.2	310	300	41	530
Probability of LCF	0.0000025	0.00019	0.00018	0.000025	0.00032
Exposed 84-kilometer (52-mile) population					
Collective dose (person-rem)	85	6,400	6,100	840	13,000
Number of LCFs	0.051	3.8	3.7	0.51	8

LCF = Latent cancer fatality.

Table 8-6a. Estimated radiation doses and radiological health impacts to the public for each analytical period and entire project—Module 1A.

Dose and health impact	Construction	Operations	Monitoring	Closure	Entire project
Inventory Module 1A					
Maximally exposed individual					
Dose (millirem)					
Maximum annual	1.4	18	17	17	18
Total	4.2	720	690	95	1,200
Probability of LCF	0.0000025	0.00044	0.00042	0.000058	0.00074
Exposed 84-kilometer (52-mile) population					
Collective dose (person-rem)	85	15,000	14,000	1,900	31,000
Number of LCFs	0.051	8.8	8.6	1.2	19

LCF = Latent cancer fatality.

The radiological doses and health impacts would result primarily from exposure of the public to naturally occurring radon-222 and its decay products released from the subsurface facilities in ventilation exhaust air. The calculated increase in probability that the maximally exposed individual would experience a latent cancer fatality would be less than 0.00074 for Module 1A. Module 1B would be slightly lower due to the decrease in the number of waste packages. The calculated increase in probability that the maximally exposed individual would experience a latent cancer fatality would be less than 0.0011 for Module 2A. The estimated increase in the number of latent cancer fatalities could be 19 or 27 for the exposed population within 84 kilometers (52 miles) over the entire project duration for Modules 1A or 2A, respectively.

Table 8-6b. Estimated radiation doses and radiological health impacts to the public for each analytical period and entire project—Module 1B.

Dose and health impact	Construction	Operations	Monitoring	Closure	Entire project
Inventory Module 1B					
Maximally exposed individual					
Dose (millirem)					
Maximum annual	1.4	17	17	17	17
Total	4.2	690	660	90	1,200
Probability of LCF	0.0000025	0.00042	0.00040	0.000055	0.00071
Exposed 84-kilometer (52-mile) population					
Collective dose (person-rem)	85	14,000	13,000	1,900	30,000
Number of LCFs	0.051	8.4	8.2	1.1	18

LCF = Latent cancer fatality.

Table 8-6c. Estimated radiation doses and radiological health impacts to the public for each analytical period and entire project—Module 2A.

Dose and health impact	Construction	Operations	Monitoring	Closure	Entire project
Inventory Module 2A					
Maximally exposed individual					
Dose (millirem)					
Maximum annual	1.4	26	25	25	26
Total	4.2	1,100	1,000	140	1,800
Probability of LCF	0.0000025	0.00064	0.00061	0.000085	0.0011
Exposed 84-kilometer (52-mile) population					
Collective dose (person-rem)	85	22,000	21,000	2,800	45,000
Number of LCFs	0.051	13	13	1.7	27

LCF = Latent cancer fatality.

Statistics published by the Centers for Disease Control and Prevention indicate that during 1998, 24 percent of all deaths in the State of Nevada were attributable to *cancer* of some type (DIRS 153066-Murphy 2000, p. 8). Assuming this rate would remain unchanged for the projected population in 2067 of about 117,000 within 84 kilometers (52 miles) of the Yucca Mountain site, about 28,000 members of this population would be likely to die from cancer-related causes. During the project duration, the corresponding number of cancer deaths unrelated to the project in the general population would be 42,000.

A *Draft Supplement Analysis for the Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DIRS 185437-DOE 2008, all) has a preliminary report that the maximum combined individual dose from current and projected Nevada Test Site operations would be approximately 0.6 millirem per year. Because the calculated population dose has been less than 0.6 person-rem for over a decade, the population dose to residents within 80 km (50 miles) is no longer estimated (DIRS 185437-DOE 2008, all, Section 5.4.4).

With one exception, DOE identified no other federal, non-federal, or private actions with spatially or temporally coincident short-term impacts in the region of influence that would result in cumulative health and safety impacts with those of the proposed repository. Chapter 3 discusses potential radiological doses from past weapons testing at the Nevada Test Site. Residents who were present during the periods when weapons testing occurred (in particular, atmospheric weapons testing from the 1950s to the early 1960s) could have received as much as 5 *rem* to the thyroid from iodine-131 releases. Using a tissue-weighting factor of 0.05 as specified in Publication 60 of the International Commission on Radiological Protection (DIRS 101836-ICRP 1991, all), this would equate to an effective *dose equivalent* of about 250 millirem. DOE has not added this dose to the dose to the hypothetical maximally exposed individual, but has included this information so long-term residents in the region of influence can evaluate their potential for impacts from past nuclear weapons testing. Potential radiological doses from past weapons testing at the Nevada Test Site could result in additional impacts to residents who were present during that period. Assuming the maximally exposed individual was present during the entire period in which weapons testing occurred, the maximally exposed individual doses listed in Tables 8-6 through 8-6c could increase by as much as 250 millirem.

8.2.8 ACCIDENTS

The cumulative preclosure impacts of *accidents* related to Inventory Modules 1 and 2 would be the same as those for the Proposed Action. In summary, disposal in the proposed repository of Inventory Module 1 or 2 could result in a very small increase in the estimated risk from accidents described in Chapter 4, Section 4.1.8 for the Proposed Action. Workers would handle the same types of materials, but the repository operations period would be longer.

Additional cumulative impacts from other federal, non-federal, or private actions have decreased from those in the Yucca Mountain FEIS due to the likely elimination of an action—the proposed VentureStar®/ Kistler project—because Kistler filed to reorganize under Chapter 11 of the U.S. Bankruptcy Code (DIRS 169260-Kistler Aerospace 2003, all). DOE does not expect other federal, non-federal, or private actions in the region to have cumulative accident impacts.

8.2.9 NOISE

The cumulative preclosure impacts on noise would be the same as those in Chapter 4, Section 4.1.9 for the Proposed Action. In summary, the emplacement of Inventory Module 1 or 2 would have noise levels from the construction and operation of the repository similar to those for the Proposed Action. An increase in noise impacts from Module 1 or 2 would result only from the increased number of shipments to the site. The expected rate of receipt would be about the same as that for the Proposed Action; therefore, the impact would be an extended period that shipping would continue beyond the Proposed Action.

DOE does not expect other federal, non-federal, or private actions in the region to add measurable noise impacts to those of the Proposed Action or Inventory Module 1 or 2 because the other activities would be some distance from the proposed repository, and overall increased noise would be unlikely.

8.2.10 AESTHETICS

The cumulative preclosure impacts to aesthetics for Inventory Modules 1 and 2 would be the same as those for the Proposed Action. In summary, there would be no impacts for Inventory Module 1 or 2 beyond those described in Chapter 4, Section 4.1.10 because the profile of the repository facility would not be different as a result of implementation of these modules. There would be no difference in the appearance of the access road or facilities built outside the analyzed land withdrawal area.

Additional cumulative impacts from other reasonably foreseeable federal, non-federal, or private actions would most likely be from anticipated growth adjacent to the repository. Nye County has written the Yucca Mountain Project Gateway Area Concept Plan (DIRS 182345-Giampaoli 2007, all) to assist in managing the development of the area outside the analyzed land withdrawal area. Future development along U.S. Highway 95 would change the landscape from its current undeveloped state; however, the plan would manage this development to minimize aesthetic impacts.

8.2.11 UTILITIES, ENERGY, MATERIALS, AND SITE SERVICES

Preclosure cumulative impacts for utilities, energy, materials, and site services for the disposal of Inventory Modules 1 or 2 would have only minor differences from those in Chapter 4, Section 4.1.11 for the Proposed Action. Because the surface facilities and the annual throughput would be the same for the inventory modules, annual impacts to electricity use, fossil-fuel demand, and residential water and sewer services would be the same as those for the Proposed Action, but would last for a longer operations period.

The emplacement of the larger inventories of Module 1 or 2 would require two to three times the subsurface excavation and underground construction materials, as listed in Table 8-6a.

Additional cumulative impacts from other reasonably foreseeable federal, non-federal, or private actions would most likely be from anticipated growth adjacent to the repository. Nye County has written the Yucca Mountain Project Gateway Area Concept Plan (DIRS 182345-Giampaoli 2007, all) to assist in managing the development of the area outside the analyzed land withdrawal area. This anticipated growth could result in future use of utilities, energy, and materials. DOE does not anticipate that this additional use would result in measurable strain on the regional supplies of energy or materials.

8.2.12 MANAGEMENT OF REPOSITORY-GENERATED WASTE AND HAZARDOUS MATERIALS

Preclosure cumulative impacts from the management of repository-generated waste and hazardous materials for the disposal of Inventory Module 1 or 2 would have only minor differences from those in Chapter 4, Section 4.1.12 for the Proposed Action. Because the surface facilities and the annual throughput would be the same for the inventory modules, the annual production of all waste types would be the same as that for the Proposed Action, but would last for a longer operations period. As described in Chapter 3, Section 3.1.12.4, there are limitations associated with the current availability of licensed commercial capacity for disposal of low-level radioactive waste. However, additional facilities are expected to be developed because the nation will continue to need to dispose of low-level radioactive waste from nuclear power plants and in the form of industrial and medical wastes. It is reasonable to conclude that disposal capacity would be available.

Additional cumulative impacts from other federal, non-federal, or private actions could occur to waste operations at regional facilities or the Nevada Test Site from the disposal of waste for Inventory Modules 1 and 2. The disposal of construction and demolition debris impacts would not change from those in the Yucca Mountain FEIS.

8.2.13 ENVIRONMENTAL JUSTICE

The cumulative preclosure impacts to *environmental justice* would be the same as those in Chapter 4, Section 4.1.13 for the Proposed Action. This Repository SEIS does not identify any high and adverse impacts to members of the general public. Further, DOE has not identified subsections of the population, including minority or low-income populations, that would receive disproportionate impacts, and it has identified no unique exposure pathways, sensitivities, or cultural practices that would expose minority or low-income populations to disproportionately high and adverse impacts. Therefore, this SEIS concludes that no disproportionately high and adverse impacts to minority or *low-income* populations would result from these cumulative activities.

DOE recognizes that American Indian people who live near Yucca Mountain have concerns about the protection of traditions and the spiritual integrity of the land that extend to the propriety of the Proposed Action, and that the implementation of the Proposed Action would continue restrictions on access to the site. Chapter 4, Section 4.1.5.1.2 discusses these views and beliefs.

8.3 Cumulative Postclosure Impacts in the Yucca Mountain Repository Region

This section updates the estimated postclosure human health and safety cumulative impact analysis of the disposal of the larger inventory projected for Inventory Modules 1 and 2 and references Chapter 8 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 8-1 to 8-116), which discusses cumulative impacts from other federal, non-federal, and private actions.

8.3.1 INVENTORY MODULE 1 OR 2 IMPACTS

The analysis of postclosure performance for Inventory Modules 1 and 2 used a scaling approach based on analyses in the Yucca Mountain FEIS, results for the Proposed Action (Chapter 5), and inventories updated since the completion of the FEIS. As discussed in Section 8.1 of the Yucca Mountain FEIS, the Module 1 inventory would contain 105,000 MTHM of commercial spent nuclear fuel and the *Proposed Action inventory* would contain 63,000 MTHM (DIRS 155970-DOE 2002, pp. 8-2 to 8-20). The first-10,000-year and the 1-million-year peak of the mean doses to individuals in the FEIS would be 60 percent higher for Module 1 than those for the Proposed Action (DIRS 155970-DOE 2002, Table I-13). The commercial spent nuclear fuel inventory in the FEIS for Module 1 would be approximately 67 percent higher than that for the Proposed Action, which indicated approximately a linear relationship between the commercial spent nuclear fuel inventory and individual radiological impacts. Module 2 impacts would add a fraction of a percent to the 1-million-year radiological impacts for the Proposed Action in the FEIS.

DOE used a bounding analysis in the Yucca Mountain FEIS to estimate the postclosure impacts from chemically toxic material. As discussed in Appendix I, Section I.6.2 of the FEIS, due to the nature of the analysis the estimated impacts would be directly proportional to the number of *waste packages* in each inventory (DIRS 155970-DOE 2002, pp. I-54 to I-62). DOE performed a similar bounding analysis for this Repository SEIS so such proportionality would also exist.

In addition to postclosure human health impacts from radioactive and chemically toxic material releases, the other potential postclosure impact that DOE identified would involve biological resources. Although the surface area affected by heat rise would be larger for Inventory Module 1 or 2, the amount of heat per unit area would be constant. Therefore, postclosure biological effects of Module 1 or 2 from heat generated by waste packages that could raise ground surface temperatures would be the same as those described in Chapter 5, Section 5.10 for the Proposed Action.

8.3.1.1 Radioactive and Chemically Toxic Material Scale Factors for Inventory Modules 1 and 2

The Proposed Action contains an inventory that would include 63,000 MTHM of commercial spent nuclear fuel; Case A of the Module 1 inventory would contain 130,000 MTHM (Section 8.1.2.1). The scaling factor for radiological impacts for Module 1 is proportional to the MTHM of commercial spent nuclear fuel. Therefore the scaling factor for Module 1 is 130,000 divided by 63,000 or about 2.1.

Rather than the 130,000 MTHM of commercial spent nuclear fuel, Case B of Module 1 would include 63,000 MTHM of commercial spent nuclear fuel and the 13,400 to 29,000 canisters of commercial high-level radioactive waste from the recycling of the balance of the commercial spent nuclear fuel. From Module 1A to 1B, there would be a reduction of 1,200 to 4,300 waste packages because of the smaller volume of waste to be disposed of. In comparison with Module 1A, Module 1B would reflect a reduction in the total radionuclide content because the uranium and plutonium in the 67,000 MTHM of recycled commercial spent nuclear fuel would have been removed and recycled into new commercial fuel assemblies for use in nuclear reactors. Therefore, DOE expects that the mean annual individual dose for Module 1B would be no greater than that for Module 1A.

The postclosure performance model DOE used for the Proposed Action indicates that waste packages containing high-level radioactive waste could fail earlier than waste packages containing commercial spent nuclear fuel. This would be due primarily to the added strength the TAD canisters would provide to the spent nuclear fuel waste packages. Codisposal waste packages contain DOE spent nuclear fuel and high-level radioactive waste, which would be received at the repository in disposable canisters. Commercial spent nuclear fuel would be placed in TAD canisters prior to insertion in a waste package. DOE has taken no additional containment credit for the TAD canisters after the projected breach of a waste package. Considering this, without further waste package design modifications ,packages containing commercial high-level radioactive waste could fail earlier than their comparable commercial spent nuclear fuel waste packages, resulting in the potential for earlier release. As discussed in Chapter 5, Section 5.1.1.1, the postclosure model predicts that failure of waste packages (including packages containing defense high-level radioactive waste) from stress corrosion cracking would not begin until around 100,000 years. Therefore, disposal of Module 1B would result in little, if any, differences from estimated Module 1A individual doses during the first 10,000 years after repository closure and would affect the timing of the doses only after the first 10,000 years and up to 1 million years after closure.

The estimated Module 2A inventory of Greater-Than-Class C waste has increased since the publication of the Draft Repository SEIS. The postclosure model DOE used for the Yucca Mountain FEIS evaluated the effects of adding approximately 6,000 cubic meters of Greater-Than-Class C waste in Module 2 and found that it increased the results by a fraction of a percent. Based on the analysis in the Yucca Mountain FEIS increasing this projected volume to 36,000 cubic meters would likely have very little effect on the overall annual individual dose beyond that projected for Module 1A.

The scaling factor used to estimate impacts from chemically toxic materials for Module 1 or 2 would be proportional to the number of waste packages. Table 8-4b in Section 8.1.2.1 lists the estimated number of waste packages for Modules 1A, 1B, and 2A. DOE developed the scaling factors by dividing the number of waste packages for each module by the estimated number for the Proposed Action, 11,200. The resultant scaling factors for Modules 1A, 1B, and 2A are 2.3, 2.2, and 3.4, respectively.

8.3.1.2 Waterborne Radioactive Material Impacts

Chapter 5 and Appendix F discuss the Proposed Action postclosure impacts. Table 8-7 summarizes the impacts for the Proposed Action. The estimated impacts from Module 1 would be about twice these values and those from Module 2 would add an additional fraction of 1 percent to the Module 1 values.

Table 8-7. Impacts to the reasonably maximally exposed individual from groundwater releases of radionuclides—combined scenario classes.

	Mean		Median		95th percentile	
	Annual individual dose (millirem)	Probability of LCF[a] per year	Annual individual dose (millirem)	Probability of LCF[a] per year	Annual individual dose (millirem)	Probability of LCF[a] per year
During the first 10,000 years after repository closure	0.24	1.4×10^{-7}	0.13	7.7×10^{-8}	0.67	4.0×10^{-7}
After the first 10,000 years and up to 1 million years after repository closure	2.0	1.24×10^{-6}	0.96	5.7×10^{-7}	9.1	5.4×10^{-6}

a. LCF = Latent cancer fatality; assuming a risk of 0.0006 latent cancer fatality per rem for members of the public (DIRS 174559-Lawrence 2002, p.2).

8.3.1.3 Waterborne Chemically Toxic Material Impacts

Table 8-8 summarizes the impacts from waterborne chemically toxic materials for the Proposed Action. The Yucca Mountain FEIS addressed chromium, but DOE has eliminated it through a screening analysis discussed in Appendix F, Section F.5.1, so Table 8-8 addresses impacts from molybdenum, nickel, and vanadium. The estimated impacts for Modules 1A, 1B, and 2A would increase from that for the Proposed Action by factors of 2.3, 2.2, and 3.4, respectively. By applying these factors to the bounding impact analysis in Appendix F, Section F.5, molybdenum and vanadium would remain below their respective oral reference doses. The oral reference dose for nickel (0.02 milligram per kilogram of body mass per day) would be slightly exceeded (0.0024). Considering the conservative assumptions described in Section F.5.2.1, this estimated concentration and intake would be unlikely. One example of a conservative assumption is that the impact estimate neglects time delays, mitigation effects by sorption in rocks, and other beneficial effects of transport in the biosphere; the mass of mobilized waterborne chemically toxic materials would be instantly available at the biosphere exposure locations.

8.3.1.4 Atmospheric Radioactive Material Impacts from Other than Volcanic Eruption

Impacts from nonvolcanic atmospheric releases are discussed in Chapter 5, Section 5.5. These releases would be extremely small. As with the Yucca Mountain FEIS it would not be expected that any significant increase of these impacts would result from Modules 1 and 2.

Table 8-8. Impacts and applicable standards for waterborne chemically toxic materials released during 10,000 years after repository closure—Proposed Action.

Material	Estimated concentration (milligram per liter)	Intake[a] (milligram per kilogram of body mass per day)	Intake standard
			Oral reference dose (milligram per kilogram of body mass per day)
Molybdenum	0.044	0.0013	0.005[b]
Nickel	0.21	0.0073	0.02[c]
Vanadium	0.0001	0.0000054	0.007[d]

Source: Appendix F, Section F.5.2.5 of this Repository SEIS.
a. Assumes daily intake of 2 liters (0.53 gallons) per day by a 70-kilogram (154-pound) individual.
b. DIRS 148228-EPA 1999, all.
c. DIRS 148229-EPA 1999, all.
d. DIRS 103705-EPA 1997, all.

8.3.2 CUMULATIVE IMPACTS FROM OTHER FEDERAL, NON-FEDERAL, AND PRIVATE ACTIONS

Section 8.3.2 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 8-76 to 8-85) discusses the cumulative postclosure impacts from two other sources—Nevada Test Site past, present, and reasonably foreseeable future actions and Beatty low-level radioactive waste disposal and hazardous waste treatment, storage, and disposal facilities. There would be no additional cumulative postclosure impacts beyond those discussed in the FEIS. This section of the Repository SEIS summarizes and updates the information from the FEIS.

8.3.2.1 Nevada Test Site—Past, Present, and Reasonably Foreseeable Future Actions

The primary mission of the Nevada Test Site historically was to conduct nuclear weapons tests. Nuclear weapons testing and other activities have resulted in radioactive contamination at the Test Site. These past activities have continuing potential for radioactive and nonradioactive contamination of some areas of the Test Site, including groundwater under the site. DOE evaluated these areas, the associated contamination, and the potential for contamination for potential cumulative impacts with postclosure impacts from the proposed repository. Deep underground testing and greater confinement disposal categories represent the primary radionuclide inventories that could, combined with the repository inventory, result in increased cumulative impacts. After evaluation, the estimated total potential cumulative impact (Yucca Mountain impact plus Nevada Test Site impact) would be 0.24 millirem per year to the *reasonably maximally exposed individual*. The Test Site impact makes an insignificant contribution to the total.

New actions could also result in additional waste disposal at the Nevada Test Site. This potential new waste, in addition to the waste discussed in the Yucca Mountain FEIS (DIRS 155970-DOE 2002, all) should result in minimal impact for waste management. The total amount of waste DOE expects to dispose of at the Test Site is within the bounds evaluated in the most recent EISs [Nevada Test Site EIS (DIRS 101811-DOE 1996, all) and programmatic waste management EIS (DIRS 101816-DOE 1997, all)] and would not contribute to postclosure impacts beyond those described in the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 8-82 to 8-84).

8.3.2.2 Beatty Low-Level Radioactive Waste Disposal and Hazardous Waste Treatment, Storage, and Disposal Facilities

The low-level radioactive waste disposal facility, formerly operated by U.S. Ecology, a subsidiary of American Ecology, is 16 kilometers (10 miles) southeast of Beatty, Nevada, and 180 kilometers (110 miles) northwest of Las Vegas. This site is about 15 kilometers (9.3 miles) west of the proposed repository. The Nevada State Health Division formally accepted permanent custody of the low-level radioactive commercial waste disposal facility in a letter to American Ecology dated December 30, 1997 (DIRS 148088-AEC 1999, all). The U.S. Ecology Hazardous Waste Treatment, Storage, and Disposal Facility is a *Resource Conservation and Recovery Act*-permitted facility, with *engineered barriers* and systems and administrative controls that minimize the potential for offsite migration of hazardous constituents. DOE has determined that cumulative postclosure impacts from the Beatty low-level radioactive waste disposal facility with the repository would be very small.

8.4 Cumulative Transportation Impacts

This section discusses the results of the cumulative impact analysis of transportation under assumed conditions. The information in Section 8.4.1 covers cumulative impacts of the transportation of spent nuclear fuel and high-level radioactive waste from 72 commercial and 4 DOE sites to the proposed repository. Chapter 6 discusses environmental impacts of national transportation. Section 8.4.2 presents the cumulative impacts from the Rail Alignment EIS.

8.4.1 NATIONAL TRANSPORTATION

This section describes estimated cumulative impacts from national transportation. Section 8.4.1.1 presents potential cumulative impacts from the storage and loading of spent nuclear fuel and high-level radioactive waste at commercial generator sites and DOE facilities. Section 8.4.1.2 presents the potential cumulative impacts from shipment of Inventory Module 1 or 2 from commercial generator sites and DOE facilities to the proposed repository. Section 8.4.1.3 presents potential cumulative national transportation impacts for the Proposed Action and Module 1 or 2 when combined with past, present, and reasonably foreseeable future shipments of radioactive material.

8.4.1.1 Cumulative Impacts of Storage and Loading at Generator Sites

The activities associated with the Proposed Action would include the loading of commercial spent nuclear fuel in TAD canisters at the commercial generator sites, loading of TAD and other canisters in rail *casks*, and loading of the rail casks on railcars. Additional related activities that could result in impacts at the generator sites include the loading of commercial spent nuclear fuel in other canisters, such as *dual-purpose canisters*, and the storage of commercial or DOE spent nuclear fuel or high-level radioactive waste. This section describes the cumulative impacts of these related actions.

The primary cumulative impacts from these actions would be from radiation exposures of workers, fatalities from industrial accidents, and from radiation exposures of members of the public.

Table 8-9 lists the cumulative radiological impacts to workers of storage and loading at the generator sites. DOE based the estimation of impacts of loading of canisters on the same methods and data as those for loading of TAD canisters (see Appendix G). The Department based the estimates of the impacts of

Table 8-9. Estimated cumulative radiological impacts of storage and loading at the generator sites for workers.

Action	Radiation dose (person-rem)	Latent cancer fatalities
Loading of canisters	120	0.074
Storage of canisters[a]	2,400	1.5
Storage of high-level radioactive waste[b]	14,000	8.5
Storage of DOE spent nuclear fuel[c]	3,600	2.2
Proposed Action	10,000	6.0
Total	30,000	18

a. DIRS 175019-Holtec 2002, all.
b. DIRS 101816-DOE 1997, all.
c. DIRS 101802-DOE 1995, all.

canister storage at the commercial generator sites on data for surveillance and maintenance of *dry storage* casks (DIRS 175019-Holtec 2002, all). DOE used a 20-year storage period to estimate impacts for canister storage under the assumptions that the average spent nuclear fuel age would be 25 years and that the spent nuclear fuel would be in a spent nuclear fuel storage pool for 5 years before being moved to dry storage.

DOE based the impacts of the storage of high-level radioactive waste on the impacts in *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (DIRS 101816-DOE 1997, all). The Department based impacts of the storage of DOE spent nuclear fuel on the impacts in *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement* (DIRS 101802-DOE 1995, all). There would be an estimated 18 latent cancer fatalities in the exposed population of workers for loading and storage at the generator sites. These activities would take place at 76 facilities across the United States over 50 years, so the probability of a latent cancer fatality for an individual worker at an individual facility would be small.

Table 8-10 lists the cumulative industrial safety impacts of the loading and storage of spent nuclear fuel and high-level radioactive waste at the generator sites. DOE based the estimation of industrial safety impacts on the same methods and data as those for the loading of TAD canisters (Appendix G). DOE based the impacts of canister storage at the commercial generator sites on data from Holtec (DIRS 175019-Holtec 2002, all) for surveillance and maintenance of dry storage casks.

Table 8-10. Cumulative industrial safety impacts of storage and loading at the generator sites for workers.

Action	Industrial safety fatalities
Loading and storage of canisters[a]	0.0079
Storage of high-level radioactive waste[b]	2.5
Storage of DOE spent nuclear fuel[c]	< 1
Proposed Action	0.25
Total	< 3.8

a. DIRS 175019-Holtec 2002, all.
b. DIRS 101816-DOE 1997, all.
c. DIRS 101802-DOE 1995, all.

DOE based the estimates of impacts of canister storage on a 20-year storage time. It based the impacts of storage of high-level radioactive waste on the impacts in *Final Waste Management Programmatic*

Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste (DIRS 101816-DOE 1997, all). The Department based the impacts of DOE spent nuclear fuel storage on the impacts in *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement* (DIRS 101802-DOE 1995, all). There would be an estimated 4 fatalities from industrial accidents in the population of workers for loading and storage at the generator sites. These activities would take place at 76 facilities across the United States over 50 years, so the probability of a fatality for an individual worker at an individual facility would be small.

8.4.1.2 Inventory Module 1 or 2 Impacts at Generator Sites

This section describes the potential cumulative impacts of loading operations at the generator sites for Inventory Modules 1 and 2. Chapter 6 presents the transportation impacts for the Proposed Action inventory.

For the Proposed Action, DOE would ship 70,000 MTHM of commercial and DOE spent nuclear fuel and high-level radioactive waste from the generator sites to the repository. For Module 1A, the inventory shipped would be about 130,000 MTHM of commercial spent nuclear fuel, about 2,500 MTHM of DOE spent nuclear fuel, and 36,000 canisters of high-level radioactive waste. As discussed in Section 8.1.2.1 for Module 1B, DOE would recycle 67,000 MTHM of commercial spent nuclear fuel of the 143,300 MTHM from Module 1A, convert it to high-level radioactive waste (about 13,400 to 29,000 canisters), and ship it to the repository. Module 2A includes the Module 1A inventory and 12,000 canisters of Greater-Than-Class C radioactive waste, using the bounding estimate for the number of high-level radioactive waste canisters. Table 8-11 lists the numbers of rail and truck casks for the Proposed Action and each of the Modules using the 29,000-canister estimate for high-level radioactive waste.

Table 8-11. Numbers of rail and truck casks for the Proposed Action, Module 1, and Module 2.

Mode	Proposed Action	Module 1A	Module 1B	Module 2A
Rail	9,500	22,000	21,000	34,000
Truck	2,700	5,000	2,700	5,000
Total	12,000	27,000	23,000	39,000

Note: Totals might differ from sums due to rounding.

In Chapter 6, Section 6.2.1, DOE estimated 1.4 fatalities from exposure to vehicle emissions and from traffic fatalities for shipment of empty TAD canisters and campaign kits to generator sites. Based on the increase in the number of casks for Module 1A—about 120 percent—DOE estimated there could be about 3 fatalities from shipment of TAD canisters and campaign kits to generator sites for Module 1A. For Module 1B, TAD canisters and campaign kits would not be necessary for the 67,000 MTHM of commercial spent nuclear fuel that DOE would recycle. Therefore, DOE estimated that there would be about 1.4 fatalities from shipment of empty TAD canisters and campaign kits to generator sites. For Module 2A, the increase in the number of casks would be about 220 percent, and DOE estimated there could be about 4.5 fatalities from shipment of TAD canisters and campaign kits to generator sites. Table 8-12 summarizes these impacts.

In Chapter 6, Section 6.2.2, DOE estimated the probability of a latent cancer fatality for members of the public who would be exposed to radioactive releases from the generator sites would be 0.0017. Based on

Table 8-12. Summary of estimated cumulative fatality impacts at generator sites.

Activity	Proposed Action	Module 1A	Module 1B	Module 2A
Transportation of canisters to generator sites	1.4[a]	3.1[a]	1.4[a]	4.5[a]
Radiation exposure of public around generator sites	0.0017	0.0038[b]	0.0053[b]	0.0054[b]
Radiation exposure of workers at generator sites	6[b]	13[b]	19[b]	19[b]
Industrial accidents at generator sites	0.41[c]	0.91[c]	1.3[c]	1.3[c]

a. From exposure to vehicle emissions and from traffic fatalities.
b. Latent cancer fatalities
c. From industrial accidents, exposure to vehicle emissions, and traffic fatalities for involved and noninvolved workers.

the increase in the number of casks for Modules 1 and 2, DOE estimated the probability of a latent cancer fatality for the exposed members of the public would be 0.0038 for Module 1A, 0.0053 for Module 1B, and 0.0054 for Module 2A (Table 8-12). For Module 1B, this would include the impacts for members of the public around generator and recycling sites for the 67,000 MTHM of spent nuclear fuel that would be recycled.

In Chapter 6, Section 6.2.3, DOE estimated there would be 6 latent cancer fatalities in the population of workers who were exposed to radiation from loading activities at the generator sites. Based on the increase in the number of casks shipped for Modules 1 and 2, DOE estimated there could be 13 latent cancer fatalities among workers for Module 1A, 19 for Module 1B, and 19 for Module 2A (Table 8-12). For Module 1B, this would include the impacts for workers at generator and recycling sites from loading and unloading the 67,000 MTHM of commercial spent nuclear fuel that would be recycled, and the loading of 29,000 canisters of high-level radioactive waste that would result from the recycling in rail casks.

In Chapter 6, Section 6.2.4, DOE estimated 0.41 fatality from industrial accidents, exposure to vehicle emissions, and traffic fatalities for involved and noninvolved workers at the generator sites. Based on the increase in the number of casks shipped for Modules 1 and 2, DOE estimated 0.91 fatality for Module 1A and 1.3 fatalities for Modules 1B and 2A (Table 8-12). For Module 1B, this would include the impacts for involved and noninvolved workers at generator and recycling sites from loading and unloading the 67,000 MTHM of commercial spent nuclear fuel that would be recycled, and the loading of 29,000 canisters of high-level radioactive waste that would result from the recycling in rail casks.

In Chapter 6, Section 6.2.5, DOE estimated the probability of a latent cancer fatality for the population within 16 kilometers (10 miles) of a generator site would range from 1.5×10^{-12} (1 chance in 700 billion) for an accident that involved the drop of a spent nuclear *fuel assembly* to 3.6×10^{-4} (1 chance in 3,000) for an accident that involved the drop of a transfer cask. Although the probability of these accidents could increase with the handling of more spent nuclear fuel, the consequences of the accidents would not increase and the impacts of loading accidents under Module 1 or 2 would be the same as those for the Proposed Action.

8.4.1.3 Inventory Module 1 and 2 Impacts for National Transportation

Table 8-13 lists the impacts for national transportation of spent nuclear fuel and high-level radioactive waste by rail and some truck shipments for the Proposed Action, Module 1, and Module 2. As with the

Table 8-13. National transportation impacts for the Proposed Action, Module 1, and Module 2.

Rail alignment	No. of casks	Members of the public radiation dose (person-rem)	Involved workers radiation dose (person-rem)	Members of the public (latent cancer fatalities)	Workers (latent cancer fatalities)	Vehicle emission fatalities	Radiological accident dose risk (person-rem)	Radiological accident risk (latent cancer fatalities)	Traffic fatalities	Total fatalities
Proposed Action										
Caliente										
Rail	9,495	800	4,700	0.48	2.8	0.99	4.1	0.0025	2.1	6.4
Truck	2,650	350	880	0.21	0.53	0.13	0.068	0.00041	0.57	1.4
Total	12,145	1,200	5,600	0.69	3.4	1.1	4.2	0.0025	2.7	7.8
Mina										
Rail	9,495	700	5,100	0.42	3	0.88	3.7	0.0022	2.2	6.5
Truck	2,650	350	880	0.21	0.53	0.13	0.068	0.00041	0.57	1.4
Total	12,145	1,100	5,900	0.63	3.6	1	3.7	0.0022	2.8	8
Module 1A										
Caliente										
Rail	21,909	1,900	11,000	1.1	6.6	2.3	9.5	0.0057	4.8	15
Truck	5,025	660	1,700	0.4	1	0.25	0.13	0.00077	1.1	2.7
Total	26,934	2,500	13,000	1.5	7.6	2.5	9.6	0.0058	5.9	18
Mina										
Rail	21,909	1,600	12,000	0.98	7	2	8.5	0.0051	5	15
Truck	5,025	660	1,700	0.4	1	0.25	0.13	0.00077	1.1	2.7
Total	26,934	2,300	13,000	1.4	8	2.3	8.6	0.0052	6.1	18
Module 1B										
Caliente										
Rail	20,537	2,300	14,000	1.4	8.3	2.9	12	0.0072	6.1	19
Truck	2,650	350	880	0.21	0.53	0.13	0.068	0.000041	0.57	1.4
Total	23,187	2,700	15,000	1.6	8.8	3.0	12	0.0072	6.7	20
Mina										
Rail	20,537	2,100	15,000	1.2	8.9	2.6	11	0.0064	6.4	19
Truck	2,650	350	880	0.21	0.53	0.13	0.068	0.000041	0.57	1.4
Total	23,187	2,400	16,000	1.4	9.4	2.7	11	0.0065	6.9	20
Module 2A										
Caliente										
Rail	33,909	2,900	17,000	1.7	10	3.5	15	0.0088	7.4	23
Truck	5,025	660	1,700	0.40	1.0	0.25	0.13	0.000077	1.1	2.7
Total	38,934	3,500	19,000	2.1	11	3.8	15	0.0089	8.5	26
Mina										
Rail	33,909	2,500	18,000	1.5	11	3.1	13	0.0079	7.8	23
Truck	5,025	660	1,700	0.40	1.0	0.25	0.13	0.000077	1.1	2.7
Total	38,934	3,200	20,000	1.9	12	3.4	13	0.0080	8.9	26

Note: Totals might differ from sums due to rounding.

cumulative impacts of loading and storage at the generator sites, DOE based the impacts of Module 1 and Module 2 on the impacts of the Proposed Action and on the increases in the number of rail and truck casks for Modules 1 and 2. For the Proposed Action, DOE estimated there could be a total of about 8 fatalities. The majority of these fatalities (about 80 percent) would be from worker radiation exposures and traffic accidents. The Department estimated there could be about 18 total fatalities for Module 1A, about 20 total fatalities from Module 1B, and about 26 total fatalities for Module 2A. As with the Proposed Action, the majority of these fatalities would be from worker radiation exposures and traffic fatalities. For Module 1B, national transportation impacts would include the impacts from transporting 67,000 MTHM of commercial spent nuclear fuel that would be recycled, and the impacts from transporting 29,000 canisters of high-level radioactive waste that would result from the recycling.

DOE does not expect radiological impacts for maximally exposed workers and members of the public to change from those for the Proposed Action due to the conservative assumptions for the Proposed Action analysis (Chapter 6, Section 6.3). Maximally exposed workers would include a crew member, an inspector, and a railyard crew member; maximally exposed members of the public would be a resident along a route, a person in a traffic jam, a person at a service station, and a resident near a rail stop. The assumptions for estimation of radiological doses include the use of the maximum allowed dose rate and conservative estimates of exposure distance and time. For example, DOE used the U.S. Department of Transportation maximum allowable dose rate of 10 millirem per hour at a distance of 2 meters (6.6 feet) [40 CFR 173.44(b)] to estimate exposures to individuals. In addition, it would be unlikely that the actual exposure distance and time for workers and the public would result in greater exposure than DOE's conservative assumptions for the Proposed Action and for Inventory Module 1 or 2.

8.4.1.4 Inventory Module 1 and 2 Impacts for Transportation Associated with the Repository

Chapter 6, Section 6.4.2 describes the impacts of the transportation of construction materials, repository components, and consumables to the repository; the impacts from workers who would commute to the repository; and the impacts of offsite shipment of nonhazardous *solid waste* and hazardous, mixed, and low-level radioactive waste. DOE estimated less than 1 latent cancer fatality and about 13 fatalities from exposure to vehicle emissions and 44 to 46 traffic fatalities due to these transportation activities.

The implementation of Inventory Module 1A, 1B, or 2A would increase this transportation as a result of additional subsurface development and the longer time necessary for repository development, emplacement, and closure. For example, for Modules 1A, 1B, and 2A, DOE would need additional repository components such as waste packages and drip shields. With the increased transportation of other material, personnel, and repository-generated wastes for Module 1A, 1B, or 2A, these transportation impacts could increase to about 14 to 15 fatalities from exposure to vehicle emissions and 47 to 51 traffic fatalities. Less than an estimated 1 latent cancer fatality would occur due to these increased transportation activities.

8.4.1.5 Cumulative Impacts from the Proposed Action, Inventory Module 1 or 2, and Other Federal, Non-Federal, and Private Actions

The overall assessment of the cumulative national transportation impacts for past, present, and reasonably foreseeable future actions concentrated on the cumulative impacts of offsite transportation, which would yield potential radiation doses to a greater portion of the general population than onsite transportation and could result in fatalities from traffic accidents. DOE used the collective dose to workers and to the general population to quantify overall cumulative radiological transportation impacts. The Department chose this measure because it relates directly to latent cancer fatalities with the use of a cancer risk coefficient and because of the difficulty in identification of a maximally exposed individual for shipments throughout the United States from 1943 through 2073. Operations at the Hanford Site and the Oak Ridge Reservation began in 1943, and 2073 is when the Repository SEIS analysis assumed radioactive material shipments to the repository for Inventory Module 1 or 2 would end.

The cumulative impacts of the transportation of radioactive material would consist of impacts from:

- Historical DOE shipments of radioactive material to and from the Nevada Test Site, the Idaho National Laboratory, the Savannah River Site, the Hanford Site, the Oak Ridge Reservation, and *naval spent nuclear fuel* and test specimens.

- Reasonably foreseeable actions that include the transportation of radioactive material in various DOE NEPA analyses; for example, the Nevada Test Site EIS (DIRS 101811-DOE 1996, all), the DOE spent nuclear fuel management EIS (DIRS 101802-DOE 1995, all; DIRS 101812-DOE 1996, all), and the DOE waste management EIS (DIRS 101816-DOE 1997, all) (see Table 8-14). In some cases, transportation impacts included impacts that might have been counted twice. For example, Table 8-14 includes the impacts from shipment of 40,000 MTHM of spent nuclear fuel to a potential Private Fuel Storage Facility in Tooele County, Utah (DIRS 157761-NRC 2001, all), but the impacts from the Proposed Action do not account for this 40,000 MTHM. Table 8-14 lists reasonably foreseeable projects that include limited transportation of radioactive material (for example, shipment of submarine reactor compartments from the Puget Sound Naval Shipyard to the Hanford Site for burial and shipments of uranium billets and low-specific-activity nitric acid from the Hanford Site to the United Kingdom). In addition, for reasonably foreseeable future actions for which there was no identified preferred alternative or Record of Decision, the analysis used the alternative that would result in the largest impacts. While this is not an exhaustive list of the projects that could include limited transportation of radioactive material, it indicates that the impacts of such projects would be low in comparison to major projects or general transportation.

- General radioactive materials transportation that would not relate to a particular action; for example, shipments of radiopharmaceuticals to nuclear medicine laboratories and shipments of commercial low-level radioactive waste to commercial disposal facilities.

- Shipments of spent nuclear fuel, high-level radioactive waste, Greater-Than-Class-C waste, and Special-Performance-Assessment-Required waste under the Proposed Action or Inventory Module 1A, 1B, or 2A.

NRC evaluated these types of shipments based on a survey of radioactive materials transportation published in 1975 (DIRS 101892-NRC 1977, all). Categories of radioactive material evaluated in this NRC document included: (1) limited quantity shipments, (2) medical, (3) industrial, (4) fuel cycle, and (5) waste. NRC estimated that the annual collective worker dose for these shipments was 5,600 person-rem (DIRS 101892-NRC 1977, p. 4-15). The annual collective general population dose for these shipments was estimated to be 4,200 person-rem (DIRS 101892-NRC 1977, p. 5-52). These collective dose estimates were used to estimate transportation collective doses for 1943 through 1982 (40 years). Based on the NRC transportation dose assessments, the cumulative transportation collective doses for

Table 8-14. Cumulative transportation-related health effects.

Category	Worker dose (person-rem)	General population dose (person-rem)	Traffic fatalities
Historical DOE shipments (DIRS 101811-DOE 1996, all)	330	230	NL
Reasonably foreseeable actions			
Private Fuel Storage Facility (DIRS 157761-NRC 2001, all)	24	184	0.78
Sodium-Bonded Spent Nuclear Fuel (DIRS 157167-DOE 2000, all)	0.0044	0.032	0.0001
Idaho High-Level Waste and Facilities (DIRS 179508-DOE 2002 , all)	520	2,900	0.98
Surplus Plutonium Disposition (DIRS 118979-DOE 1999, all)	60	67	0.053
Sandia National Laboratories Site-Wide EIS (DIRS 157155-DOE 1999, all)	94	590	1.3
Depleted Uranium Hexafluoride (DIRS 152493-DOE 1999, all)	--	750	4
Tritium Production in a Commercial Light Water Reactor (DIRS 157166-DOE 1999, all)	16	80	0.06
Parallex Project (DIRS 157153-DOE 1999, all)	0.00001	0.00007	0.00005
Los Alamos National Laboratory Site-Wide EIS (DIRS 185511-DOE 2008, all)	910	290	2.7
Plutonium Residues at Rocky Flats (DIRS 155932-DOE 1998, all)	2.1	1.3	0.0078
Import of Russian Plutonium-238 (DIRS 157156-DOE 1993, all)	1.8	4.4	0.0036
Nevada Test Site Expanded Use (DIRS 101811-DOE 1996, all)	--	150	8
Spent nuclear fuel management (DIRS 101802-DOE 1995, all; DIRS 101812- DOE 1996, all)	360	810	0.77
Waste Management Programmatic EIS (DIRS 101816-DOE 1997, all)	16,000	20,000	36
Waste Isolation Pilot Plant (DIRS 148724-DOE 1997, Appendix E)	790	5,900	5
Molybdenum-99 production (DIRS 101813-DOE 1996, all)	240	520	0.1
Tritium supply and recycling (DIRS 103208-DOE 1995, all)	--	--	0.029
Surplus highly enriched uranium disposition (DIRS 103216-DOE 1996, all)	400	520	1.1
Storage and Disposition of Fissile Materials (DIRS 103215-DOE 1996, all)	--	2,400	5.5
Stockpile Stewardship (DIRS 103217-DOE 1996, all)	--	38	0.064
Pantex (DIRS 103218-DOE 1996, all)	250	490	0.006
West Valley (DIRS 179454-DOE 2003, all)	520	410	0.15
S3G and D1G prototype reactor plant disposal (DIRS 103221-DOE 1997, all)	2.9	2.2	0.010
S1C prototype reactor plant disposal (DIRS 103219-DOE 1996, all)	6.7	1.9	0.0037
Container system for naval spent nuclear fuel (DIRS 101941-USN 1996, all)	11	15	0.045
Cruiser and submarine reactor plant disposal (DIRS 103479-USN 1996, all)	5.8	5.8	0.00095
Submarine reactor compartment disposal (DIRS 103477-USN 1984, all)	--	0.053	NL
Uranium billets (DIRS 103189-DOE 1992, all)	0.5	0.014	0.00056
Nitric acid (DIRS 103212-DOE 1995, all)	0.43	3.1	NL
Los Alamos Relocation of Area 18 FEIS (DIRS 162639-DOE 2002, all)	< 1	< 1	0.00020
Construction, Operation of Depleted DUF_6 Conversion Facility, Portsmouth, Ohio FEIS (DIRS 182373-DOE 2004, all)	520	29	0.45
Enrichment Facility in Lea County, New Mexico (DIRS 182375-NRC 2005, all)	1,500	450	24
Decontamination, Demolition, and Removal of Facilities at West Valley (DIRS 182374-DOE 2006, all)	14	11	0.013
Hanford Site Solid Waste Program FEIS (DIRS 182376-DOE 2004, all)	1,200	11,000	2.4
Moab Uranium Mill Tailings FEIS (DIRS 182377-DOE 2005, all)	0.09	3.4	0.33
Mixed-Oxide Fuel Fabrication at Savannah River Site (DIRS 178816-NRC 2005, all)	530	560	0.056
Complex Transformation Programmatic EIS (DIRS 185273-DOE, 2007, all)	3,700	210	0.20
Subtotal of historical DOE shipments and reasonably foreseeable actions	28,000	49,000	94
General radioactive material transportation (1943 to 2073)	350,000	300,000	28
Subtotal of nonrepository-related transportation impacts	380,000	350,000	120
Proposed Action	5,600 – 5,900	1,100 – 1,200	2.7 – 2.8
Module 1A	13,000	2,300 – 2,500	5.9 – 6.1
Module 1B	15,000 – 16,000	2,400 – 2,700	6.7 – 6.9
Module 2A	19,000 – 20,000	3,200 – 3,500	8.5 – 8.9
Total collective dose (total latent cancer fatalities) and total traffic fatalities			
Proposed Action	390,000 (230)	350,000 (210)	120
Module 1A	390,000 (230)	350,000 (210)	130
Module 1B	400,000 (240)	350,000 (210)	130
Module 2A	400,000 (240)	350,000 (210)	130

Note: Numbers are rounded to 2 significant figures; therefore, totals may differ from sums.
NL = Not listed; information was not listed in the reference.

1943 through 1982 were 220,000 person-rem for workers and 170,000 person-rem for the general population.

In 1983, another survey of radioactive materials transportation in the United States was conducted. This survey included NRC, *Agreement State* licensees, and DOE. Both spent nuclear fuel and radioactive waste shipments were included in the survey. Weiner et al. (DIRS 146270-Weiner et al. 1991, all) used the survey to estimate collective doses from general transportation. These transportation dose assessments were used to estimate transportation doses for 1983 through 2073 (91 years). Weiner et al. evaluated eight categories of radioactive material shipments: (1) industrial, (2) radiography, (3) medical, (4) fuel cycle, (5) research and development, (6) unknown, (7) waste, and (8) other. Based on a median external exposure rate, an annual collective worker dose of 1,400 person-rem and an annual collective general population dose of 1,400 person-rem were estimated (DIRS 146270-Weiner et al. 1991, Table VI). Over the 91-year period from 1983 through 2073, the collective worker and general population doses would be 130,000 person-rem.

For the period from 1943 through 2073, the collective worker dose would be 350,000 person-rem and the collective population dose would be 300,000 person-rem.

NRC evaluated traffic fatalities and estimated that there could be 0.213 traffic fatality per year from radioactive material shipments (DIRS 101892-NRC 1977, p. 5-52). Using this estimate, for the 131-year period between 1943 through 2073, there could be 28 traffic fatalities.

Table 8-14 lists the cumulative doses to workers and the general population from the transportation of radioactive material, and it lists the numbers of traffic fatalities. The estimated cumulative transportation-related collective worker doses would range from 390,000 to 400,000 person-rem (230 to 240 latent cancer fatalities) for the Proposed Action, Modules1A, 1B, and 2A over the period 1943 through 2073. The estimated general population doses would be about 350,000 person-rem (210 latent cancer fatalities) for the Proposed Action, Modules 1A, 1B, and 2A over the period 1943 through 2073. Most of the doses to workers and the general population would result from general transportation of radioactive material. For perspective, about 600,000 people die from cancer in the United States every year.

For transportation accidents that involved radioactive material, the dominant risk would be from accidents that do not relate to the cargo (traffic or vehicular accidents). The radiological accident risk (latent cancer fatalities) from transportation accidents is typically less than 1 percent of the vehicular accident risk. In addition, no acute radiological fatalities from transportation accidents have ever occurred in the United States. Therefore, the number of vehicular accident fatalities was used to quantify the cumulative impacts of transportation accidents.

From 1943 through 2073, DOE estimated 5 million motor vehicle fatalities and about 130,000 *railroad* accident fatalities. Based on the estimated number of traffic fatalities for the reasonably foreseeable actions and for the Proposed Action and Inventory Modules 1A, 1B, and 2A in Table 8-14, the transport of radioactive material could contribute a total of about 120 to 130 traffic fatalities over the period 1943 through 2073.

8.4.2 NEVADA RAIL ALIGNMENT TRANSPORTATION

The Rail Alignment EIS, Chapter 5, includes detailed information about the cumulative impacts of each of the technical resource areas evaluated in the Repository SEIS. The Rail Alignment EIS, Chapter 5, is herby incorporated by reference. The cumulative impacts summary Table 8-16 in Section 8.6.1 includes the cumulative impacts from the Rail Alignment EIS.

8.5 Cumulative Manufacturing Impacts

This section describes potential cumulative environmental impacts from the manufacture of repository components DOE would require to emplace Inventory Module 1A, 1B, or 2A in the proposed repository. DOE has identified no adverse cumulative impacts from other federal, non-federal, or private actions because it has identified no actions that, when combined with the Proposed Action or Inventory Module 1A, 1B, or 2A, would exceed the capacity of existing manufacturing facilities.

The overall approach and analytical methods and the baseline data that DOE used for the evaluation of cumulative manufacturing impacts for Inventory Module 1A, 1B, or 2A were the same as those discussed in Chapter 4, Section 4.1.14 for the Proposed Action. The evaluation focused on ways in which the manufacture of repository components could affect environmental resources at a representative manufacturing site and potential impacts to material sources and supplies.

Table 8-15 lists the total number of repository components DOE would require for the Proposed Action and Inventory Modules 1A, 1B, and 2A. The total number would increase by as much as 120 percent for Modules 1A, 1B, and 2A in comparison with the Proposed Action. The highest total number of

Table 8-15. Number of offsite-manufactured components required for the Proposed Action and Inventory Modules 1A, 1B, and 2A.

		Number to be manufactured[a]			
Component	Description	Proposed Action	Module 1A	Module 1B	Module 2A
Rail shipping casks or overpacks	Storage and shipment of SNF and HLW	79	99	99	99
Legal-weight truck shipping casks	Storage and shipment of uncanistered fuel	30	30	30	30
Waste packages	Outside container for SNF and HLW for emplacement in the repository	11,200	25,900	24,800	37,900
TAD canisters	Standardized canisters to hold commercial SNF	7,400	14,300	13,200	26,300
Emplacement pallets	Support for emplaced waste packages	11,200	25,900	24,800	37,900
Drip shields	Titanium covers for waste packages	11,500	26,200	25,100	38,200
Aging overpacks	Metal and concrete storage vaults for aging	2,500	2,500	2,500	2,500
Shielded transfer casks	Casks for transfer of canisters between and in site facilities	6 to 10	10	10	10

a. The number of components is an approximation based on the best available estimates.
HLW = High-level radioactive waste.
SNF = Spent nuclear fuel.
TAD = Transportation, aging, and disposal (canister).

repository components would be for Module 2A, so this was the number that DOE used in the cumulative impact analysis. Section 8.1.2.1 and Table 8-2a present a range of waste canisters for Inventory Module 1B, which would translate to a range of waste packages, TAD canisters, emplacement pallets, and drip shields. For ease of presentation and to be conservative, Table 8-15 presents only the high value of the applicable range.

DOE based the Proposed Action evaluation on a 24-year manufacturing period for all components other than the drip shields. This 24-year period would keep pace with the repository facilities' maximum processing capacity and, therefore, is conservative (a longer manufacturing period would spread the impacts over a longer period). Project timelines have not been established for the inventory modules, but it is reasonable to assume that the additional inventory would require a longer time for handling and emplacement. Similarly, it is reasonable to assume that component manufacturing would occur over an extended period. Because the Module 2A inventory would be more than triple that of the Proposed Action, it would take more than three times as long for repository facilities to handle the inventory at maximum capabilities. This evaluation derived an 80-year manufacturing period for Module 2A components by using the repository's maximum waste package handling rate with the exception of the drip shields, which are not linked to the rate at which the repository facilities would handle waste packages. Because there would be more than triple the number of waste packages under Module 2A than under the Proposed Action, this evaluation made the conservative assumption that drip shields would be needed over a 30-year period, compared with the 10-year period for the Proposed Action evaluation.

Because the increased number of most repository components would be manufactured over a longer period, at a rate very similar to that for the Proposed Action, annual impacts would be very similar. The drip shields, however, would increase in numbers by 230 percent for the Module 2A inventory and the manufacturing period would increase by an estimated 200 percent, going from 10 to 30 years. As a result, the annual Module 2A impacts for air quality, socioeconomics, material use, and waste generation would be as much as 11 percent higher than those for drip shield manufacture in Chapter 4, Section 4.1.14 for the Proposed Action, and these impacts would continue for 30 years rather than the 10 years for the Proposed Action. The total number of worker injuries and illness or fatalities could increase in proportion to the increase in manufactured components, and they would occur over an estimated 110 years considering the assumed 80 years for the manufacture of most components plus the separate 30 years assumed for the drip shields. The potential number of reportable injuries and illnesses over the entire 110-year period for Module 2A could be about 4,600, and the estimated number of fatalities could be 1.7; that is, based on national averages for the type of work involved, a fatality could occur during the manufacture of repository components under Module 2A. As for the Proposed Action, there would be few or no impacts on other resources because existing manufacturing facilities would meet projected manufacturing needs, new construction would not be necessary, and environmental justice impacts (that is, disproportionately high and adverse impacts to minority or low-income populations) would be unlikely.

8.6 Summary of Cumulative Impacts

This section summarizes the cumulative impacts DOE has discussed in this chapter. In addition, it presents the viewpoint of Nye County as a cooperating agency and site of the Proposed Action of this Repository SEIS.

8.6.1 CUMULATIVE IMPACTS FROM ALL SOURCES

Table 8-16 summarizes cumulative impacts from all sources. DOE has included *qualitative* descriptions if they are more meaningful than quantitative values, even though the previous sections might provide quantitative values. In other cases, quantitative values provide a better representation of potential impacts.

Table 8-16. Summary of cumulative impacts.

Resource area	Cumulative impact
Land use and ownership	The ownership, management, and use of the analyzed land withdrawal area would not change for Inventory Module 1 or 2. The amount of land for surface facilities would increase somewhat for Module 1 or 2 because of the larger excavated rock storage area and additional ventilation shafts for the larger repository. This would have no substantial cumulative land use or ownership impact. The Nye County Yucca Mountain Project Gateway Area Concept Plan is a land use concept to ensure orderly and compatible development for the area around the repository site entrance. Development could affect land use. Cumulative impacts to land use and ownership in the Caliente and Mina rail alignment region of influence on local-scale of the proposed railroad and other existing and reasonably foreseeable projects could be moderate to large, particulary in the City of Caliente, the Town of Goldfield, or within the Walker River Paiute Reservation. Cumulative impacts of reasonably foreseeable projects and right-of-way on public land would be small on a regional scale, as they would only affect a small percentage of public land.
Air quality	The activities that produced releases of criteria pollutants (nitrogen dioxide, sulfur dioxide, carbon monoxide, and particulate matter) and carbon dioxide would be roughly the same for Inventory Module 1 or 2 as those described for the Proposed Action. The changes would be the increased land disturbance and particulate matter for the larger excavated rock storage area and additional ventilation shafts from the larger subsurface repository. Carbon dioxide output for Inventory Module 1 or 2 would be the same annually as that for the Proposed Action, but would last for a longer period. In addition, the increase in the manufacturing of drip shields associated with Module 2 could result in 11-percent higher impacts from the drip shield impacts discussed in Chapter 4. Potential cumulative impacts to air quality and climate from construction and operation of a Caliente or Mina railroad would be small, but could approach moderate if the potential violations of the *National Ambient Air Quality Standards* occurred from quarry or staging yard construction.
Hydrology	
Surface water	Additional land disturbances for the emplacement of Inventory Module 1 or 2 would be small and in an area already altered for the Proposed Action. Changes to runoff, infiltration rates, natural drainage alteration, and contaminant movement in soil would not increase much from the Proposed Action. The cumulative impacts to surface-water resources of the Caliente or Mina proposed railroad and other existing or reasonably foreseeable projects would be small. Project planning and best management practices would help avoid or reduce potential impacts to changes in drainage, infiltration rate, and flood control from the proposed railroad or other ongoing or reasonably foreseeable future actions. DOE and other planned projects would be subject to requirements that ensure impacts to wetlands are minimized, and BLM Resource Management Plans have objectives that protect riparian and wetland areas. Spill-control and management plans would reduce the likelihood of spills and contamination from the proposed railroad and other projects.

Table 8-16. Summary of cumulative impacts (continued).

Resource area	Cumulative impact
Groundwater	Anticipated impacts to groundwater from the emplacement of Inventory Modules 1 and 2 would be the same or very similar to those for the Proposed Action. This would include changes to infiltration, potential for contaminant migration, and potential to deplete groundwater resources. Water demand at the start of construction activities for the emplacement of Inventory Module 1 or 2 combined with the baseline demands from the Nevada Test Site would remain below the lowest value of perennial yield, but for only 1 year. The Advanced Accelerator project proposed for the Test Site could increase water use and be cumulative with the Proposed Action. Potential also exists for impacts from the development in the proposed Yucca Mountain Project Gateway Area Concept Plan, which Nye County presented to manage development and minimize impacts. Overall, the needs of the proposed railroad would represent a small portion of the current cumulative water usage within the Caliente or Mina region of influence, which in some locations would continue to exceed perennial yield values. The cumulative impacts to groundwater resources of the proposed railroad and other existing and reasonably foreseeable projects, could be moderate to large but impacts of the proposed railroad would be minimized.
Biological resources and soils	Cumulative preclosure nonradiological impacts to biological resources would be similar to those for the Proposed Action. Those impacts would occur primarily as a result of site clearing, placement of material in the excavated rock storage pile, habitat loss, and the loss of individuals of some animal species during site clearing and from vehicle traffic. Inventory Module 1 or 2 would require disturbance of biological resources in a larger area than the Proposed Action would disturb, primarily because the excavated rock storage pile would be larger. Cumulative impacts to biological resources in the Caliente or Mina rail alignment region of influence could be small to moderate.
Cultural resources	Cumulative preclosure impacts to cultural resources could increase slightly from those for the Proposed Action due to a slight increase in land disturbance for Inventory Module 1 or 2. The emplacement of either module would require small additional disturbances to land in areas DOE surveyed during site characterization activities and an increase in time of operation. The cumulative impacts to cultural resources in the Caliente or Mina rail alignment region of influence would be small because intensive field surveys would be conducted and mitigation measures, including avoidance, implemented. DOE would identify and evaluate cultural resources, as required by Section 106 of the *National Historic Preservation Act*, and would take appropriate measures to avoid or mitigate adverse impacts to such resources.
Socioeconomics	Cumulative preclosure impacts to socioeconomics would be similar to impacts for the Proposed Action. The increased inventory associated with Module 1 or 2 would not result in a larger number of employees, but would result in a longer operations period. Annual socioeconomic impacts would occur for a longer period. In addition, the increase in the manufacturing of drip shields associated with Module 2 could result in 11-percent higher impacts from the drip shield impacts discussed in Chapter 4. The cumulative impacts in the Caliente or Mina rail alignment region of influence could be moderate because of the numerous planned development projects.

Table 8-16. Summary of cumulative impacts (continued).

Resource area	Cumulative impact
Occupational and public health and safety	
Nonradiological	The total estimated impacts from industrial hazards for Inventory Module 1 or 2 could increase by 60 to 120 percent over those impacts for the Proposed Action. The impacts from manufacturing for Modules 1 and 2 would increase in proportion to the increase in components manufactured.
	For both the Caliente and Mina railroads, under Module 1, up to 21,909 casks would be transported to the repository by rail; and under Module 2, 33,909 casks would be transported to the repository by rail. To estimate the cumulative health and safety impacts of Modules 1 and 2, the impacts of the Proposed Action were increased by the ratio of the number of casks transported in the Module versus the Proposed Action. For Module 1, the nonradiological health and safety impacts noted above would increase by an additional 65 percent over the impacts under the Proposed Action. For Module 2, nonradiological health and safety impacts would increase by 119 percent over the impacts under the Proposed Action.
Radiological	Calculated values for latent cancer fatalities for repository workers during the construction, operations, monitoring, and closure periods for Module 1A could be about 7.9 fatalities and, for Module 2A, about 12 fatalities. Impacts for Module 1B would be lower than those for Module 1A due to the decrease in the number of waste packages.. The likelihood that the maximally exposed individual could experience a latent cancer fatality would be less than 0.00074 for Module 1A and 0.0011 for Module 2A. Module 1B would be slightly lower than Module 1A due to the decrease in waste packages.
	For workers along the Caliente or Mina rail line, DOE estimated that there could be 1.2 latent cancer fatalities for Module 1, and 1.7 latent cancer fatalities for Module 2.
	For members of the public along the Caliente rail alignment, DOE estimated that 0.00034 latent cancer fatality for Module 1, and 0.00052 latent cancer fatality for Module 2 could occur from transportation of spent nuclear fuel and high-level radioactive waste.
	For members of the public along the Mina rail alignment, DOE estimated that 0.0020 latent cancer fatality for Module 1, and 0.0030 latent cancer facility for Module 2 could occur from transportation of spent nuclear fuel and high-level radioactive waste.
Accidents	Disposal in the proposed repository of Inventory Module 1 or 2 would result in a very small increase in the estimated risk from accidents.
Noise	The emplacement of Inventory Module 1 or 2 would have noise levels associated with the construction and operation of the repository similar to those for the Proposed Action. An increase in potential noise impacts would be from the increased number of shipments and increased shipping time for Inventory Module 1 or 2.
	Cumulative impacts from noise in the Caliente or Mina rail alignment region of influence could be moderate to large. No vibration impacts would result from the proposed railroad because of the localized and short-term nature of the vibration sources and no cumulative vibration impacts are expected.

Table 8-16. Summary of cumulative impacts (continued).

Resource area	Cumulative impact
Aesthetics	Because the profile of the repository facilities and the appearance of access roads would not change as a result of implementation of Inventory Modules 1 or 2, there would be no additional impacts.
	The Nye County Yucca Mountain Project Gateway Area Concept Plan is a land use concept to ensure orderly and compatible development for the area around the repository. Development could affect aesthetics.
	There would be no known interactions of the proposed railroad with other reasonably foreseeable activities that would affect a Class I or Class II area in the Caliente or Mina regios of influence. The cumulative impacts to aesthetic resources of the proposed railroad and other existing and reasonably foreseeable projects could be small to moderate in the Caliente and Mina regions of influence because of the potential impacts to the Class III and IV land.
Utilities, energy, materials, and site services	Because the surface facilities and the annual throughput would be the same for Inventory Module 1 or 2 and the Proposed Action, annual impacts to electricity use, fossil-fuel demand, and residential water and sewer services would be the same as those for the Proposed Action. These impacts would last for a longer duration due to the increased operations period. In addition, the increase in the manufacturing of drip shields associated with Module 2 could result in 11-percent higher impacts from the drip shield impacts discussed in Chapter 4.
	The Nye County Yucca Mountain Project Gateway Area Concept Plan is a land use concept to ensure orderly and compatible development for the area around the repository. Development could affect utilities, energy, materials, and services.
	The cumulative impacts to utilities, energy, and materials of the proposed Caliente or Mina railroad and other existing and reasonably foreseeable projects would be small..
Waste management	Because the surface facilities and the annual throughput would be the same for Inventory Module 1 or 2 and the Proposed Action, the annual production of waste types would be the same as that for the Proposed Action. These impacts would last for a longer duration due to the increased operations period. In addition, the increase in the manufacturing of drip shields associated with Module 2 could result in 11-percent higher impacts from the drip shield impacts discussed in Chapter 4.
	The cumulative impacts to hazardous materials and waste of the proposed Caliente or Mina railroad and other existing and reasonably foreseeable projects would be small.
Environmental justice	No disproportionately high and adverse cumulative impacts to minority or low-income populations would occur for Inventory Module 1 or 2 or the Caliente or Mina rail alignment.
	DOE recognizes that American Indian people who live in the region have concerns about the protection of traditions and the spiritual integrity of the land that extend to the propriety of the Proposed Action, and that the implementation of the Proposed Action would continue restrictions on access to the site.

8.6.2 NYE COUNTY VIEWPOINT (AS WRITTEN BY NYE COUNTY)

Nye County would host the repository and associated facilities and would be the funnel through which all waste shipments converged for disposal, regardless of the final mode or method of transportation. The proposed repository is one of many federal and private sector actions that have affected, or have the potential to affect, county resources. About 98 percent of the total land area of Nye County is under the stewardship of federal agencies, which have conducted a wide range of activities, including atomic and conventional weapons testing and training, habitat and wilderness preservation, waste disposal, and resource development. Past, present, and reasonably foreseeable future activities by these agencies have direct and indirect cumulative impacts on the county environment and economy. These impacts are cumulative with activities in the private sector, including mining and milling, agriculture, and land development, although impacts from such activities could be offset by economic and other benefits to the county.

From the Nye County perspective, impacts from the proposed repository would be cumulative with all past, present, and reasonably foreseeable future actions by the federal and private sectors. Therefore, in accordance with its status as a cooperating agency for this Repository SEIS, Nye County is providing its perspective on the cumulative impacts of the Proposed Action. DOE based the discussion in this section on the technical resource document prepared by the County (DIRS 182884-NWRPO 2007, all). This section provides an objective assessment that reflects the county's unique perspective on cumulative impacts.

8.6.2.1 Nye County's Assessment of Baseline Environment and Baseline Conditions

In Nye County's view, the baseline for the Proposed Action predates all historical repository-related actions, regardless of when the actions occurred. The conditions that currently exist in the regions of influence include impacts of past repository-related actions (for example, the segregation of certain land from mineral entry), and reflect direct or *indirect impacts* related to the repository program, rather than true baseline conditions. Nye County does not believe that the current existing conditions are the baseline against which DOE should measure repository and cumulative impacts.

Where the implementation of historical federal actions has affected Nye County (for example, withdrawal of public land from any form of public entry for the Nevada Test and Training Range and the Nevada Test Site), the existing conditions include the impacts associated with those actions. Those impacts contribute to the cumulative impacts of past federal actions and to the total cumulative impacts of federal and non-federal actions on the county.

8.6.2.2 Nye County's Assessment of Region of Influence

From the Nye County perspective, the region of influence should include Nye County in its entirety as well as the region around the county. The County recognizes that the region of influence that DOE considered for analysis of cumulative impacts will vary depending on the evaluated element of the affected environment, and that DOE should base its analysis on the region in which impacts could reasonably be expected to occur. For geology, cultural resources, noise, and biological resources and soils, the region of influence can be limited to only those areas that would be disturbed, or where activities would occur. The region of influence for air quality includes all topographic basins in which land disturbances or emissions would occur, and where additional urban development would occur as a result of employee in-migration. For socioeconomics and occupational and public health and safety, the region of influence potentially includes all of Nye County, and could include each potentially affected unit of local government and the State of Nevada. The region of influence for surface-water resources includes hydrographic basins in which DOE would take actions and any basins to which they are tributary. For groundwater resources, the region of influence includes the entire Death Valley regional flow system.

8.6.2.3 Nye County's Assessment of Impacts of Past and Present Federal and Private Sector Actions

Past and present actions by federal agencies in Nye County are characterized in four broad areas: (1) land withdrawals and designations; (2) conventional and nuclear weapons testing and training; (3) waste disposal operations; and (4) congressional mandates regarding land and resource uses. The Nye County technical resource document describes adverse and beneficial direct and indirect impacts from these actions (DIRS 182884-NWRPO 2007, all).

Federal agencies have withdrawn more than 10,500 square kilometers (2.6 million acres) in Nye County for missions that include the Nevada Test Site, Nevada Test and Training Range, Death Valley National Park, National Wildlife Refuges, and American Indian reservations. In addition, agencies have designated more than 240 square kilometers (59,000 acres) for conservation, wildlife, or preservation. These land withdrawals and designations have had or will have significant adverse impacts due to the loss of potential revenues to Nye County from restrictions on development of mineral, renewable energy, oil and gas, and water resources; loss of future productivity from the withdrawn lands; and significant alterations of transportation routes through road closures and lack of rights-of-way across withdrawn lands. The designation by the Bureau of Land Management of about 190 square kilometers (46,000 acres) of federal land in Nye County for disposal to the private sector will result in impacts on water availability, infrastructure, and the environment as development occurs. Impacts from private sector development could be offset by economic and other benefits to the County provided that appropriate resources are applied to ensure development occurs in a controlled manner. Nye County is preparing a Yucca Mountain Project Gateway Area Concept Plan to provide a basis for managing development near the gateway to the repository, but might not have adequate resources to implement the plan without support from DOE. The Proposed Action would permanently withdraw about 180 square kilometers (44,000 acres) of additional public land currently within the taxing district for the town of Amargosa Valley. The impacts of that withdrawal would be cumulative with the other land withdrawals and designations.

Above-ground and subsurface nuclear weapons tests, conventional weapons and weapons systems tests, firing ranges, and activities associated with these operations result in significant disturbances over hundreds of square kilometers. Significant adverse impacts have included blast and collapse craters, radioactive contamination of soils and groundwater, safety hazards from unexploded ordnance, fugitive emissions from contaminated soils, annoyance and startle effects from supersonic aircraft, and a remaining radionuclide burden of more than 300 million *curies*. Significant injury to natural resources, especially water resources, has occurred with a corresponding significant loss of long-term productivity.

Waste disposal actions have included disposal of about 9.8 million curies of radioactive wastes in craters, the Greater Confinement Disposal site, and the Area 5 Radioactive Waste Disposal Site on the Nevada Test Site; disposal of ordnance and other waste on U.S. Air Force and DOE lands; disposal of low-level radioactive waste and hazardous waste at a privately operated site near the community of Beatty; and disposal of municipal waste at Amargosa Valley and Pahrump. Impacts associated with the latter two actions are offset by economic and other benefits to the county. The Proposed Action would add a significant new contribution to the radioactive burden in the county, generate an appreciable volume of industrial and construction wastes, and result in an increased demand for municipal waste disposal capacity in employment and housing centers. If DOE transported the high-level radioactive wastes to the repository site without incident, and the repository performed at least as well as estimated by the *Total*

System Performance Assessment (Chapter 5), no significant new impacts to the environment would result from waste disposal at the repository. However, releases of radioactive constituents during transportation and handling or after emplacement could have significant impacts. *Stigma* associated with waste disposal (and disposal of radioactive waste in particular) could be a significant impact, but would vary by demographics. Although Nye County does not perceive any stigma from the Proposed Action at this time, public perception and the stigma associated with nuclear waste and waste management facilities could attach to the county and affect in-migration, adding to cumulative impacts from the Proposed Action.

Congressional mandates for resource management, protection, and preservation have resulted in significant adverse impacts on Nye County through the imposition of severe restrictions on water, mineral, and land development, with a corresponding decrease in long-term productivity from those lands and loss of potential tax revenues. Impacts from the implementation of the *Nuclear Waste Policy Act* are cumulative with those of other congressional mandates.

8.6.2.4 Nye County's Perspective of Reasonably Foreseeable Future Actions

Reasonably foreseeable future actions considered in Nye County planning include both federal and non-federal actions that are likely to occur by 2050. Federal actions would include continued operations at the Nevada Test Site and the Nevada Test and Training Range; implementation of resource management and general management plans for national parks, wildlife refuges, and public lands; and construction, operation, and closure of a high-level nuclear waste repository at Yucca Mountain.

DOE based the identification of reasonably foreseeable actions by local government and the private sector on planning estimates of future population, land development patterns, and the availability of additional natural resources. Reasonably foreseeable actions by local government and the private sector should lead to an increase in population in Amargosa Valley to about 50,000 persons by 2050, with a corresponding population increase in Pahrump to about 150,000 persons. These projections do not include the incremental impacts from construction and operation of the proposed repository. All remaining farmland in Pahrump should be retired from agriculture by 2030 and agriculture in Amargosa Valley should cease by 2050. At least one new precious metal mine is likely to be permitted and opened in the southern part of the county in a rural, generally undeveloped area; it would have an operating life of 40 years or less. Dairy operations should cease in Pahrump by 2012 and in Amargosa Valley by 2040. The waste disposal site at Beatty is likely to continue operations for 20 years, after which state regulatory authorities will permit no hazardous, mixed-waste, or low-level waste disposal operations. All groundwater resources in the southern part of Nye County will be appropriated and placed to a beneficial use by 2050.

8.6.2.5 Nye County's Perspective of Cumulative Adverse Impacts

The cumulative adverse impacts of past, present, and future federal actions and mandates are significant. The most significant adverse impact is from conventional and nuclear weapons testing activities that have contaminated isolated areas on DOE and U.S. Air Force-controlled lands, and massive and widespread soil and groundwater contamination in large areas on the Nevada Test Site. The Nye County Water Resources Plan (August 2004) estimated that the volume of groundwater contaminated from weapons testing is about 6.17 billion cubic meters (5 million acre-feet). This contamination has significantly reduced the water resources available for use in the county. Contamination of the soils and groundwater on DOE-controlled land is cumulative with that on and under Air Force-controlled lands, and contamination from other sources, which includes waste disposal activities by the federal and private sectors. Soil or groundwater contamination that occurred as a result of the Proposed Action would add to the contamination that has already accumulated, further decreasing the water resources available to the county and the long-term productivity of the contaminated areas.

The second most important adverse impact from past federal actions is the loss of access to lands due to withdrawal by DOE, the Department of Defense, and the Department of the Interior, and the designation of lands for environmental protection through National Parks, National Wildlife Refuges, and Areas of Critical Environmental Concern. More than 8,100 square kilometers (2 million acres) of land in Nye County are not available for the development of mineral and water resources. The withdrawal of additional land for the Proposed Action would add to the cumulative impact of the loss of lands for water and mineral resource development.

The third most important adverse impact from federal actions relates to the inventory of *radioactivity* that weapons testing and past and continuing radioactive waste disposal on the Nevada Test Site, as well as commercial disposal of low-level radioactive waste near Beatty, have deposited in Nye County. In total, more than 300 million curies have been deposited at sites in Nye County, primarily on the Nevada Test Site. The Proposed Action would add an estimated 14 billion or more curies to this cumulative amount.

The last major category of adverse impacts is loss of local control as a result of congressional mandates and federal policies on land and resource use. Early federal policies led to the settlement and development of Nye County and the adverse as well as beneficial impacts from mining, ranching, farming, and urbanization that followed the implementation of these policies. In the mid-1900s, federal policies led to the development of vast weapons testing and military training programs that have resulted in significant adverse environmental impacts as discussed above. Subsequent federal policies aimed at environmental protection led to significant constraints on the development of resources the county needed to sustain its economic viability. Compliance with these more recent federal policies has resulted in reductions in employment in some sectors, increased costs for development of water and land resources, decreased tax revenues, and loss of long-term productivity for large areas in Nye County. DOE based the Proposed Action on a legislative mandate (the *Nuclear Waste Policy Act*) that would impose further constraints on resource utilization and would be cumulative with the significant adverse impacts that have already occurred.

Although Nye County believes that these cumulative adverse impacts have occurred and would increase incrementally as a result of the Proposed Action, it also believes that many of the impacts could be addressed and mitigated through implementation of various, routine measures. Identification and implementation of such measures could be facilitated through consultation and cooperation between the County and DOE. In Chapter 9, Nye County presents its perspective on the types of measures that could be jointly pursued by DOE and Nye County to minimize and mitigate the expected incremental impacts of the Proposed Action. With a memorandum of understanding/consultation and cooperation agreement (NWPA, Section 117), Nye County will assist DOE in the identification of environmental and socioeconomic impacts and their significance, and then cooperatively plan and develop effective mitigation measures. As the situs jurisdiction for the Yucca Mountain Project, Nye County has a tremendous stake in the NEPA process and will continue to participate as a cooperating agency and protect the safety, environmental values, and economic well-being of the residents of Nye County.

REFERENCES

148088 AEC 1999 AEC (American Ecology Corporation) 1999. "AE News, 1998 News Releases." Boise, Idaho: American Ecology Corporation. Accessed April 20, 1999. TIC: 243770. URL: http://www.americanecology.com/page1398.html

103081 BLM 1999 BLM (Bureau of Land Management) 1999. *Cortez Gold Mines, Inc. Pipeline Infiltration Project.* Environmental Assessment NV063-EA98-062. Battle Mountain, Nevada: Bureau of Land Management. ACC: MOL.20010727.0170.

178102 BLM 2004 BLM (Bureau of Land Management) 2004. *Record of Decision for the Approved Nevada Test & Training Range Resource Management Plan and Final Environmental Impact Statement.* Las Vegas, Nevada: U.S. Department of the Interior, Bureau of Land Management. ACC: MOL.20061031.0155.

182343 BSC 2006 BSC (Bechtel SAIC Company) 2006. *2006 Projection of Future Spent Nuclear Fuel Discharges.* 000-00C-CRWW-00100-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20061003.0001.

103162 CEQ 1997 CEQ (Council on Environmental Quality) 1997. *Considering Cumulative Effects Under the National Environmental Policy Act.* Washington, D.C.: Council on Environmental Quality. TIC: 243482.

101214 CRWMS M&O 1996 CRWMS M&O 1996. *Nevada Potential Repository Preliminary Transportation Strategy Study 2.* B00000000-01717-4600-00050 REV 01. Two volumes. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19960724.0199; MOL.19960724.0200.

172280 DLA 2003 DLA (Defense Logistics Agency) 2003. *Environmental Assessment, Disposition of Thorium Nitrate.* Fort Belvoir, Virginia: Defense Logistic Agency, Defense National Stockpile Center. ACC: MOL.20041122.0200.

172281 DOD 2003 DOD (U.S. Department of Defense) 2003. *Finding of No Significant Impact, Defense National Stockpile Center, Disposition of Thorium Nitrate, Environmental Assessment.* Fort Belvoir, Virginia: U.S. Department of Defense, Defense Logistics Agency. ACC: MOL.20041122.0201.

103189	DOE 1992	DOE (U.S. Department of Energy) 1992. *Environmental Assessment for the Shipment of Low Enriched Uranium Billets to the United Kingdom from the Hanford Site, Richland, Washington.* DOE/EA-0787. Richland, Washington: U.S. Department of Energy. ACC: MOL.20010730.0389.
157156	DOE 1993	DOE (U.S. Department of Energy) 1993. *Environmental Assessment of the Import of Russian Plutonium-238.* DOE/EA-0841. Washington, D.C.: U.S. Department of Energy, Office of Nuclear Energy. TIC: 251416.
101802	DOE 1995	DOE (U.S. Department of Energy) 1995. *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement.* DOE/EIS-0203-F. Idaho Falls, Idaho: U.S. Department of Energy, Idaho Operations Office. ACC: MOL.20010727.0192; MOL.20010727.0193; MOL.20010727.0194.
103208	DOE 1995	DOE (U.S. Department of Energy) 1995. *Final Programmatic Environmental Impact Statement for Tritium Supply and Recycling, Executive Summary.* DOE/EIS-0161. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20010730.0377.
103212	DOE 1995	DOE (U.S. Department of Energy) 1995. *Environmental Assessment, Disposition and Transportation of Surplus Radioactive Low Specific Activity Nitric Acid, Hanford Site, Richland, Washington.* DOE/EA-1005. Two volumes. Washington, D.C.: U.S. Department of Energy. TIC: 243921.
101811	DOE 1996	DOE (U.S. Department of Energy) 1996. *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada.* DOE/EIS-0243. Las Vegas, Nevada: U.S. Department of Energy, Nevada Operations Office. ACC: MOL.20010727.0190; MOL.20010727.0191.
101812	DOE 1996	DOE (U.S. Department of Energy) 1996. *Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel.* DOE/EIS-0218F. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20010727.0195; MOL.20010727.0196.

101813	DOE 1996	DOE (U.S. Department of Energy) 1996. *Medical Isotopes Production Project: Molybdenum-99 and Related Isotopes, Environmental Impact Statement.* Two volumes. DOE/EIS-0249-F. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20010727.0169.
103215	DOE 1996	DOE (U.S. Department of Energy) 1996. *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement.* DOE/EIS-0229. Summary and four volumes. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20010724.0328; MOL.20010727.0147; MOL.20010727.0148; MOL.20010727.0149.
103216	DOE 1996	DOE (U.S. Department of Energy) 1996. *Disposition of Surplus Highly Enriched Uranium Final Environmental Impact Statement.* DOE/EIS-0240. Two volumes and summary. Washington, D.C.: U.S. Department of Energy, Office of Fissile Materials Disposition. ACC: MOL.20010727.0179.
103217	DOE 1996	DOE (U.S. Department of Energy) 1996. *Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management.* DOE/EIS-0236. Summary and four volumes. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20010802.0028; MOL.20010802.0029.
103218	DOE 1996	DOE (U.S. Department of Energy) 1996. *Final Environmental Impact Statement for the Continued Operation of the Pantex Plant and Associated Storage of Nuclear Weapon Components.* DOE/EIS-0225. Three volumes. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20010727.0158.
103219	DOE 1996	DOE (U.S. Department of Energy) 1996. *Final Environmental Impact Statement, S1C Prototype Reactor Plant Disposal.* DOE/EIS-0275. Two volumes. Washington, D.C.: U.S. Department of Energy, Office of Naval Reactors. ACC: MOL.20010727.0176.
101816	DOE 1997	DOE (U.S. Department of Energy) 1997. *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste.* DOE/EIS-0200-F. Summary and five volumes. Washington, D.C.: U.S. Department of Energy, Office of Environmental Management. ACC: MOL.20010727.0150; MOL.20010727.0151; MOL.20010727.0152.

103221	DOE 1997	DOE (U.S. Department of Energy) 1997. *Final Environmental Impact Statement, Disposal of the S3G and D1G Prototype Reactor Plants.* DOE/EIS-0274. Two volumes. Washington, D.C.: U.S. Department of Energy, Office of Naval Reactors. ACC: MOL.20010730.0388.
148724	DOE 1997	DOE (U.S. Department of Energy) 1997. *Waste Isolation Pilot Plant Disposal Phase, Final Supplemental Environmental Impact Statement, Appendices.* DOE/EIS-0026-S-2. Volume 2. Carlsbad, New Mexico: U.S. Department of Energy, Carlsbad Area Office. TIC: 238195.
155932	DOE 1998	DOE (U.S. Department of Energy) 1998. *Final EIS on Management of Certain Plutonium Residues and Scrub Alloy Stored at the Rocky Flats Environmental Technology Site, Summary*. DOE/EIS-0277F. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20011009.0063.
118979	DOE 1999	DOE (U.S. Department of Energy) 1999. *Surplus Plutonium Disposition Final Environmental Impact Statement.* DOE/EIS-0283. Washington, D.C.: U.S. Department of Energy, Office of Fissile Materials Disposition. TIC: 246385.
152493	DOE 1999	DOE (U.S. Department of Energy) 1999. *Final Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride.* DOE/EIS-0269. Germantown, Maryland: U.S. Department of Energy. ACC: MOL.20001010.0216.
157153	DOE 1999	DOE (U.S. Department of Energy) 1999. *Environmental Assessment for the Parallex Project Fuel Manufacture and Shipment.* DOE/EA-1216. Washington, D.C.: U.S. Department of Energy, Office of Fissile Materials Disposition. ACC: MOL.20020327.0438.
157155	DOE 1999	DOE (U.S. Department of Energy) 1999. *Site-Wide Environmental Impact Statement.* DOE/EIS-0281. Two volumes. Albuquerque, New Mexico: U.S. Department of Energy, Albuquerque Operations Office. ACC: MOL.20020222.0027; MOL.20020222.0028.
157166	DOE 1999	DOE (U.S. Department of Energy) 1999. *Final Environmental Impact Statement for the Production of Tritium in a Commercial Light Water Reactor*. DOE/EIS-0288. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20020326.0368.

157167	DOE 2000	DOE (U.S. Department of Energy) 2000. *Final Environmental Impact Statement for the Treatment and Management of Sodium-Bonded Spent Nuclear Fuel.* DOE/EIS-0306. Washington, D.C.: U.S. Department of Energy, Office of Nuclear Energy, Science and Technology. ACC: MOL.20020225.0097.
155970	DOE 2002	DOE (U.S. Department of Energy) 2002. *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada.* DOE/EIS-0250F. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20020524.0314; MOL.20020524.0315; MOL.20020524.0316; MOL.20020524.0317; MOL.20020524.0318; MOL.20020524.0319; MOL.20020524.0320.
162638	DOE 2002	DOE (U.S. Department of Energy) 2002. *Supplement Analysis for the Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada.* DOE/EIS-0243-SA-01. Las Vegas, Nevada: U.S. Department of Energy, National Nuclear Security Administration, Nevada Operations Office. ACC: MOL.20030409.0001.
162639	DOE 2002	DOE (U.S. Department of Energy) 2002. *Final Environmental Impact Statement for the Proposed Relocation of Technical Area 18 Capabilities and Materials at the Los Alamos National Laboratory.* DOE/EIS-0319. Volume 1. Washington, D.C.: U.S. Department of Energy, National Nuclear Security Administration. ACC: MOL.20030409.0002.
179508	DOE 2002	DOE (U.S. Department of Energy) 2002. *Idaho High-Level Waste and Facilities Disposition, Final Environmental Impact Statement.* DOE/EIS-0287. Idaho Falls, Idaho: U.S. Department of Energy, Idaho Operations Office. ACC: MOL.20070613.0004.
179454	DOE 2003	DOE (U.S. Department of Energy) 2003. *West Valley Demonstration Project Waste Management Environmental Impact Statement, Final Summary.* DOE/EIS-0337F. West Valley, New York: U.S. Department of Energy, West Valley Area Office. ACC: MOL.20070613.0003.
182373	DOE 2004	DOE (U.S. Department of Energy) 2004. *Final Environmental Impact Statement for Construction and Operation of a Depleted Uranium Hexafluoride Conversion Facility at the Portsmouth, Ohio, Site.* DOE/EIS-0360. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20071003.0058.

182376	DOE 2004	DOE (U.S. Department of Energy) 2004. *Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement Richland, Washington.* DOE/EIS-0286F. Volume I. Sections 1 through 7. Richland, Washington: U.S. Department of Energy, Richland Operations Office. ACC: MOL.20070913.0517.
182346	DOE 2005	DOE (U.S. Department of Energy) 2005. *Annual Report - FY 2004, Radioactive Waste Shipments to and from the Nevada Test Site (NTS).* DOE/NV-1032. Las Vegas, Nevada: U.S. Department of Energy, National Nuclear Security Administration. ACC: MOL.20070810.0043.
182377	DOE 2005	DOE (U.S. Department of Energy) 2005. *Remediation of the Moab Uranium Mill Tailings, Grand and San Juan Counties, Utah, Final Environmental Impact Statement*. DOE/EIS-0355. Washington, D.C.: U. S. Department of Energy. ACC: MOL.20071003.0059.
182374	DOE 2006	DOE (U.S. Department of Energy) 2006. *Environmental Assessment for the Decontamination, Demolition, and Removal of Certain Facilities at the West Valley Demonstration Project.* DOE/EIS-1552. West Valley, New York: U.S. Department of Energy, West Valley Demonstration Project. ACC: MOL.20071003.0060.
185273	DOE 2007	DOE (U.S. Department of Energy) 2007. *Draft Complex Transformation Supplemental Programmatic Environmental Impact Statement.* DOE/EIS-0236-S4. Summary and two volumes. Washington, D.C.: U.S. Department of Energy, National Nuclear Security Administration. ACC: MOL.20080304.0037.
185274	DOE 2007	DOE (U.S. Department of Energy) 2007. *Draft Programmatic Environmental Impact Statement of the Designation of Energy Corridors in the 11 Western States.* DOE/EIS-0386. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20080328.0086.
185437	DOE 2008	DOE (U.S. Department of Energy) 2008. *Draft Supplement Analysis for the Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada*. DOE/EIS-0243-SA-03. Las Vegas, Nevada: U.S. Department of Energy, National Nuclear Security Administration, Nevada Site Office. ACC: MOL.20080513.0176.
185511	DOE 2008	DOE (U.S. Department of Energy) 2008. *Final Site-Wide Environmental Impact Statement for Continued Operation of Los Alamos National Laboratory, Los Alamos, New Mexico*. DOE/EIS-0380. Three volumes. Washington, D.C.: U.S. Department of Energy, National Nuclear Security Administration. ACC: MOL.20080529.0125.

185475	DOJ 2008	U.S. Department of Justice 2008. *Final Environmental Impact Statement Proposed Contractor Detention Facility, Las Vegas, Nevada Area*. Arlington, Virginia: U.S. Department of Justice, Office of the Federal Detention Trustee. ACC: MOL.20080529.0055.
103705	EPA 1997	EPA (U.S. Environmental Protection Agency) 1997. *Health Effects Assessment, Summary Tables, FY-1997 Update.* EPA 540/R-97-036. Washington, D.C.: U.S. Environmental Protection Agency. ACC: MOL.20010724.0301.
148228	EPA 1999	EPA (U.S. Environmental Protection Agency) 1999. "Nickel, Soluble Salts; CASRN Various." IRIS (Integrated Risk Information System). Washington, D.C.: U.S. Environmental Protection Agency. Accessed June 10, 1999. ACC: MOL.20010719.0364. URL: http://www.epa.gov/iris/subst/0271.htm
148229	EPA 1999	EPA (U.S. Environmental Protection Agency) 1999. "Nickel, Soluble Salts; CASRN Various." *IRIS (Integrated Risk Information System)*. Washington, D.C.: U.S. Environmental Protection Agency. Accessed June 10, 1999. ACC: MOL.20010719.0364. URL: http://www.epa.gov/iris/subst/0271.htm
181232	Fitzpatrick-Maul 2007	Fitzpatrick-Maul, D. 2007. "SEIS Water Balance Revision 4." E-mail from D. Fitzpatrick-Maul to L. Morton, April 16, 2007, with attachment. ACC: MOL.20070816.0027; MOL.20070808.0055.
182841	Gamble 2007	Gamble, R. 2007. "*Nye County Comprehensive Economic Development Strategy*." E-mail from R. Gamble to L. Morton, October 9, 2007, with attachment. ACC: MOL.20071009.0076; MOL.20070913.0316.
182345	Giampaoli 2007	Giampaoli, M.C. 2007. *Yucca Mountain Project Gateway Area Concept Plan.* Pahrump, Nevada: Nuclear Waste Repository Project Office, Nye County, Nevada. ACC: MOL.20070712.0048.
175019	Holtec 2002	Holtec International 2002. *Final Safety Analysis Report for the Holtec International Storage, Transfer, and Repository Storage Cask System (HI-STAR 100 Cask System).* Volume I. Docket No. 72-1008, Rev. 1. Marlton, New Jersey: Holtec International. TIC: 257520.

101836	ICRP 1991	ICRP (International Commission on Radiological Protection) 1991. "1990 Recommendations of the International Commission on Radiological Protection." Volume 21, No. 1-3 of *Annals of the ICRP*. ICRP Publication 60. New York, New York: Pergamon Press. TIC: 235864.
185296	Joyce 2008	Joyce, J. 2008. "Transmittal of Updated GTCC Inventory and TAD Estimates." Email from J. Joyce to J. Summerson, March 13, 2008, with attachment. ACC: MOL.20080328.0084.
169260	Kistler Aerospace 2003	Kistler Aerospace. 2003. "Kistler Aerospace Corporation Restructures its Finances to Achieve the Reusable Launch Vehicle's First Flight." Kirkland, Washington: Kistler Aerospace. Accessed April 21, 2004. TIC: 256006. URL: http://www.kistleraerospace.com/newsinfo/pressreleases/071503print.html
182702	Koutsandreas 2007	Koutsandreas, D. 2007. "Revised HLW Canisters Numbers for the YM EIS." E-mail from D. Koutsandreas to S. Gomberg, March 22, 2007. ACC: MOL.20070913.0503.
174559	Lawrence 2002	Lawrence, A. 2002. "Radiation Risk Estimation from Total Effective Dose Equivalents (TEDEs)." Memorandum from A. Lawrence (DOE) to distribution, August 9, 2002, with attachments. ACC: MOL.20050815.0190.
182804	Maher 2006	Maher, M. 2006. "Nye County, Nevada Request to Initiate Transaction for Acquisition of 292.46 Acres of Land for Commercial Purposes Pursuant to Public Law #106-113." Letter from M. Maher (Nye County) to J. Palma (BLM), March 21, 2006, with enclosure. ACC: MOL.20070913.0510
153066	Murphy 2000	Murphy, S.L. 2000. *Deaths: Final Data for 1998. National Vital Statistics Reports.* Vol. 48, No. 11. Hyattsville, Maryland: National Center for Health Statistics. TIC: 249111.
101892	NRC 1977	NRC (U.S. Nuclear Regulatory Commission) 1977. *Final Environmental Impact Statement on the Transportation of Radioactive Materials by Air and Other Modes.* NUREG-0170. Two volumes. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 221616.

157761	NRC 2001	NRC (U.S. Nuclear Regulatory Commission) 2001. *Final Environmental Impact Statement for the Construction and Operation of an Independent Spent Fuel Storage Installation on the Reservation of the Skull Valley Band of Goshute Indians and the Related Transportation Facility in Tooele County, Utah.* NUREG-1714. Two volumes. Washington, D.C.: U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards. TIC: 253836.
178816	NRC 2005	NRC (U.S. Nuclear Regulatory Commission) 2005. *Environmental Impact Statement on the Construction and Operation of a Proposed Mixed Oxide Fuel Fabrication Facility at the Savannah River Site, South Carolina*. NUREG-1767, Volume 1. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20060111.0289.
182375	NRC 2005	NRC (U.S. Nuclear Regulatory Commission) 2005. *Environmental Impact Statement for the Proposed National Enrichment Facility in Lea County, New Mexico.* NUREG-1790. Volume 1. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20071003.0061.
182710	NWRPO 2007	NWRPO (Nuclear Waste Repository Project Office) 2007. *Nye County Public Safety Report.* NWRPO-2007-06. Las Vegas, Nevada: Nye County Nuclear Waste Repository Project Office. ACC: MOL.20070913.0315.
182884	NWRPO 2007	NWRPO (Nye County Nuclear Waste Repository Project Office) 2007. *Nye County Perspective: Potential Impacts Associated with the Long-Term Presence of a Nuclear Waste Repository at Yucca Mountain, Ney County, Nevada. Site Count Viewpoint on Cumulative Impacts and Recommended Mitigation Actions.* Pahrump, Nevada: Nye County Nuclear Waste Repository Project Office. ACC: MOL.20071009.0078.
185367	Seley 2008	Seley, W. 2008. “Wind Energy Applications - Nye and Esmeralda County, Nevada.” Email from W. Seley (BLM) to H. Woods, April 15, 2008, with attachment. ACC: MOL.20080521.0035.
185368	Seley 2008	Seley, W. 2008. “Solar Energy Chart.” Email from W. Seley (BLM) to H. Woods (NV BLM), April 15, 2008, with attachment. ACC: MOL.20080521.0034.
185502	Schwartz 2008	Schwartz, F.G. 2008. “GNEP Spent Fuel and Waste Generation Data.” Memorandum from F.G. Schwartz (DOE) to J.R. Summerson (DOE/Nevada Operations Office), May 19, 2008, with attachments. ACC: MOL.20080528.0005.

103472	USAF 1999	USAF (U.S. Air Force) 1999. *Renewal of the Nellis Air Force Range Land Withdrawal: Legislative Environmental Impact Statement.* Washington, D.C.: U.S. Air Force. ACC: MOL.20010726.0068.
172314	USAF 2003	USAF (U.S. Air Force) 2003. *Predator Force Structure Change at Indian Springs Air Force Auxiliary Airfield, Nevada.* Washington, D.C.: U.S. Air Force. ACC: MOL.20041206.0122.
182839	USAF 2005	USAF (U.S. Air Force) 2005. *Wing Infrastructure Development Outlook (WINDO) Environmental Assessment.* Las Vegas, Nevada: U.S. Air Force, Nellis Air Force Base. ACC: MOL.20070913.0514.
181607	USAF 2006	USAF (U.S. Air Force) 2006. *Environmental Assessment for Increased Depleted Uranium Use on Target 63-10, Nevada Test and Training Range.* Nellis Air Force Base, Nevada: U.S. Air Force. ACC: MOL.20070712.0025.
182838	USAF 2006	USAF (U.S. Air Force) 2006. *Expeditionary Readiness Training (ExpeRT) Course Expansion, Final Environmental Assessment.* Indian Springs, Nevada: U.S. Air Force, Creech Air Force Base. ACC: MOL.20070913.0516.
181492	USAF 2007	USAF (U.S. Air Force) 2007. *Final Base Realignment and Closure (BRAC) Environmental Assessment for Realignment of Nellis Air Force Base*. Nellis Air Force Base, Nevada: U.S. Air Force. ACC: MOL.20070712.0026.
185372	USAF 2007	USAF (U.S. Air Force) 2007. *Final, Range 74 Target Complexes Environmental Assessment Nevada Test and Training Range, Nevada.* Nellis Air Force Base, Nevada: U.S. Air Force. ACC: MOL.20080501.0029.
103477	USN 1984	USN (U.S. Department of the Navy) 1984. *Final Environmental Impact Statement on the Disposal of Decommissioned, Defueled Naval Submarine Reactor Plants.* Three volumes. Washington, D.C.: U.S. Department of the Navy. ACC: MOL.20010810.0026.
101941	USN 1996	USN (U.S. Department of the Navy) 1996. *Department of the Navy Final Environmental Impact Statement for a Container System for the Management of Naval Spent Nuclear Fuel.* DOE/EIS-0251. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20010724.0299.

103479	USN 1996	USN (U.S. Department of the Navy) 1996. *Final Environmental Impact Statement on the Disposal of Decommissioned, Defueled Cruiser, Ohio Class, and Los Angeles Class Naval Reactor Plants.* Washington, D.C.: U.S. Department of the Navy. ACC: MOL.20010726.0071.
146270	Weiner et al. 1991	Weiner, R.F.; LaPlante, P.A.; and Hageman, J.P. 1991. "An Approach to Assessing the Impacts of Incident-Free Transportation of Radioactive Materials: II. Highway Transportation." *Risk Analysis, 11,* (4), 661-666. New York, New York: Plenum Press. TIC: 236745.

9

Best Management Practices and Management Actions to Mitigate Potential Adverse Environmental Impacts

TABLE OF CONTENTS

LIST OF TABLES

9. BEST MANAGEMENT PRACTICES AND MANAGEMENT ACTIONS TO MITIGATE POTENTIAL ADVERSE ENVIRONMENTAL IMPACTS

9.1 Introduction

This chapter describes *mitigation* measures that the U.S. Department of Energy (DOE or the Department) would implement to mitigate adverse *impacts* to the environment that could occur if the Department implemented the *Proposed Action* to construct, operate, monitor, and eventually close a *geologic repository* for the *disposal* of *spent nuclear fuel* and *high-level radioactive waste* at Yucca Mountain.

The Council on Environmental Quality defines mitigation as (40 CFR 1508.20):

“ (a) Avoiding the impact altogether by not taking a certain action or parts of an action.

(b) Minimizing impacts by limiting the degree or magnitude of the action and its implementation.

(c) Rectifying the impact by repairing, rehabilitating, or restoring the *affected environment.*

(d) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.

(e) Compensating for the impact by replacing or providing substitute resources or environments.”

The mitigation measures that DOE would implement fall into two categories: a general category called *best management practices* and a specific category called management actions. DOE has defined best management practices for this *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F-S1) (*Repository* SEIS) as the processes, techniques, procedures, or considerations it would employ to avoid or reduce the potential environmental impacts of its Proposed Action in a cost-effective manner while meeting the *Yucca Mountain Repository* project objectives. While best management practices are not regulatory requirements, they can overlap and support such requirements. Use of best management practices would not replace any local, state, or federal requirements. Best management practices are integral to the design, *construction,* and *operation* of the Yucca Mountain Repository, and the repository design incorporates them. Specific management actions DOE would take to mitigate potential adverse impacts of the Proposed Action include compliance with other government agency stipulations or specific guidance, coordination with government agencies or interested parties, implementation of DOE policy decisions, monitoring of relevant ongoing and future activities and, if appropriate, instituting corrective actions. Corrective actions would include, for instance, limiting the degree or magnitude of the action; reducing or eliminating the impact over time by preservation and maintenance operations; and repairing, rehabilitating, or restoring the affected environment.

The impact avoidance and reduction framework DOE has used in this Repository SEIS includes the following:

- As Chapter 2 discusses, the Proposed Action would adhere to U.S. Nuclear Regulatory Commission (NRC) safety requirements in 10 CFR Part 63 for the construction, operations, *monitoring*, and *closure* of a *geologic* repository and follow or exceed the requirements of 10 CFR Part 71 for the transportation of spent nuclear fuel and high-level *radioactive* waste. The incorporation of safety factors and controls in the engineering design and operational procedures would help prevent *accidents* and thereby minimize potential releases to the environment.

- As Chapters 4 and 6 discuss, DOE would implement best management practices to mitigate potential environmental impacts it identified for the Proposed Action.

- In this chapter, DOE summarizes best management practices and presents the management actions it would undertake to mitigate potentially adverse environmental impacts further.

- Chapter 10 presents unavoidable adverse impacts that would remain after DOE implemented best management practices and management actions.

9.2 Yucca Mountain Repository

DOE views the best management practices and management actions discussed in Sections 9.2.1 and 9.2.2, respectively, as representing the initial step in a longer-term, iterative process to further develop, detail, and eventually implement these practices and actions. The Department considers the process to be longer-term, in that the best management practices and management actions identified in this Repository SEIS would be further developed and detailed through (1) the regulatory compliance process, (2) development of the final design and associated specifications, and (3) consultation with directly affected parties. The process is iterative, in that DOE intends to consult with directly affected parties as the practices and actions advance from the conceptual to the more detailed, as engineering of the repository advances from preliminary through final design, and during implementation and monitoring of their effectiveness.

DOE based this process, in part, on the use of an adaptive management approach described herein as: consider the magnitude of potential impacts, mitigate, implement, monitor, and adapt. Using this approach, the Department could respond to unanticipated changes in local conditions or subsequently developed information, for example, and thus make cost-effective adjustments to its best management practices and management actions, as necessary. DOE developed a similar adaptive management approach as part of the *Nevada Test Site Resource Management Plan* (DIRS 103226-DOE 1998, all).

In undertaking this process, DOE would:

1. Consider the magnitude of potential adverse environmental impacts, based on the environmental conditions (affected environment) and analyses of this Repository SEIS;

2. Develop detailed best management practices and management actions in response to these adverse impacts. In this step, DOE would identify the desired outcome of these practices and actions and

identify associated performance measures by which it could determine the effectiveness of such practices and actions during their implementation;

3. Identify monitoring protocols to determine the effectiveness of these best management practices and management actions given the desired outcome. Before developing these protocols, DOE would undertake additional studies to further assess the then-current baseline conditions (affected environment), as appropriate. The protocols would be developed to distinguish between changes in conditions due to DOE's actions and those from other causes;

4. Consider the cost of implementation, as well as monitoring, when developing the final best management practices and management actions;

5. Determine the need to adapt or modify the best management practices and management actions, based on performance (outcome) monitoring, after such practices and actions have been implemented; and

6. Determine the extent to which the regulatory community and other directly affected parties find such mitigation measures and their associated monitoring protocols and performance measures to be acceptable.

DOE would undertake this mitigation process in consultation with federal, state, and local regulatory authorities having jurisdiction over the construction and operation of the proposed repository and *railroad*, and in consultation with directly affected parties. To that end, DOE is proposing to charter one or more Mitigation Advisory Boards, each to be led by the governmental entities through which the *rail line* would pass or in which it would construct and operate the repository. For example, as the situs county of the Proposed Action for this Repository SEIS, the Board for Nye County would provide advice on the development of mitigation measures for the construction, operations, monitoring, and closure of the Yucca Mountain Repository and the construction and operation of the railroad. DOE would determine in the future the exact construction of the Boards and the processes under which they would operate.

9.2.1 BEST MANAGEMENT PRACTICES

Chapter 9 of the *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F; DIRS 155970-DOE 2002, pp. 9-1 to 9-30) (Yucca Mountain FEIS) presented mitigation measures DOE determined it would implement or identified for consideration to reduce potential impacts from the construction, operations, monitoring, and eventual closure of the proposed repository. This chapter summarizes, reorganizes, and incorporates by reference the mitigation measures presented in the FEIS. For this Repository SEIS, many of those mitigation measures are best management practices. Table 9-1 summarizes best management practices DOE has identified for this SEIS.

Table 9-1. Summary of best management practices for potential environmental impacts of the proposed repository.

Environmental resource	Best management practice
Land use	• Reclaim lands disturbed during the construction process. • Reclaim lands disturbed by surface facilities as they become no longer necessary. • Restore disturbed areas to their approximate condition before repository construction; follow guidelines in DOE's *Reclamation Implementation Plan* (DIRS 154386-YMP 2001, all).
Air quality	• Reduce fugitive dust emissions using standard dust control measures (such as water spraying, chemical treatment, and wind fences). • Reduce maximum fugitive dust by minimizing activities that were near each other. • Use fossil-fuel vehicles that meet at least the Tier 3 emission standards. • Use air filters to reduce air emissions in waste handling buildings. • Inspect regularly and maintain construction equipment to ensure the proper operation of pollution control devices.
Surface water	• Minimize disturbance of surface areas and vegetation, thereby minimizing changes in surface-water flow and soil porosity that would change infiltration and runoff rates. • Minimize physical changes to drainage channels by building bridges or culverts where roadways would intersect areas of intermittent water flow. Perform hydrologic studies as necessary and design drainage structures to minimize erosion up- and downstream of these structures. • Use erosion and runoff control features such as proper placement of pipe, grading, and use of riprap to enhance the effectiveness of the bridges or culverts and minimize erosion and associated sediment transport. • Maintain natural contours to the maximum extent feasible, stabilize slopes, and avoid unnecessary off-road vehicle travel to minimize erosion. • In and near floodplains, follow reclamation guidelines. • Train employees in the handling, storage, distribution, and use of hazardous materials. • Manage hazardous materials in accordance with an approved Spill Prevention, Control, and Countermeasures Plan. • Conduct fueling operations and store hazardous materials and other chemicals in bermed areas or use other appropriate secondary containment to reduce the likelihood of inadvertent releases. • Store hazardous materials away from floodplains to decrease the probability of an inadvertent spill in these areas. • Maintain and move hazardous and mixed wastes in closed containers. • Select herbicide products (used for weed control) that would minimize impacts to water bodies and wildlife. • Provide rapid response cleanup and remediation capability, techniques, procedures, and training for potential spills. • Use sediment-trapping devices such as hay or straw bales, fabric fences, and devices to control water flow and discharge to trap sediments moved by runoff. • Prepare and submit a Storm Water Pollution Prevention Plan consistent with state and federal standards for construction activities. • Use measures to prevent runoff or floodwaters from reaching areas where they could contact contaminated surfaces or cause release of hazardous materials (such as constructing structures above specified flood elevations, designing facilities to withstand a specific flood event, or constructing stormwater ponds or diversion structures).

Table 9-1. Summary of best management practices for potential environmental impacts of the proposed repository (continued).

Environmental resource	Best management practice
Surface water (continued)	• Remove structures and impermeable surfaces when no longer necessary and reclaim disturbed areas to help restore infiltration and runoff rates to near preconstruction conditions.
Groundwater	• Recycle water collected in subsurface areas for use in dust suppression and other activities. • Implement measures to minimize the potential for water use during operations that could interfere with waste isolation in the repository. • Minimize surface disturbance, thereby minimizing changes in surface-water flow and soil porosity that could change infiltration and runoff rates. • Monitor to detect and define unanticipated spills, releases, or similar events. • Construct evaporation ponds with synthetic liners and/or leak detection systems to prevent infiltration and potential groundwater contamination.
Biological resources and soils	• Develop and implement methods to control invasive species and noxious weeds on disturbed sites (including long-term topsoil stockpiles) during repository construction and operation. • Develop and implement a worker education program that would include training to prevent the intentional or unintentional take of sensitive or protected plant and animal species. • Conduct preconstruction surveys to ensure that work would not affect important biological resources and to determine the reclamation potential of sites. • Implement measures to relocate or avoid sensitive species. • Minimize groundbreaking or land-clearing activities in nesting habitat during the critical nesting period for migratory birds. If activities must occur during the nesting season, conduct surveys for migratory bird nests before initiating those activities. Prohibit activities that would harm nesting migratory birds or result in nest abandonment. • Before ground-disturbing activities, collect data to plan for the restoration of disturbed areas and minimize impacts to sensitive habitats. • Phase construction to the extent practicable. Limit grading activities to the phase immediately under construction and limit ground disturbance to areas necessary for project-related construction activities. • Reduce side slopes of evaporation and stormwater ponds or construct a ramp in the ponds to minimize loss of animals that could become trapped due to depth of water or steep slopes. • Cover sanitary waste in landfills frequently to minimize use by scavenger species. • Stockpile topsoil removed during construction activities for use during reclamation efforts. • Stabilize stockpiled topsoil to prevent erosion by reestablishing vegetation. • Conduct measures to reclaim disturbed areas that could include backfilling and grading to restore natural drainage patterns and create a stable landform; spreading and contouring stockpiled topsoil; creating erosion-control structures; ripping, seeding, spreading, and anchoring mulch; and fencing to reduce loss of new vegetation to herbivores.

Table 9-1. Summary of best management practices for potential environmental impacts of the proposed repository (continued).

Environmental resource	Best management practice
Cultural resources	• Ensure that onsite employees complete cultural resource sensitivity and protection training to reduce the potential for intentional or accidental harm to sites or artifacts. Work with American Indian tribes to involve tribal representatives in the training. • Conduct preconstruction surveys to ensure that work would not affect important archaeological resources and to determine the research potential of sites. Work with American Indian tribes to involve tribal monitors in survey activities. • If construction could threaten important archaeological resources, and modification or relocation of roads or structures would not be reasonable, develop appropriate mitigation measures.
Occupational and public health and safety	• Use ventilation to keep radon levels low in subsurface areas. • Design and operate the ventilation system to control ambient air velocities to minimize dust resuspension. • Use engineering controls during subsurface work to control exposures of workers to silica dust, including the use of dust shields and air curtains on tunnel boring machines, water sprays and atomizing nozzles, isolated work areas, air stream scrubbing, and provision of fresh air to work areas through duct lines. • Use administrative controls such as access restrictions or respiratory protection if dust concentrations exceeded applicable limits for cristobalite until engineering controls could establish acceptable conditions. • Avoid erionite-bearing strata where practicable during repository construction and drift development. • If drilling encountered erionite, close operations in potentially affected areas until proper engineering controls were in place; controls for exposure to silica dust would apply to potential exposure to erionite. • Use monitoring devices and respirators with high-efficiency particulate air filters as appropriate. • Design task procedures to reduce the potential for accidents. • Implement health and safety procedures and administrative controls to minimize risks to construction and operations workers. • Develop and implement emergency response plans for use during construction and operations. • Develop and implement an Ordnance and Explosives Safety Construction Support Program applicable to construction activities. Include ordnance and explosives training for all construction personnel working in the areas designated by the U.S. Department of Defense as being at risk of containing unexploded ordnance. • Employ unexploded ordnance technicians to screen areas identified as having a potential for unexploded ordnance before allowing workers to conduct field surveys or construction work in such areas.
Noise	• Use noise suppressors on ventilation fans to maintain noise levels below recommended exposure limits. • Use engineering controls to control noise levels during construction. • Regularly inspect and maintain construction equipment to ensure that noise-control devices were in good working condition. • Use personal hearing protection as necessary to supplement engineering controls.
Aesthetics	• Use exterior lighting only where necessary to accomplish facility tasks. • Limit the height of exterior lighting units. • Use shielded or directional lighting to limit the effects of the lighting to areas where it is necessary.

Table 9-1. Summary of best management practices for potential environmental impacts of the proposed repository (continued).

Environmental resource	Best management practice
Utilities, energy, and materials	• Implement procedures and equipment that would minimize the use of utility services, energy, and materials. • Incorporate high-performance and sustainable building criteria into the design and construction of nonnuclear facilities.
Waste and hazardous materials	• Implement a Pollution Prevention/Waste Minimization Program (and include it in DOE's Environmental Management System) that would evaluate methods to eliminate, reduce, or minimize the amounts of hazardous materials used and hazardous wastes generated. • Recycle wastewater to reduce the amount of water necessary for repository facilities and the amount of wastewater that could require disposal. • Use decontamination techniques that would reduce waste generation in comparison with other techniques. • Collect and sample wastewater from surface facilities (such as floor and equipment drains) and water from the emplacement side of the subsurface to determine proper management and disposal. • Use evaporation ponds and oil-water separators to reduce wastewater volumes. • Institute preventive maintenance and inventory management programs to minimize waste from breakdowns and overstocking. • When practicable, recycle nonradioactive materials such as paper, plastic, glass, nonferrous metals, steel, fluorescent bulbs, shipping containers, oils, and lubricants rather than dispose of them. • Encourage the reuse of materials and the use of recycled materials. • Avoid use of hazardous materials where feasible. • Update DOE's *Spill Prevention, Control, and Countermeasures Plan for Site Activities* (DIRS 172055-DOE 2004, all) to include actions DOE would take during repository construction and operation to prevent, control, and remediate spills of petroleum products and other hazardous materials and reporting requirements for a spill or release. • Ensure that equipment is available to respond to spills and identify the location of such equipment. • Dispose of drill cuttings through land application. • Inspect and replace worn or damaged components. • Salvage extra materials and use for other construction activities or for regrading activities.

DOE = U.S. Department of Energy.

9.2.2 MANAGEMENT ACTIONS

DOE is firmly committed to its implementation of sound stewardship practices that are protective of air, water, land, and cultural and ecological resources that repository activities could affect. DOE would accomplish its commitment through implementation of the Environmental Management System, which is part of its Integrated Safety Management System at the Yucca Mountain Project site. This structured approach to adaptive management through monitoring is currently an active part of DOE's management structure; DOE would continue this practice throughout the Proposed Action.

The Council on Environmental Quality recognizes the benefits of aligning the complementary processes of the *National Environmental Policy Act* (NEPA) and an environmental management system and encourages federal agencies to do so where appropriate (DIRS 185325-CEQ 2007, all). The Council states that an environmental management system can improve the NEPA process by supporting an adaptive management approach for projects that face uncertain or unforeseen conditions during implementation. Taking advantage of the complementary elements of these two processes can help managers make decisions more effectively, reduce environmental impacts, and further NEPA policy goals and processes.

DOE encourages the integration of NEPA and environmental management systems and would continue to do so as part of the Proposed Action. The structure of the Integrated Safety Management System/ Environmental Management System fully supports mitigation of impacts DOE has identified in this Repository SEIS. For example, as part of the planning process DOE would establish measurable environmental objectives and set measurable goals and targets (such as pollution prevention goals for reductions in waste generation). DOE would then implement programs, procedures, and controls for monitoring and measuring progress; document progress; and, if appropriate, institute corrective actions.

This section identifies management actions that DOE would use upon implementation of the Proposed Action, including actions it currently uses as part of the Yucca Mountain Project Environmental Management System.

To minimize potential impacts from the Proposed Action, DOE would prepare a Mitigation Action Plan that identified specific commitments for mitigation of adverse environmental impacts due to the Proposed Action. The plan would describe specific actions DOE would take to implement mitigation commitments and would reflect available information about the course of action. DOE could revise this plan as more specific and detailed information became available. The Mitigation Action Plan would incorporate all practicable measures to avoid or minimize adverse environmental and human health impacts that could result from the Proposed Action and would include the Environmental Management System. The Mitigation Action Plan would contain:

- An introduction describing the basis, function, and organization of the plan,
- A summary of the impacts DOE would mitigate,
- A description of specific mitigation measures,
- A description of the Mitigation Action Plan monitoring and reporting system DOE would implement to ensure that it met elements of the plan and that those elements were effective, and
- A schedule for actions and identification of the responsible parties.

DOE would develop the Mitigation Action Plan for the repository in consultation with the proposed Mitigation Advisory Board for Nye County.

DOE would conduct monitoring activities during all phases of the project to ensure the appropriate implementation of the Proposed Action and to ensure mitigation of impacts. The following are examples of activities DOE would perform:

- Conduct the Performance Confirmation Program, which would consist of a focused program of tests, experiments, and analyses during all analytical periods of the repository project, to monitor repository conditions, assess the adequacy of the geotechnical and design parameters, and preserve the ability to perform waste retrieval, if necessary. The Performance Confirmation Program would continue until *permanent closure* of the repository.

- Monitor *groundwater* quality, air emissions, and the repository workplace to ensure worker safety and other aspects of project interaction with the natural and human environment.
- Conduct cultural resource monitoring as appropriate before and during surface disturbance activities to identify and assess the potential for impacts to previously unidentified archaeological resources.
- Monitor reclaimed lands to determine if reclamation efforts were successful following guidance in DOE's *Reclamation Implementation Plan* (DIRS 154386-YMP 2001, all).
- Monitor emplaced waste in the repository starting with the first waste package *emplacement* and continuing through closure.
- After completion of emplacement, continue to monitor and inspect *waste packages* and continue performance activities.
- After sealing the repository openings, conduct *postclosure* monitoring to ensure acceptable repository performance. Define details of this program during processing of the license amendment for repository closure.

DOE currently uses the following measures as part of its Environmental Management System and would continue to use them upon implementation of the Proposed Action:

- Provide assistance to state or local governments to mitigate economic, social, public health and safety, and environmental impacts under Section 116(c) of the *Nuclear Waste Policy Act*, as amended (NWPA) (42 U.S.C. 10101 et seq.).
- Observe all terms and conditions, reporting requirements, and conservation recommendations in the U.S. Fish and Wildlife Service Final Biological Opinion (DIRS 155970-DOE 2002, Appendix O), which includes five reasonable and prudent measures to minimize impacts to the desert tortoise and 18 terms and conditions with which DOE must comply to implement the five measures.
- Continue the Yucca Mountain Project Native American Interaction Program, which has been in existence since 1985, to promote a government-to-government relationship with American Indian tribes and to concentrate on the continued protection of important cultural resources.
- Continue to abide by Section 106 of the *National Historic Preservation Act* (16 U.S.C. 470 et seq.) process during negotiation of the draft programmatic agreement among DOE, the Advisory Council on Historic Preservation, and the Nevada State Historic Preservation Office.

In addition, DOE has identified the following management actions it would implement as part of the Proposed Action:

- The Bureau of Land Management would conduct mineral examinations to assess valid existing rights in all mining claims within the lands subject to permanent legislative withdrawal. DOE would provide just compensation for the acquisition of such valid property rights.

- DOE would continue to work with the U.S. Air Force to accommodate its need to fly through the Nevada Test Site airspace. The Department would authorize specific Air Force activities over the repository consistent with the repository safety analysis. DOE would continue to allow military flights over the repository by fixed-wing aircraft with the following restrictions: (1) a maximum of 1,000 flights per year above 4,300 meters (14,000 feet) above mean sea level altitude; (2) a prohibition of maneuvering of aircraft—flight is to be straight and level; (3) a prohibition of carrying ordnance over the flight-restricted airspace; and (4) a prohibition of electronic jamming activity over the flight restricted airspace.

- Before any ground-disturbing activities, DOE would identify geodetic control monuments in areas that could be disturbed. The Department would notify the Office of the Director of the National Oceanic and Atmospheric Administration, National Geodetic Survey no less than 90 days before planned activities that could disturb or destroy a monument. If a geodetic control monument required relocation, DOE would consult with the Administration to develop a mitigation measure that could include compensation for the cost of monument relocation.

- DOE would conduct a formal delineation of waters of the United States in the vicinity of the proposed repository surface facilities and, if necessary, develop a plan to avoid when practicable and otherwise minimize impacts to those waters. If repository activities would affect waters of the United States, DOE would consult with the U.S. Army Corps of Engineers and obtain permit coverage for those impacts. If the activities were not covered under a nationwide permit, DOE would apply to the Corps of Engineers for a regional or individual permit.

- DOE would work closely with the Nevada Department of Transportation if it was necessary to implement mitigative actions along U.S. Highway 95 near the intersection with Nevada State Route 373 and Gate 510 to the Nevada Test Site. As discussed in Chapter 6, Section 6.4.3 of this Repository SEIS, an increase in traffic due to the Proposed Action could affect traffic conditions in this area, resulting in a decrease in the level of service [from a baseline level of service “B” (almost free flow conditions) to a level of service “D” (high-density but still stable conditions)]. Widening U.S. Highway 95 to four lanes could improve the level of service. While widening of the highway could be an effective mitigation measure, such action would be the responsibility of the Nevada Department of Transportation. Implementation of this type of mitigation action (that is, widening U.S. Highway 95) would require further NEPA review. That NEPA documentation would include an evaluation of environmental impacts from the action and mitigation measures that could be necessary as a result of its implementation.

9.2.3 NYE COUNTY PERSPECTIVE ON MANAGEMENT ACTIONS TO MITIGATE POTENTIAL ADVERSE IMPACTS

This section presents the viewpoint of Nye County as a cooperating agency and the situs county of the Proposed Action of this Repository SEIS.

As discussed in the Nye County Viewpoint in Chapter 8, Section 8.6.2, the County believes that the majority of the direct, indirect, and *cumulative impacts* of past and ongoing federal actions, as well as those incremental impacts that can be reasonably expected to occur if the Proposed Action is implemented, can be effectively mitigated. Even the groundwater *contamination* that resulted from nuclear testing, although not directly remediable, can be addressed through management actions. It is imperative from Nye County's perspective, however, that the Repository SEIS clearly identify the full spectrum of appropriate mitigation measures, whether or not DOE has the jurisdictional authority for implementation of the mitigation measures.

Nye County believes that DOE's evaluation in this Repository SEIS of potential impacts from the Proposed Action has been adequately rigorous. Because of differences in perspective between DOE and Nye County, however, coupled with uncertainty about future conditions, the County believes that the conclusions about potential impacts presented in this SEIS should be continuously assessed and evaluated through an appropriate monitoring program.

Nye County believes that the most prudent course of action, should the Proposed Action be implemented, would be to include an aggressive and comprehensive program of environmental monitoring, including monitoring of socioeconomic factors. As the local jurisdiction affected by the Proposed Action and as a cooperating agency in the preparation of this Repository SEIS, Nye County's view is that there is mutual benefit for the federal and local government in partnering to monitor, assess, and evaluate conditions at and around the repository site as repository-related activities take place. In this way, Nye County can assist DOE in the identification of any potential impacts, whether significant or not, and cooperatively develop effective and efficient mitigations, as appropriate, through ongoing adaptive management.

The Council on Environmental Quality's NEPA Task Force, in *Modernizing NEPA Implementation* (DIRS 185310-CEQ 2003, all), recommended the use of an adaptive management approach (predict, mitigate, implement, monitor, and adapt). DOE can take action with an adaptive management plan in place to account for unanticipated changes in local conditions or subsequent information that might affect the original environmental and socioeconomic conclusions that were presented in this Repository SEIS. Using the recommended adaptive management approach, DOE would be able to make cost-saving adjustments when the Proposed Action and mitigation strategies are implemented. The ability to adjust when necessary, and to have a strategy in place for such adjustments, would provide management flexibility when constraints and opportunities are encountered.

The adaptive management plan would be designed and implemented as part of the Proposed Action. As indicated by its title, the plan is meant to be "adaptive." The plan would be modified, if necessary, to address inefficiencies in approach or changes in environmental and socioeconomic conditions. Monitoring data collected as part of the planned activities would be analyzed and reviewed regularly to ensure early detection of potential issues.

The initial adaptive management plan would be based on the existing environmental conditions described in this Repository SEIS and the current knowledge of resources in the vicinity of the repository. The initial plan would be focused on the establishment of environmental and socioeconomic baseline conditions and management of the monitoring and mitigation activities associated with the Yucca Mountain Repository. It would specifically address the management of monitoring and mitigation activities associated with construction and operation of the repository and related facilities, while recognizing the need for identification of non-repository-related environmental and socioeconomic stressors that could exacerbate potential repository-related impacts.

Nye County proposes to constructively engage DOE to assist in identifying the resource areas that it believes will be susceptible to further impacts. Such identification would be based on the County's perspective on cumulative impacts as presented in Chapter 8, Section 8.6.2, and on the results of DOE's analyses presented in the body and appendices of this Repository SEIS. Nye County believes that such mutual consultation and cooperation should be documented through formal agreements. Nye County also believes that it would be beneficial to both DOE and the County if the adaptive management approaches for both rail and repository activities in Nye County were integrated.

With a memorandum of understanding/consultation and cooperation agreement (NWPA Section 117), Nye County will assist DOE in the identification of environmental and socioeconomic impacts and their significance, and then cooperatively plan and develop effective mitigation measures. Some mitigation measures need to be started several years before the Yucca Mountain Project starts (for example, road construction and worker training programs). As the situs jurisdiction for the Yucca Mountain Project, Nye County has a tremendous stake in the NEPA process and will continue to participate as a cooperating agency and protect the safety, environmental values, and economic well-being of the residents of Nye County.

9.3 Transportation

Transportation-related mitigation measures that DOE identified in the Yucca Mountain FEIS included measures for national transportation impacts and State of Nevada transportation impacts. Since completion of the FEIS, DOE issued a policy statement for waste *shipments* to Yucca Mountain. Chapter 2, Sections 2.1.7.2 and 2.1.7.3 and Chapter 6 of this Repository SEIS discuss this in detail. Briefly, DOE would use *dedicated trains* for most waste shipments and thereby derive benefits in safety, security, cost, and operations. DOE has updated the mitigation measures with the measures in Chapter 6 of this SEIS and in the Rail Alignment EIS. The following sections discuss the best management practices and mitigation measures for national and Nevada transportation activities.

9.3.1 NATIONAL TRANSPORTATION

As Chapter 6 of this Repository SEIS describes, potential impacts from national transportation activities would occur primarily to occupational and public health and safety. Because the Proposed Action shipments would represent a relatively small incremental increase in national highway or rail traffic, they would have little or no measurable impacts on other resource areas. Therefore, the best management practices DOE implemented during the proposed transportation of spent nuclear fuel and high-level radioactive waste would be those that improved the protection of workers and the public. Appendix H of this SEIS includes detailed descriptions of supplemental information about transportation activities for the Proposed Action. This information includes discussions of transportation regulations, operational practices, *cask* safety and testing programs, emergency response, security, and liability.

As indicated in the Yucca Mountain FEIS, Section 180(c) of the NWPA requires DOE to provide technical assistance and funds to states for training local government and American Indian tribal public safety officials through whose jurisdictions DOE could plan to transport spent nuclear fuel or high-level radioactive waste. As a specific management action to mitigate impacts, DOE would provide such training. The training would cover procedures for safe, routine transportation and for emergency response situations.

The shipment of spent nuclear fuel and high-level radioactive waste is highly regulated and subject to the utmost scrutiny. DOE carefully follows the U.S. Department of Transportation and NRC transportation rules now and will follow or exceed any future rules that Congress, the Department of Transportation, or the NRC might establish. For example, as discussed in Section 6.3.4 of this Repository SEIS, the NRC has promulgated rules (10 CFR 73.37) and interim compensatory measures (67 FR 63167, October 10, 2002) specifically to protect the public from harm that could result from sabotage of spent nuclear fuel casks. The purposes of these security measures are to minimize the possibility of sabotage and to facilitate recovery of spent nuclear fuel shipments that could come under the control of unauthorized persons. These measures include the use of armed escorts to accompany all shipments, safeguarding of the detailed shipping schedule information, monitoring of shipments through satellite tracking and a communication center with 24-hour staffing, and coordination of logistics with state and local law enforcement agencies, all of which would contribute to shipment security. The Department has committed to follow these rules and measures (see 69 FR 18557, April 8, 2004).

9.3.2 NEVADA TRANSPORTATION

Chapter 7 of the Rail Alignment EIS presents information about best management practices and mitigation in relation to the construction and operation of a railroad in Nevada. It presents information from the analysis of the Proposed Action and Shared-Use Option and consolidates information from the environmental consequence and mitigation analyses. DOE incorporates by reference the best management practices and mitigation measures in Chapter 7 for the construction and operation of a railroad in Nevada.

DOE would use an adaptive management approach, similar to the approach described in Section 9.2 of this Repository SEIS, to further develop and detail the best management practices and mitigation measures identified in Chapter 7 of the Rail Alignment EIS. In addition, the Department proposes to charter Mitigation Advisory Boards to assist in these efforts.

The Rail Alignment EIS discusses best management practices and mitigation measures related to transportation along the proposed rail line in the Caliente or Mina rail corridor. The EIS does not include practices or measures for transportation along other rail lines in Nevada (that is, along rail lines from the Nevada border to the beginning of the Caliente or Mina rail corridors). Rather, the transportation-related best management practices and management actions that DOE discusses in Section 9.3.1 of this Repository SEIS for national transportation would apply to the transport of spent nuclear fuel and high-level radioactive waste along other rail lines or highways in Nevada.

REFERENCES

185310 CEQ 2003 CEQ (Council on Environmental Quality) 2003. *The NEPA Task Force Report to the Council on Environmental Quality, Modernizing NEPA Implementation*. Washington, D.C.: Council on Environmental Quality. ACC: MOL.20080414.0051.

185325	CEQ 2007	CEQ (Council on Environmental Quality) 2007. *Aligning National Environmental Policy Act Processes with Environmental Management Systems: A Guide for NEPA and EMS Practitioners.* Washington, D.C.: Council on Environmental Quality. ACC: MOL.20080429.0002.
103226	DOE 1998	DOE (U.S. Department of Energy) 1998. *Nevada Test Site Resource Management Plan.* DOE/NV-518. Las Vegas, Nevada: U.S. Department of Energy. ACC: MOL.20010731.0305.
155970	DOE 2002	DOE (U.S. Department of Energy) 2002. *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada.* DOE/EIS-0250F. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20020524.0314; MOL.20020524.0315; MOL.20020524.0316; MOL.20020524.0317; MOL.20020524.0318; MOL.20020524.0319; MOL.20020524.0320.
172055	DOE 2004	DOE (U.S. Department of Energy) 2004. *Spill Prevention, Control, and Countermeasures Plan for Site Activities.* BAB000000-01717-4600-00009 Rev 02. Las Vegas, Nevada: U.S. Department of Energy, Office or Repository Development. ACC: DOC.20040329.0003.
154386	YMP 2001	YMP (Yucca Mountain Site Characterization Project) 2001. *Reclamation Implementation Plan.* YMP/91-14, Rev. 2. Las Vegas, Nevada: Yucca Mountain Site Characterization Office. ACC: MOL.20010301.0238.

10

Unavoidable Adverse Impacts; Short-Term Uses and Long-Term Productivity; and Irreversible or Irretrievable Commitment of Resources

TABLE OF CONTENTS

10. UNAVOIDABLE ADVERSE IMPACTS; SHORT-TERM USES AND LONG-TERM PRODUCTIVITY; AND IRREVERSIBLE OR IRRETRIEVABLE COMMITMENT OF RESOURCES

The *construction, operations, monitoring,* and eventual *closure* of the proposed *Yucca Mountain Repository* and the associated transportation of *spent nuclear fuel* and *high-level radioactive waste* could produce some environmental *impacts* that the U.S. Department of Energy (DOE or the Department) could not mitigate. Similarly, some aspects of the *Proposed Action* could affect the long-term productivity of the environment or would require the permanent use of some resources. This chapter discusses unavoidable adverse impacts, the relationship between short-term uses and long-term productivity, and irreversible or irretrievable commitment of resources.

In keeping with previous chapters of this *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F-S1) (Repository SEIS), this chapter contains discussions of the *repository*, national transportation, and transportation in the State of Nevada. This chapter summarizes, incorporates by reference, and updates Chapter 10 of the *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F; DIRS 155970-DOE 2002, pp. 10-1 to 10-14) (Yucca Mountain FEIS). This chapter also incorporates by reference the information presented in Chapter 8 of the Rail Alignment EIS.

10.1 Unavoidable Adverse Impacts

This section summarizes potential impacts due to the Proposed Action that would be unavoidable and adverse and that would remain after DOE implemented *best management practices* and *mitigation* measures, which are discussed in Chapters 4, 6, and 9 of this Repository SEIS, and references Chapter 8 of the Rail Alignment EIS.

10.1.1 YUCCA MOUNTAIN REPOSITORY

This section summarizes unavoidable adverse impacts from the construction, operations, monitoring, and closure of the proposed repository. This Repository SEIS provides estimated potential environmental impacts in Chapter 4, Section 4.1. Adverse impacts that would remain after implementation of best management practices and the institution of management action mitigation measures are unavoidable adverse impacts.

10.1.1.1 Land Use

To develop a repository at Yucca Mountain, DOE would have to obtain permanent control of the geologic repository operations area, currently under the control of DOE (National Nuclear Security Administration), the U.S. Department of Defense (U.S. Air Force), and the U.S. Department of the Interior (Bureau of Land Management). This would require congressional action. The geologic repository operations area would occupy a small portion of a larger area [600 square kilometers (230 square miles or approximately 150,000 acres)], which would include a buffer zone.

As Chapter 4, Section 4.1.1 discusses, DOE would disturb or clear land for *subsurface* and surface facility activities during the construction and operations analytical periods. The total land disturbance for the proposed repository would be approximately 9 square kilometers (2,200 acres), which would include land inside and outside the *analyzed land withdrawal area*.

10.1.1.2 Air Quality

Construction, operations, monitoring, and closure of a repository at Yucca Mountain would produce small impacts to regional *air quality*. During the construction analytical period, land disturbance and rock excavation would produce *fugitive dust* emissions, as would the operation of concrete batch plants (Chapter 4, Section 4.1.2). DOE would control most of these emissions with dust suppression methods. During the construction and operations analytical periods, construction equipment and other machinery would emit *nitrogen dioxide*, *sulfur dioxide*, and carbon monoxide. Exposures of maximally exposed individuals of the public to these *criteria pollutants* would be a small fraction of applicable regulatory limits. Other impacts would come from materials such as cristobalite. Chapter 4, Section 4.1.2 discusses emission of cristobalite particles from the subsurface exhaust ventilation system during excavation operations and as fugitive dust from the excavated rock storage pile.

10.1.1.3 Hydrology

As Chapter 4, Section 4.1.3 notes, repository construction and operation would result in minor changes to runoff and infiltration rates and minimal alteration of natural surface-water drainage channels. Repository activity would result in the unavoidable crossing of washes and their associated *floodplains*. The potential for flooding that could cause damage would be small.

Potential *contaminants* that could spill during construction would consist mostly of fuels (diesel, propane, and gasoline) and lubricants (oils and grease) for equipment. DOE would construct and install fuel storage tanks early in the construction analytical period with appropriate secondary containment. Other potential contaminants such as paints, solvents, strippers, and concrete additives would be present in small quantities. DOE would minimize the potential for spills to occur and, if they occurred, would minimize *contamination* by following its *Spill Prevention, Control, and Countermeasures Plan for Site Activities* (DIRS 172055-DOE 2004, all), which would be updated for repository construction.

DOE would withdraw *groundwater* during the construction and operations analytical periods. The highest annual water demand for the Proposed Action would be below the Nevada State Engineer's ruling of perennial yield (the amount that can be withdrawn annually without depleting reserves) for the *Jackass Flats hydrographic area* (DIRS 105034-Turnipseed 1992, pp. 9 and 12). The Proposed Action would withdraw groundwater that would otherwise move into *aquifers* of the *Amargosa Desert*, but the combined water demand for the repository and Nevada Test Site activities in Jackass Flats would, at most, have small impacts on the availability of groundwater in the Amargosa Desert area in comparison with the quantities of water already being withdrawn there.

10.1.1.4 Biological Resources and Soils

As Chapter 4, Section 4.1.4 notes, the construction of surface facilities and the disposition of excavated rock from subsurface construction would remove or alter vegetation in the analyzed land withdrawal area and within the 37-square-kilometer (9,100-acre) offsite area directly to the south. Removal of vegetation would result in impacts to small amounts of widely distributed land cover types that are not under-represented in the affected area. The largest losses would be to the Sonora-Mojave Creosotebush-White Bursage Desert Scrub and Sonora-Mojave Mixed Salt Desert Scrub, with disturbance of approximately 0.25 percent and 0.15 percent of these land cover types in the affected areas, respectively. The removal of vegetation could result in colonization by invasive plant species, which could suppress *native species*. DOE would use reclamation methods that would reduce the likelihood that *invasive species* would overtake species on reclaimed lands.

Direct impacts to biological resources would occur through: (1) loss of *habitat* from construction of facilities and infrastructure; (2) localized deaths of individuals of some species, particularly burrowing species of small mammals and reptiles during land disturbances, and deaths of individual animals from vehicle collisions; (3) fragmentation of undisturbed habitat that could create a *barrier* to the movement of individual species; and (4) displacement of wildlife because of an aversion to the noise and activity of construction, operations, monitoring, and closure of the repository. DOE anticipates that the effect of the impacts to biological resources would be small because habitats similar to those at Yucca Mountain are widespread locally and regionally. The species that occur at the site are generally widespread throughout the Mojave or *Great Basin* deserts, and the deaths of some individuals due to proposed repository activities would have a small impact on the regional populations of those species or on the overall biodiversity of the region. Large areas of undisturbed and unfragmented habitat would be available away from disturbed areas and impacts to wildlife from noise and vibration would occur only near the source of the noise.

The desert tortoise is the only species in the analyzed land withdrawal area listed as threatened under the *Endangered Species Act*, as amended (16 U.S.C. 1531 et seq.). There are no endangered or *candidate species* and no species that are proposed for listing. Repository construction would result in the loss of a small portion of the desert tortoise habitat at the northern edge of its range in an area where the abundance of desert tortoises is low.

Several species that are classified as sensitive by the Bureau of Land Management occur in the *region of influence*. Impacts to bat species would be small because of their low abundance on the site and broad distribution. Impacts to the common chuckwalla and Western burrowing owl from disturbance and loss of individuals would be small because they are widespread regionally and are not abundant in the land withdrawal area. Impacts to the Western red-tailed skink would be small because it is widespread regionally and occupies small pockets of isolated habitat that would not be overly affected by any proposed disturbances. One species of insect, Giuliani’s dune scarab beetle, has been reported only in the southern portion of the analyzed land withdrawal area away from any proposed disturbances, and therefore would not be affected.

Construction and operation activities at the proposed repository would disturb land and expose bare soil to wind and water erosion. Studies during Yucca Mountain *site characterization* work and experience at the Nevada Test Site indicate that natural succession on disturbed, semiarid land would be a very slow process (Chapter 4, Section 4.1.4.3.2). Soil recovery would be unlikely without reclamation. DOE is committed to reclamation of disturbed areas.

10.1.1.5 Cultural Resources

In the Yucca Mountain FEIS, DOE provided a summary of the American Indian view of cultural resource management and preservation. In the view of American Indians, the implementation of the Proposed Action would further degrade the environmental setting. Even after closure and reclamation, the presence of the repository would, from the perspective of American Indians, represent an irreversible impact to traditional lands. That perspective in the context of this section would therefore indicate that any action would result in unavoidable adverse impacts.

Some unavoidable adverse impacts could occur to archaeological sites and other cultural resources. There could be a loss of archaeological information due to illicit artifact collection. In addition, excavation activities could cause a loss of archaeological information. Chapter 4, Section 4.1.5 discusses impacts to cultural resources in the region of influence.

10.1.1.6 Socioeconomics

The construction and operation of a repository at Yucca Mountain would result in increased employment and population, which would place increased demands on housing and public services such as public safety and schools (Chapter 4, Section 4.1.6), particularly in Nye County and other locations in the region of influence where the populations are smaller and existing infrastructure is less developed. However, the increases, in southern Nevada as a whole and the metropolitan Las Vegas area in particular, would be small in comparison with *total employment*, population, *real disposable personal income*, *Gross Regional Product*, and state and local government spending in the region of influence.

For the five socioeconomic parameters DOE evaluated for this Repository SEIS, the changes in economic parameters would increase by less than 1 percent over the projected baseline values (Chapter 3, Section 3.1.7). The less-than-1-percent estimate assumes historical residential patterns. The potential impacts could be greater than a 1-percent change over baseline for communities in Nye County and elsewhere in the region of influence if more of the onsite workers and their families chose to live outside the Las Vegas/Clark County area.

Chapter 9, Section 9.2.3 provides Nye County's perspective on management actions to mitigate potential adverse impacts. This section presents the County's viewpoint as a cooperating agency and the situs county of the Proposed Action for this Repository SEIS.

10.1.1.7 Occupational and Public Health and Safety

There would be a potential for injuries or fatalities to workers from the construction, operations, monitoring, and closure of the proposed repository due to common industrial *accidents* and inhalation of cristobalite and *erionite*. In addition, during the construction analytical period, workers could encounter unexploded ordnance at some surface locations. Engineering controls, administrative controls, and training and safety programs would reduce but not eliminate the potential for worker injuries or fatalities. Chapter 4, Section 4.1.7.1 discusses nonradiological occupational and public health and safety issues.

Chapter 4, Section 4.1.7.2 discusses potential radiological impacts to workers and the public. The types of potential health and safety impacts to workers during the construction analytical period would include those from exposure to naturally occurring radionuclides (primarily radon-222 and its decay products).

Engineering controls and training and safety programs would reduce but not eliminate the potential. During the operations analytical period, radiological impacts to workers could occur during the receipt, handling, aging, and *emplacement* of spent nuclear fuel and high-level *radioactive* waste and continued development of the subsurface facility. Monitoring of emplaced *waste packages* and closure activities would also result in some exposures.

Members of the public could be exposed to airborne releases of radon-222 and its decay products from the subsurface exhaust ventilation air throughout the construction, operations, monitoring, and closure analytical periods. Table 4-24 lists the estimated individual *risk* of contracting a latent *cancer* for the maximally exposed member of the public and the exposed population within 84 kilometers (52 miles) of the repository for all analytical periods of the project (construction, operations, monitoring, and closure).

10.1.1.8 Utilities, Energy, Materials, and Site Services

The construction, operations, monitoring, and closure of a repository at Yucca Mountain would result in the unavoidable use of energy (mostly electricity and petroleum products) and material (mostly cement, steel, and copper). In addition, DOE would consume nickel, palladium, and titanium in the manufacture of repository components. The consumption of energy and construction material (cement, steel, and copper) would not be large enough to affect national or regional supplies. The consumption of nickel, palladium, and titanium would have a moderate affect on supply but could be supported by U.S. and world markets. Chapter 4, Section 4.1.11 lists the amounts of resources the Proposed Action would consume. Chapter 4, Section 4.1.14 presents information on the quantities of materials required for the manufacture of repository components, such as the palladium and titanium required for *drip shields*.

In relation to site services, DOE would respond to and mitigate most onsite incidents, which would include underground incidents, without outside support (Chapter 4, Section 4.1.11.6). The Fire, Rescue and Medical Facility would provide space for fire protection, firefighting services, underground rescue services, emergency and occupational medical services, and *radiation* protection. A helicopter pad would enable emergency medical evacuations. DOE would coordinate the operation of this facility with facilities in Nye County and at the Nevada Test Site to increase response capabilities.

Traffic volumes along U.S. Highway 95 would increase as a result of repository construction and operation. Increased traffic could result in more accidents, which could affect Nye County law enforcement and emergency services.

10.1.2 NATIONAL TRANSPORTATION

Chapter 6 identifies the following unavoidable impacts from the transport of spent nuclear fuel and high-level radioactive waste from 72 commercial and 4 DOE sites to a siding for the Caliente or Mina *rail corridor*.

10.1.2.1 Occupational and Public Health and Safety

Certain adverse impacts to workers and the public from the transportation of spent nuclear fuel and high-level radioactive waste would be unavoidable. The loading and transportation of these materials would have the potential to affect workers and the public through industrial accidents, exposure to radiation and vehicle emissions, and traffic accidents.

10.1.2.1.1 *Impacts from Loading Canisters at Generator Sites*

DOE estimated the following impacts could occur from loading activities at the generator sites:

- About 1.2 traffic fatalities and about 0.23 fatality from vehicle emissions would result from shipping about 6,500 empty *transportation, aging, and disposal* (TAD) *canisters* and 4,900 campaign kits to generator sites. Chapter 6, Section 6.2.1 presents a discussion of the transportation of canisters to generator sites.

- The *population dose* to members of the public within 16 kilometers (10 miles) of the generator sites would be 2.9 *person-rem* over the duration of loading operations. In the exposed population, the estimated *probability* of a *latent cancer fatality* would be 0.0017 or about 1 chance in 600. The estimated radiation *dose* to the maximally exposed member of the public 800 meters (0.5 mile) from a generator site would be 7.7×10^{-6} *rem*. The estimated probability of a latent cancer fatality for this individual would be 4.6×10^{-9} or about 1 chance in 200 million.

- The collective radiation dose for workers who performed loading activities would be 10,000 person-rem. In the exposed population of workers, this radiation dose would result in 6.0 latent cancer fatalities.

10.1.2.1.2 *Incident-Free Transportation*

DOE estimated the following impacts could occur from *incident-free* transportation of spent nuclear fuel and high-level radioactive waste to Nevada:

- About 4 latent cancer fatalities could occur in the population of transportation workers who would be exposed to radiation from the *shipments*. Because many workers would be involved, the risk for an individual worker would be small.

- There would be about 1 (0.7) latent cancer fatality among members of the public who would be exposed to radiation. Because this estimate is for the entire population of individuals who would be exposed along the transportation routes over the course of shipments to the repository, the risk for a single individual would be small.

- The number of vehicles bound for Yucca Mountain would be small in relation to normal traffic volume, which would result in a small impact on air quality.

10.1.3 NEVADA TRANSPORTATION

Chapter 8 of the Rail Alignment EIS and Chapter 10, Section 10.1.3 of the Yucca Mountain FEIS present information about unavoidable adverse impacts related to the construction and operation of a *railroad* in Nevada. Chapter 8 presents information drawn from the analysis of the Proposed Action and Shared-Use Option and consolidates information from the environmental impacts and mitigation analyses. The chapter addresses all environmental resource categories with an emphasis on those that could experience unavoidable adverse impacts.

10.2 Relationship Between Short-Term Uses and Long-Term Productivity

The Proposed Action would require short-term uses of the environment that would affect long-term environmental productivity. This section describes possible impacts to long-term productivity from those short-term uses.

This Repository SEIS identified two distinct periods for the evaluation of the use of the environment by the Proposed Action:

- A 105-year period for surface activities that would consist of construction, operations, monitoring, and closure of the proposed repository. DOE activities during this period would include construction of facilities, receipt and emplacement of spent nuclear fuel and high-level radioactive waste, recovery of recyclable materials, ventilation of subsurface emplacement areas, decontamination, closure of surface and subsurface facilities, reclamation of land, and monitoring. This period would be the only time during which DOE would involve the surface of the land used for the repository.

- The balance of a 1-million-year period that would consist of an evaluation of impacts from the disposal of spent nuclear fuel and high-level radioactive waste for the first 10,000 years and an evaluation of impacts for up to 1 million years.

In general, transportation and disposal activities associated with the proposed repository would benefit long-term productivity by the removal of spent nuclear fuel and high-level radioactive waste from commercial and DOE sites around the country. In addition, removing these materials from existing sites would free people and resources committed—now and in the future—to the monitoring and safeguarding of these materials for other potentially more productive activities. Removal could create conditions that would enable the initiation of other productive uses at the commercial and DOE sites. Finally, disposing of spent nuclear fuel and high-level radioactive waste in the proposed repository would provide a long-term global benefit by isolating the materials from concentrations of human population and human activity, thereby reducing the potential for sabotage.

10.2.1 YUCCA MOUNTAIN REPOSITORY

In the Yucca Mountain FEIS, DOE described "short-term" as the time from start of construction to the end of relevant surface and subsurface human activity and "long-term" as the time from the end of the short-term period to the time environmental resources had recovered from the potential for impacts and were again productive, or a maximum of 1 million years. "Productivity" refers to the ability of an element of the environment to generate crops, provide habitat, or otherwise serve as a medium for the creation of value. For transportation purposes, short-term refers to the time of construction or actual transportation, and long-term refers to the time from the end of the short-term period to the time of environmental recovery.

10.2.1.1 Land Use

The withdrawal of land for the repository would total about 600 square kilometers (150,000 acres), which would include about 180 square kilometers (44,000 acres) in the town of Amargosa Valley taxing district, resulting in loss of productivity. The repository, however, would enable consideration of other uses for sites where spent nuclear fuel and high-level radioactive waste are being stored and the land buffering those sites. Many present storage sites are in locations that would permit a wider range of *alternative* uses than would Yucca Mountain.

10.2.1.2 Hydrology

As noted in Chapter 3, Section 3.1.4 of this Repository SEIS, the proposed repository is in the Alkali Flat-Furnace Creek groundwater basin, which discharges mainly at Alkali Flat and potentially to the Furnace Creek area of Death Valley, and is part of the Death Valley regional groundwater flow system. Death Valley is hydrologically isolated and separated from other surface and subsurface water. Once water enters Death Valley it can leave only by *evapotranspiration*. There would, however, be the potential for materials disposed of at the proposed repository to reach groundwater at some time between several thousand and 1 million years. If such contamination reached groundwater, and if the water exceeded applicable regulatory requirements, there could be an attendant loss of productivity for the affected groundwater and for surface waters in the basin. Conversely, the disposal of spent nuclear fuel and high-level radioactive waste at Yucca Mountain would free a wide range of major and minor water bodies throughout the United States from the potential threat of radioactive contamination from the materials at the present storage sites.

10.2.1.3 Biological Resources and Soils

As described in Chapter 4, Section 4.1.4 of this Repository SEIS, biological resources would be affected directly by land disturbances. The overall impact to populations of species would be limited because the area disturbed and the number of individual animals lost would be small in relation to the regional availability.

Long-term productivity loss for soils would be limited to areas affected by land disturbances. DOE would revegetate these areas after the completion of closure activities. The disposal of spent nuclear fuel and high-level radioactive waste at Yucca Mountain would remove these materials from proximity to biota near the present storage sites across the United States.

10.2.2 TRANSPORTATION ACTIONS

Chapter 8 of the Rail Alignment EIS presents information on short-term uses and long-term productivity related to the construction and operation of a railroad in Nevada. The chapter presents information drawn from the analysis of the Proposed Action and Shared-Use Option and consolidates information from the environmental impacts and mitigation analyses.

The major long-term benefit of the transport of spent nuclear fuel and high-level radioactive waste to the repository would be the permanent consolidation of these materials in an isolated location away from concentrations of people, with highly limited long-term *exposure pathways* to such concentrations.

10.3 Irreversible or Irretrievable Commitment of Resources

The Proposed Action would involve the irreversible or irretrievable commitment of land, energy, and materials. The commitment of a resource is irreversible if its primary or secondary impacts limit future options for the resource. An irretrievable commitment refers to the use or consumption of resources that are neither renewable nor recoverable for later use by future generations. Construction, operations, monitoring, and eventual closure of a repository at Yucca Mountain would result in a permanent commitment of land, groundwater, surface, subsurface, mineral, biological, soil, and air resources; materials such as copper, nickel, palladium, steel, titanium, and cement; and energy in forms such as fossil fuels and electricity. Water use would support construction, operations, monitoring, and closure of the repository and construction of the proposed railroad. Radiological contamination of groundwater beyond safe levels, although not likely (Chapter 5), could limit future groundwater uses. There would be an irreversible and irretrievable commitment of natural resources such as land use and habitat productivity.

10.3.1 YUCCA MOUNTAIN REPOSITORY

Construction, operations, monitoring, and eventual closure of a repository at Yucca Mountain would result in a permanent commitment of the analyzed land withdrawal area, including about 180 square kilometers (44,000 acres) in the town of Amargosa Valley taxing district, which would include surface and subsurface resources. The public could not make use of resources in that area.

Mitigation approaches that would involve the excavation of archaeological sites to prevent degradation by construction activities would destroy the contexts of those sites and reduce the finite number of such resources in the region. DOE expects that its activities at the proposed repository would affect no more than a minimal number of such sites.

Electric power, fossil fuels, and construction materials would be irreversibly committed to the project. Aggregate would be crushed and mixed in concrete for use in the repository. Chromium, molybdenum, nickel, and steel used to manufacture the TAD canisters as well as the palladium and titanium used in drip shields would be an irreversible and irretrievable commitment of resources. Some copper and steel ramps and access mains to subsurface facilities would be recyclable, while some in the emplacement *drifts* would be irreversibly and irretrievably lost. Most of the steel used for the surface facilities would be recyclable and, therefore, not an irreversible or irretrievable commitment. Some steel, such as rebar, would be difficult to recycle. The quantity of resources consumed would be small in comparison with their national consumption or their availability to consumers in southern Nevada.

10.3.2 TRANSPORTATION ACTIONS

The manufacture of *transportation casks* would require commitment of aluminum, chromium, copper, depleted uranium, lead, molybdenum, nickel, and steel. With the exception of nickel, the required amounts of these materials would be low in relation to U.S. production and supply (DIRS 155970-DOE 2002, p. 10-13). The shipment of spent nuclear fuel and high-level radioactive waste to Nevada would involve irreversible commitments of electric power, fossil fuels, and construction materials.

Chapter 8 of the Rail Alignment EIS presents information on irreversible and irretrievable commitment of resources related to the construction and operation of a railroad in Nevada. The chapter presents information drawn from the analysis of the Proposed Action and Shared-Use Option and consolidates information from the environmental impacts and mitigation analyses.

REFERENCES

155970	DOE 2002	DOE (U.S. Department of Energy) 2002. *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*. DOE/EIS-0250F. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20020524.0314; MOL.20020524.0315; MOL.20020524.0316; MOL.20020524.0317; MOL.20020524.0318; MOL.20020524.0319; MOL.20020524.0320.
172055	DOE 2004	DOE (U.S. Department of Energy) 2004. *Spill Prevention, Control, and Countermeasures Plan for Site Activities.* BAB000000-01717-4600-00009 Rev 02. Las Vegas, Nevada: U.S. Department of Energy, Office of Repository Development. ACC: DOC.20040329.0003.
105034	Turnipseed 1992	Turnipseed, R.M. 1992. “Official Ruling in the Matter of Application 52338 Filed to Appropriate the Waters from an Underground Source Within the Forty Mile Canyon-Jackass Flats Groundwater Basin, Nye County, Nevada.” Letter from R.M. Turnipseed (State Engineer, State of Nevada) to C. Gertz (YMP), March 2, 1992. ACC: HQX.19930511.0006.

11

Statutory and Other Applicable Requirements

TABLE OF CONTENTS

LIST OF TABLES

11. STATUTORY AND OTHER APPLICABLE REQUIREMENTS

This chapter identifies major requirements that could be applicable to the *Proposed Action*, which is to construct, operate, monitor, and close a *geologic repository* for the *disposal* of *spent nuclear fuel* and *high-level radioactive waste* at Yucca Mountain.

On February 14, 2002, the Secretary of Energy, in accordance with the *Nuclear Waste Policy Act*, as amended (42 U.S.C. 10101 et seq.) (NWPA), transmitted the recommendation, and the *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F; DIRS 155970-DOE 2002, all) (Yucca Mountain FEIS), to the President for approval of the *Yucca Mountain site* for development of a *geologic* repository. The President considered the site to qualify for application to the U.S. Nuclear Regulatory Commission (NRC) for construction authorization and recommended the site to Congress. On July 23, 2002, the President signed the *Yucca Mountain Development Act of 2002* (Public Law 107-200; 116 Stat. 735), which approved the Yucca Mountain site for development as a geologic repository for the disposal of spent nuclear fuel and high-level radioactive waste. In referring to acts of Congress, this chapter refers to the law as amended in the United States Code, or it refers to the unamended act by Public Law number.

The U.S. Department of Energy (DOE or the Department) has reviewed and updated this chapter for this *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F-S1) (Repository SEIS). This chapter summarizes, incorporates by reference, and updates Chapter 11 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 11-1 to 11-25) and presents new information, as applicable, from statutory and other applicable requirements that have arisen since completion of the FEIS. In this chapter:

- Section 11.1 summarizes statutes and regulations that establish DOE's authority to construct and operate a geologic repository in the State of Nevada. This section also summarizes the license application statutes and authority for the proposed *Yucca Mountain Repository*.

- Section 11.2 summarizes statutes and regulations that set environmental protection requirements that could apply to the *construction* and *operation* of the repository and to transportation of radioactive materials.

- Section 11.3 summarizes potential licenses, permits, and approvals DOE could require to construct and operate the proposed repository.

- Section 11.4 summarizes DOE Orders and describes the mechanism by which these Orders give precedence to NRC rules in relation to the repository.

- Section 11.5 refers to a list of other federal regulations and DOE Orders that are potentially applicable to the construction, operations, *monitoring*, and *closure* of a geologic repository.

- Section 11.6 refers to statutes, regulations, requirements, and orders specific to the proposed Nevada *railroad*.

11.1 Statutes and Regulations that Establish or Affect Authority To Propose, License, and Develop a Geologic Repository

This section describes the DOE analysis of statutes and regulations that establish or affect the Department's authority to construct and operate the proposed Yucca Mountain Repository. It summarizes, incorporates by reference, and updates Section 11.1 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 11-1 to 11-7).

11.1.1 NUCLEAR WASTE POLICY ACT OF 1982, AS AMENDED (42 U.S.C. 10101 et seq.)

The NWPA establishes the Federal Government's responsibility for the disposal of spent nuclear fuel and high-level radioactive waste and the generators' responsibilities to bear the costs of disposal. Congress amended the original *Nuclear Waste Policy Act of 1982* in 1987 and identified the Yucca Mountain site in Nye County, Nevada, as the only site for study as a potential location for a geologic repository.

Other than appropriations, no changes have been made to the NWPA since completion of the Yucca Mountain FEIS.

11.1.2 YUCCA MOUNTAIN DEVELOPMENT ACT OF 2002 (42 U.S.C. 10135)

On February 15, 2002, President George W. Bush approved the Secretary of Energy's recommendation of Yucca Mountain as the site for the development of a repository for the disposal of spent nuclear fuel and high-level radioactive waste. The House of Representatives approved the Yucca Mountain site on May 8, 2002, as did the Senate on July 9, 2002. The Act is a joint resolution of the House of Representatives and the Senate to approve the site at Yucca Mountain, Nevada, for the development of a repository for the disposal of spent nuclear fuel and high-level radioactive waste pursuant to the NWPA. The joint resolution acknowledged that the governor of the State of Nevada submitted a notice of disapproval on April 8, 2002. This approval of the site at Yucca Mountain became known as the *Yucca Mountain Development Act*, which the President signed into law on July 23, 2002.

11.1.3 ENERGY POLICY ACT OF 1992 (42 U.S.C. 13201 et seq.)

Congress passed the *Energy Policy Act of 1992* in part to modify the rulemaking authorities of the U.S. Environmental Protection Agency (EPA) and NRC in relation to the proposed repository at Yucca Mountain. Congress had previously directed EPA to establish standards to protect the general environment from offsite releases of radioactive materials in repositories. Section 801(a) of the Energy Policy Act directs EPA (1) to retain the National Academy of Sciences to make findings and recommendations on reasonable public health and safety standards for Yucca Mountain, and (2) to establish Yucca Mountain-specific standards based on and consistent with the National Academy of Sciences findings and recommendations. Section 801(b) of the Act directs NRC to modify its technical requirements and criteria for geologic repositories to be consistent with the site-specific EPA Yucca

Mountain standard (40 CFR Part 197). Section 801(c) of the Act requires that DOE continue its oversight of the Yucca Mountain site after repository-closure to prevent: (1) unreasonable *risk* of breaching the repository's *barriers*, and (2) increase in the *exposure* of individual members of the public to *radiation* beyond allowable limits.

11.1.4 DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES IN A PROPOSED GEOLOGIC REPOSITORY AT YUCCA MOUNTAIN (10 CFR PART 63) AND ENVIRONMENTAL RADIATION PROTECTION STANDARDS FOR YUCCA MOUNTAIN (40 CFR PART 197)

In 2001, both EPA and NRC adopted public health and safety standards for any radioactive material to be disposed of in a Yucca Mountain Repository. In 2004, in response to legal challenges, the U.S. Court of Appeals for the District of Columbia Circuit struck down the portions of those standards that addressed the period for which compliance must be demonstrated and remanded the provisions to the federal agencies for revision.

In 2005, EPA proposed new standards to address the court's decision. The proposed standards incorporate multiple compliance criteria applicable at different times for protection of individuals and the environment, and in circumstances involving *human intrusion* into the repository. The proposals also identify certain specific processes that must be considered in projecting repository performance. When finalized, these standards will be codified in 40 CFR Part 197, Subpart B.

Because Section 801 of the *Energy Policy Act of 1992* requires NRC to modify its technical requirements for licensing of a Yucca Mountain Repository to be consistent with the standards promulgated by EPA, NRC also proposed new standards in 2005 to implement the proposed EPA standards for *doses* that could occur after 10,000 years but within the period of geologic stability. The proposed NRC standards also specify a value to be used to represent climate change after 10,000 years, as required by EPA, and specify that calculations of radiation doses for workers use the same weighting factors that EPA proposed for calculating individual doses to members of the public. When finalized, these standards will be codified in 10 CFR Part 63.

In developing the *Total System Performance Assessment* (TSPA)-LA model for the analysis in this Repository SEIS, DOE took into consideration the regulatory requirements in the proposed EPA and NRC standards to provide a perspective on potential radiological *impacts* during the *postclosure* period. The TSPA-LA model for the analyses in this Repository SEIS was finalized for purposes of the compliance assessment included in the application DOE submitted to the NRC for construction authorization for the Yucca Mountain Repository.

11.1.5 NATIONAL ENVIRONMENTAL POLICY ACT OF 1969 (42 U.S.C. 4321 et seq.)

DOE has prepared this Repository SEIS in accordance with the provisions of the *National Environmental Policy Act* (NEPA) as implemented by Council on Environmental Quality regulations (40 CFR Parts 1500 through 1508) and DOE NEPA regulations (10 CFR Part 1021), and in conformance with the NWPA.

11.1.6 ATOMIC ENERGY ACT OF 1954, AS AMENDED (42 U.S.C. 2011 et seq.)

The *Atomic Energy Act of 1954*, as amended, provides fundamental jurisdictional authority to DOE and NRC over governmental and commercial use of nuclear materials. This Act ensures proper management, production, possession, and use of radioactive materials. To comply with the Act, DOE established a system of requirements it issued as DOE Orders. (Section 11.4 discusses DOE Orders.)

The Act gives NRC authority to regulate the possession, transfer, storage, and disposal of nuclear materials, as well as aspects of transportation packaging design for radioactive materials that include testing for packaging certification. The Act gives EPA the authority to develop standards for the protection of the environment and public health from radioactive material.

11.1.7 FEDERAL LAND POLICY AND MANAGEMENT ACT OF 1976 (43 U.S.C. 1701 et seq.)

The *Federal Land Policy and Management Act of 1976* governs the use of federal lands under the administration of the U.S. Department of the Interior. The *analyzed land withdrawal area* for the proposed repository encompasses public lands under the administration of the Bureau of Land Management, which is an agency of the Department of the Interior. The Bureau governs public lands primarily through the regulations on the establishment of rights-of-way (43 CFR Part 2800) and administrative withdrawals of public domain land from public use (43 CFR Part 2300). The Act, by which the government accomplishes most federal land withdrawals, contains a detailed procedure for application, review, and study by the Bureau of Land Management, as well as decisions by the Secretary of the Interior on withdrawal and on the terms and conditions of withdrawal. Only Congress has the power to withdraw federal lands permanently for the exclusive purposes of specific agencies. Through legislative action, Congress can authorize and direct a permanent withdrawal of lands such as those proposed for the Yucca Mountain Repository.

11.2 Statutes, Regulations, and Executive Orders for Environmental Protection

This section describes the environmental protection statutes, regulations, and Executive Orders relevant to the proposed Yucca Mountain Repository. It summarizes, incorporates by reference, and updates Section 11.2 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 11-7 to 11-20).

11.2.1 PROTECTION AND ENHANCEMENT OF ENVIRONMENTAL QUALITY (EXECUTIVE ORDER 11514, AS AMENDED)

Executive Order 11514 directs federal agencies to continuously monitor and control their activities continually to protect and enhance the quality of the environment. The Order also requires the development of procedures both to ensure the fullest practical provision of timely public information and understanding of federal plans and programs with potential environmental impacts, and to obtain the views of interested parties. DOE has promulgated regulations to ensure compliance with NEPA.

11.2.1a Strengthening Federal Environmental, Energy, and Transportation Management (Executive Order 13423)

Executive Order 13423 directs federal agencies to conduct their environmental-, transportation-, and energy-related activities in support of their respective missions in an environmentally, economically, and fiscally sound, integrated, continuously improving, efficient, and sustainable manner.

11.2.2 AIR QUALITY

11.2.2.1 Clean Air Act of 1963, as Amended (42 U.S.C. 7401 et seq.)

The purpose of the *Clean Air Act of 1963* is to "protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population." Pursuant to the Act, EPA has established National Ambient Air Quality Standards at 40 CFR Parts 50 through 99 to protect the public health and the environment. More specifically, the Act regulates emissions of hazardous air pollutants, including *radionuclides*, through the National Emissions Standards for Hazardous Air Pollutants Program (40 CFR Parts 61 and 63).

11.2.2.2 Nevada Revised Statutes: Air Emission Controls, Chapter 445B

Nevada Revised Statutes, Air Emission Controls, and regulations in the Nevada Administrative Code implement state and federal clean air provisions. DOE would need operating permits from the Nevada Division of Environmental Protection, Bureau of Air Pollution Control, for the control of gaseous and particulate emissions from construction and operation of the proposed repository.

As part of Yucca Mountain *site characterization*, DOE has obtained an *air quality* operating permit from the State of Nevada. The permit placed specific operating conditions on systems that DOE used during site characterization activities. These conditions included limiting the emission of *criteria pollutants*, defining the number of hours per day and per year a system may operate, and determining the testing, monitoring, and recordkeeping required for the system. This operating air quality permit was updated and renewed in 2006 (DIRS 179968-DeBurle 2006, all).

11.2.3 WATER QUALITY

11.2.3.1 Safe Drinking Water Act of 1974, as Amended [42 U.S.C. 300(f) et seq.]

The primary objective of the *Safe Drinking Water Act* is to protect the quality of public water supplies. This includes any drinking water system at the proposed repository. The Act gives EPA the responsibility and authority to regulate public drinking water supplies by establishing drinking water standards, delegating authority for the enforcement of drinking water standards to the states, and protecting *aquifers* from pollution hazards. The Nevada Division of Environmental Protection, Bureau of Safe Drinking Water, is the state agency responsible for the enforcement of drinking water standards. EPA regulations for this program are codified at 40 CFR Part 141, and Nevada rules for this program are codified at Nevada Administrative Code Chapter 445A. Nevada primary drinking water standards are identical to the national standards. The proposed repository would include a drinking water system that would obtain water from a source outside the geologic repository operating area, and DOE would operate the system in accordance with Nevada permitting requirements.

Since completion of the Yucca Mountain FEIS, a standard for natural uranium has gone into effect, but a proposed standard for radon is still pending. EPA implemented the standard for uranium at 0.03 milligrams per liter [40 CFR 141.66(e)]. In addition, EPA lowered the primary drinking water standard for arsenic from 0.05 milligram per liter to 0.01 milligram per liter (40 CFR 141.23).

11.2.3.2 Clean Water Act of 1977 (33 U.S.C. 1251 et seq.)

The purpose of the *Clean Water Act of 1977*, which amended the *Federal Water Pollution Control Act* (Public Law 92-500, Section 2, 86 Stat. 816), is to "restore and maintain the chemical, physical, and biological integrity of the Nation's water." EPA has delegated to the State of Nevada the authority to implement and enforce most programs in the state under the *Clean Water Act of 1977*. An exception is Section 404, which gives the U.S. Army Corps of Engineers permitting authority over activities that discharge dredge or fill material into waters of the United States.

Under the Act, the State of Nevada sets water quality standards, and EPA and the state regulate and issue permits for point-source discharges as part of the National Pollutant Discharge Elimination System permitting program. EPA regulations for this program are in 40 CFR Part 122, and Nevada rules for this program are in Nevada Administrative Code Chapter 445A. If the construction or operation of a Yucca Mountain Repository would result in point-source discharges, DOE would obtain a National Pollutant Discharge Elimination System permit from the state.

Sections 401 and 405 of the *Water Quality Act of 1987* added Section 402(p) to the *Clean Water Act of 1977*. Section 402(p) requires EPA to establish regulations for EPA or individual states to issue permits for stormwater discharges from industrial activity, which includes construction activities that could disturb 0.2 square kilometer (5 acres) or more (40 CFR Part 122). Nevada rules for this program are in Nevada Administrative Code Chapter 445A.

Under Section 404 of the *Clean Water Act of 1987*, DOE would need to obtain a permit from the U.S. Army Corps of Engineers for discharges of dredge or fill materials into any waters of the United States, which include *wetlands*. For example, DOE has obtained a Section 404 permit for construction activities it might conduct in Coyote Wash and its tributaries. However, in 2006, the Supreme Court (*Rapanos v. U.S.* and *Carabell v. U.S.)* addressed the jurisdictional scope of Section 404 of the *Clean Water Act*, specifically the term "the waters of the U.S." This ruling could affect whether the U.S. Army Corps of Engineers could determine that any dry wash at the Yucca Mountain site is a water of the United States. Appendix C provides further discussion of specific washes at the proposed repository.

Since completion of the Yucca Mountain FEIS, DOE has conducted additional analyses of Section 404 provisions and their impact in relation to the repository and to the Caliente and Mina *rail corridors*. Chapter 4 and Appendix C of this Repository SEIS discuss these analyses.

11.2.3.3 Nevada Revised Statutes: Water Controls, Chapter 445A

Nevada Revised Statutes, Water Controls, classifies the waters of the state, establishes standards for the quality of waters in the state, and specifies permit and notification provisions for stormwater discharges and for other discharges to the waters of the state in accordance with provisions of the *Clean Water Act of 1977* (33 U.S.C. 1251 et seq.) and the *Safe Drinking Water Act of 1974* (42 U.S.C. 300 et seq.). These statutes and the regulations in the Nevada Administrative Code set drinking water standards, specifications for certification, and conditions for issuance of variances and exemptions; set standards and requirements for the construction of wells and other water supply systems; establish the different classes of wells and aquifer exemptions; and establish requirements for well operation, monitoring, plugging, and abandonment activities.

The Yucca Mountain FEIS reported that DOE obtained Underground Injection Control and Public Water System permits for site characterization activities at Yucca Mountain. Actually, only one Underground Injection Control Permit was obtained and it covers tracers, pump tests, surface discharges, and similar activities. A Public Water System Permit establishes the terms for the provision of potable water.

Since completion of the Yucca Mountain FEIS, DOE has determined that the Nevada Division of Environmental Protection, Bureau of Water Pollution Control, requires a temporary permit for work in waterways of the state. DOE would apply for a temporary permit before using equipment in waters of the state, including dry washes, that could directly discharge pollutants into waterways.

11.2.3.4 Nevada Revised Statutes: Adjudication of Vested Water Rights, Appropriation of Public Waters, Underground Water and Wells, Chapter 534

These Nevada Revised Statutes prescribe requirements for establishing state water rights for use of public waters of the state, which includes underground waters. These statutes provide procedures for the drilling, construction, and plugging of wells for the extraction of underground water.

DOE filed a water appropriation request with the Office of the Nevada State Engineer on July 22, 1997, for permanent rights to withdraw 530,000 cubic meters (430 acre-feet) of water annually. These applications were for the five well sites at J-12, J-13, and the C-Wells complex. The use is considered industrial and includes but is not limited to road construction, facility construction, drilling, dust suppression, tunnel and pad construction, testing, culinary and domestic uses, and other uses that relate to the site. These water appropriation permit applications have been denied by the Nevada State Engineer. The U.S. Department of Justice, on behalf of DOE, has appealed this decision in U.S. District Court.

11.2.3.5 Executive Order 11988, Floodplain Management

Executive Order 11988 directs federal agencies to establish procedures to ensure that agencies, for any federal action in a *floodplain*, consider the potential effects of flood hazards and floodplain management, and to avoid floodplain impacts where possible. DOE implementing regulations are in 10 CFR Part 1022.

11.2.3.6 Compliance with Floodplain/Wetlands Review Requirements (10 CFR Part 1022)

The Yucca Mountain FEIS discussed compliance with floodplain and wetland review requirements. These federal regulations establish DOE procedures for identification of proposed actions in floodplains and provide for early public review of the proposed actions. If DOE determines that an action it proposes would take place wholly or partly in a floodplain or wetland, the regulation requires preparation of a floodplain or wetland assessment with a project description and a discussion of project impacts, *alternatives*, and *mitigations*. If there is no practicable alternative to impacts to and within a floodplain or wetland, DOE must design or modify its action to minimize potential harm.

Appendix C of this Repository SEIS contains a floodplain and wetlands assessment that examines the effects of proposed repository construction and operations.

11.2.4 HAZARDOUS MATERIALS PACKAGING, TRANSPORTATION, AND STORAGE

11.2.4.1 Roles of the U.S. Department of Transportation and the U.S. Nuclear Regulatory Commission in Regulation of the Transportation of Radioactive Materials

As the Yucca Mountain FEIS described, NRC and the U.S. Department of Transportation share primary responsibility for regulation of the safe transportation of radioactive materials in the United States. The Department of Transportation has the responsibility to develop and implement transportation safety standards for hazardous materials, including radioactive materials. Title 49 CFR establishes Department of Transportation standards and requirements for packaging, transporting, and handling radioactive materials for all modes of transportation. These standards address labeling, shipping papers, placarding, loading and unloading, allowable radiation levels, and limits for *contamination* of packages and vehicles, among other requirements. The regulations specify safety requirements for vehicles and transportation operations, training for personnel who perform handling and transportation of hazardous materials, and liability insurance requirements for carriers.

NRC sets performance standards for transportation packaging (*shipping casks*) for materials with higher levels of *radioactivity*. The U.S. Department of Transportation, by agreement with NRC, accepts the standards of 10 CFR Part 71 for packaging. NRC also establishes safeguards and security regulations to minimize the possibility of theft, diversion, or attack on shipments of radioactive materials (10 CFR Part 73). NRC revised Class 7 (radioactive materials) requirements on October 1, 2004, to align with the International Atomic Energy Agency regulations for the safe transport of radioactive materials. NRC coordinated the final rule with the Department of Transportation to ensure consistency between NRC and Department of Transportation regulations (69 FR 58841, October 1, 2004).

The shipment of spent nuclear fuel and high-level radioactive waste is highly regulated and subject to the utmost scrutiny. DOE carefully follows U.S. Department of Transportation and NRC transportation rules now and will follow or exceed any others that might be established in the future, whether by Congress, the Department of Transportation, or NRC.

11.2.4.2 Hazardous Materials Transportation Act (49 U.S.C. 1801 et seq.)

The *Hazardous Materials Transportation Act* gives the U.S. Department of Transportation the authority to regulate the transport of hazardous materials, including the radioactive materials that DOE would transport to the proposed Yucca Mountain Repository from 72 commercial and 4 DOE sites. Department of Transportation regulations (49 CFR Parts 171 through 180) require the identification of hazardous materials that DOE would transport to Yucca Mountain. The rules for selection of routes that carriers must use to transport such materials, and guidance to states in the designation of preferred routes, are in 49 CFR Part 397.

11.2.4.3 Emergency Planning and Community Right-to-Know Act of 1986 (42 U.S.C. 1001 et seq.)

The Yucca Mountain FEIS described Subtitle A of the *Emergency Planning and Community Right-to-Know Act of 1986* (also known as “SARA Title III”). Federal facilities, which would include a repository at Yucca Mountain, must provide information on hazardous and toxic chemicals to state emergency response commissions, local emergency planning committees, and EPA. The goal of providing this information is to ensure that emergency plans are sufficient to respond to unplanned releases of hazardous substances. The required information includes inventories of specific chemicals used or stored and descriptions of releases that occur from sites.

11.2.4.4 Nevada Revised Statutes: State Fire Marshal, Chapter 477 and Hazardous Materials, Chapter 459

The State of Nevada could require a Hazardous Materials Storage Permit for DOE to store hazardous materials in quantities above those the Uniform Fire Code specifies (Nevada Revised Statutes, Chapter 477). To receive such a permit, if necessary, DOE would submit an application to the Nevada State Fire Marshal that described its plans for the storage of hazardous materials in excess of specified quantities. DOE obtained a permit from the State Fire Marshal for the storage of flammable materials during site characterization activities. This permit is still active. In addition, DOE would be required to manage and dispose of hazardous waste pursuant to Nevada Revised Statutes Chapter 459 – Hazardous Materials.

11.2.4.5 U.S. Nuclear Regulatory Commission Radioactive Materials Packaging and Transportation Regulations (10 CFR Parts 71 and 73)

Under 10 CFR Part 71, NRC regulates the packaging and transport of spent nuclear fuel for its licensees, which include commercial shippers of radioactive material. In addition, under an agreement with the U.S. Department of Transportation, NRC sets the standards for packages containing Type B quantities of radioactive materials, which include spent nuclear fuel and high-level radioactive waste. An applicant provides the results of its analyses and tests to NRC in a Safety Analysis Report for Packaging. On approving the report, NRC issues a Certificate of Compliance. Under the NWPA, DOE is required to use NRC-certified *casks* for shipment of spent nuclear fuel or high-level radioactive waste to the repository.

The regulations at 10 CFR Part 73 govern safeguards and physical security during the shipment of spent nuclear fuel. These regulations specify requirements for vehicles, carrier personnel, communications, notification of state governors, escorts, and route planning for such shipments.

The shipment of spent nuclear fuel and high-level radioactive waste is highly regulated and subject to the utmost scrutiny. DOE carefully follows U.S. Department of Transportation and NRC transportation rules now and will follow or exceed any others that might be established in the future, whether by Congress, the Department of Transportation, or NRC.

11.2.4.6 U.S. Department of Transportation Hazardous Materials Packaging and Transportation Regulations (49 CFR Subchapter C – Hazardous Materials Regulations, Parts 171 Through 180)

The U.S. Department of Transportation regulates the shipment of hazardous materials, which include spent nuclear fuel and high-level radioactive waste, by land, air, and navigable water. As outlined in a 1979 memorandum of understanding with NRC (44 FR 38690, July 2, 1979), the Department of Transportation specifically regulates carriers of spent nuclear fuel and the conditions of transport, such as routing for highway shipments, handling and storage, and vehicle and driver requirements. The Department of Transportation does not regulate the routing of rail shipments of radioactive materials.

The purposes of the public highway routing regulations of the U.S. Department of Transportation are to reduce the impacts of the transportation of *Highway Route Controlled Quantities of Radioactive Materials* [49 CFR 173.403(1)], to establish consistent and uniform requirements for route selection, and to identify the roles of state and local governments in the routing.

U.S. Department of Transportation regulations include requirements for carriers, drivers, vehicles, routing, packaging, labeling, marking, placarding, shipping papers, training, and emergency response. The requirements specify the maximum dose rate external to the packaging and the maximum allowable levels of radioactive surface contamination on packages and vehicles.

The shipment of spent nuclear fuel and high-level radioactive waste is highly regulated and subject to the utmost scrutiny. DOE carefully follows U.S. Department of Transportation and NRC transportation rules now and will follow or exceed any others that might be established in the future, whether by Congress, the Department of Transportation, or NRC.

11.2.5 CONTROL OF POLLUTION

11.2.5.1 Pollution Prevention Act of 1990 (42 U.S.C. 13101 et seq.)

The *Pollution Prevention Act of 1990* establishes a national policy for waste management and pollution control that focuses first on source reduction, then on environmentally safe recycling, treatment, and disposal. DOE requires each of its sites to establish specific goals to reduce the generation of waste.

11.2.5.2 Standards for Protection Against Radiation (10 CFR Part 20)

The purpose of these standards is to provide standards and procedures for protection against radiation from NRC-licensed activities. Provisions of 10 CFR Part 20 address repository occupational dose limits, public dose limits, survey and monitoring procedures, exposure control in *restricted areas*, respiratory protection and controls, precautionary procedures, and related topics.

11.2.5.3 DOE Worker Safety and Health Program (10 CFR Part 851)

The purpose of these regulations, which became effective on May 25, 2007, is to ensure that DOE contractor workplaces are free from recognized hazards that can cause death or serious physical harm. To accomplish this objective, 10 CFR Part 851 establishes management responsibilities, worker rights, safety and health standards, and required training. Contractors include parent corporations and subcontractors that have responsibilities for work at a DOE site in furtherance of a DOE mission. The contractor must provide DOE with a worker and safety health program that describes the methods it will use to implement the requirements. DOE must review and approve these programs. For example, this regulation prohibits a DOE contractor from performing work at a covered workplace unless an approved worker and safety health program is in place.

11.2.5.4 Low-Level Radioactive Waste Policy Amendments Act of 1985 (42 U.S.C. 2021b Through 2021j)

Under the *Low-Level Radioactive Waste Policy Amendments Act of 1985*, DOE is responsible for the disposal of any *low-level radioactive waste* that operations at the proposed Yucca Mountain Repository could generate. DOE would control and dispose of site-generated low-level radioactive waste in a DOE low-level waste disposal site, a site in an *Agreement State*, or in an NRC-licensed site. In addition, this Act assigns responsibility for disposal of greater-than-class-C low-level radioactive waste to the Federal Government.

11.2.5.5 Resource Conservation and Recovery Act, as Amended (42 U.S.C. 6901 et seq.)

EPA regulates the treatment, storage, and disposal of hazardous and nonhazardous waste in accordance with the provisions of the *Solid Waste Disposal Act*, as amended by the *Resource Conservation and Recovery Act* and the *Hazardous and Solid Waste Amendments Act of 1984*, and applicable state laws.

EPA regulations that implement the *hazardous waste* portions of the *Resource Conservation and Recovery Act* define hazardous wastes and specify requirements for their transportation, handling, treatment, storage, and disposal (40 CFR Parts 260 through 272).

Subtitle C of the Act requires characterization and management of covered hazardous wastes. DOE could generate hazardous waste during repository operations. It would track the amount of hazardous wastes each month (to determine generator status) during construction and operations. Sections 444.850 to 444.8746 of the Nevada Administrative Code are the corresponding requirements for wastes that EPA regulates under Subtitle C.

11.2.5.6 Noise Control Act of 1972 (42 U.S.C. 4901 et seq.)

Section 4 of the *Noise Control Act of 1972* directs federal agencies to carry out programs in their jurisdictions "to the fullest extent within their authority" and in a manner that furthers a national policy of promoting an environment free from noise that jeopardizes health and welfare. This law provides requirements for control of noise from construction, operations, or closure activities at Yucca Mountain.

11.2.5.7 Nevada Revised Statutes: Sanitation, Chapter 444

These statutes and their matching regulations in the Nevada Administrative Code establish the standards, permits, and requirements for septic tanks and other sewage disposal systems for single-family dwellings, communities, and commercial buildings. The construction and operation of a *sanitary sewage* collection system at Yucca Mountain requires a permit from the Nevada Division of Environmental Protection. Since completion of the Yucca Mountain FEIS, Nevada has clarified that applicants must submit plans and specifications to the Division for approval.

These statutes and regulations set forth the definitions, methods of disposal, and special requirements for *solid waste* collection and transportation standards, as well as classification of landfills. DOE operates a permitted large-capacity septic system at the Yucca Mountain site under these provisions. This general permit to operate and discharge from a large-capacity septic system expires on July 22, 2009.

EPA has authorized the State of Nevada to regulate the management and disposal of solid, hazardous, and *mixed wastes* in the state. The Nevada Division of Environmental Protection or an equivalent solid waste management authority would regulate the on- and offsite disposal of nonhazardous solid wastes from the proposed repository.

11.2.5.8 Executive Order 12088, Federal Compliance with Pollution Control Standards

Executive Order 12088, as amended by Executive Order 12580, *Superfund Implementation Control Standards*, generally directs federal agencies to comply with applicable administrative and procedural pollution control standards of, but not limited to, the *Clean Air Act*, the *Noise Control Act*, the *Clean Water Act*, the *Safe Drinking Water Act*, the *Toxic Substances Control Act*, and the *Resource Conservation and Recovery Act*. DOE must comply with this Order for a range of activities for the proposed repository.

11.2.5.9 Executive Order 12856, Right-To-Know Law and Pollution Prevention Requirements

Executive Order 12856 directs federal agencies to reduce and report toxic chemicals that enter any waste stream; improve emergency planning, response, and *accident* notification; and encourage the use of clean technologies and testing of innovative prevention technologies. In addition, the Executive Order states that federal agencies are persons for purposes of the *Emergency Planning and Community Right-to-Know Act* (SARA Title III), which requires agencies to meet the requirements of the Act. DOE must comply with these orders, as applicable, for a range of DOE activities for the proposed repository.

11.2.6 CULTURAL RESOURCES

11.2.6.1 National Historic Preservation Act, as Amended (16 U.S.C. 470 et seq.)

The *National Historic Preservation Act* provides for the placement of sites with significant national historic value on the *National Register of Historic Places*. The Act requires no permits or certifications.

11.2.6.2 Archaeological Resources Protection Act, as Amended (16 U.S.C. 470aa et seq.)

The *Archaeological Resources Protection Act* requires a permit for the excavation or removal of archaeological resources from publicly held or American Indian lands. Excavations must further archaeological knowledge in the public interest, and the removed resources are to remain the property of the United States. If a resource is discovered on land that an American Indian tribe owns, the tribe must give its consent before a permit is issued, and the permit must contain terms or conditions the tribe requests.

11.2.6.3 American Indian Religious Freedom Act of 1978 (42 U.S.C. 1996)

The *American Indian Religious Freedom Act of 1978* reaffirms American Indian religious freedom under the First Amendment and establishes the policy to protect and preserve the inherent and constitutional right of American Indians to believe, express, and exercise their traditional religions. This law ensures the protection of sacred locations and access of American Indians to those sacred locations and traditional resources that are integral to the practice of their religions.

11.2.6.4 Native American Graves Protection and Repatriation Act of 1990 (25 U.S.C. 3001)

The *Native American Graves Protection and Repatriation Act of 1990* directs the Secretary of the Interior to guide the repatriation of federal archaeological collections and collections that are culturally affiliated with American Indian tribes and held by museums that receive federal funding. Major provisions of this law include (1) the establishment of a review committee with monitoring and policymaking responsibilities, (2) the development of regulations for repatriation that include procedures for the identification of lineal descent or cultural affiliation needed for claims, (3) the oversight of museum programs for meeting the inventoryrequirements and deadlines of this law, and (4) the development of procedures to handle unexpected discoveries of graves or grave artifacts during activities on federal or tribal land. Certain provisions of this Act would govern DOE if any surveys or excavations under the Proposed Action led to discoveries of American Indian graves or grave artifacts.

11.2.6.5 Antiquities Act (16 U.S.C. 431 et seq.)

The *Antiquities Act* protects historic and prehistoric ruins, monuments, and objects of antiquity (including paleontological resources) on federally owned or controlled lands. If DOE found historic or prehistoric ruins or objects during the construction or operation of proposed repository facilities, it would have to determine if adverse effects to these ruins or objects would occur. If adverse effects would occur, the Secretary of the Interior would have to grant permission to proceed with the activity (36 CFR Part 296 and 43 CFR Parts 3 and 7).

11.2.6.6 Executive Order 13007, Indian Sacred Sites

Executive Order 13007 directs federal agencies, to the extent permitted by law and not inconsistent with agency missions, to avoid adverse effects to sacred sites and to provide access to those sites to American Indians for religious practices. The Executive Order directs agencies to plan projects to provide protection of and access to sacred sites to the extent compatible with the project.

11.2.6.7 Executive Order 13175, Consultation and Coordination with Indian Tribal Governments

Executive Order 13175 directs federal agencies to establish regular and meaningful consultation and collaboration with American Indian tribal governments in the development of federal policies that have tribal implications, to strengthen United States government-to-government relationships with tribes, and to reduce the imposition of unfunded mandates on tribal governments.

11.2.7 ENVIRONMENTAL JUSTICE

11.2.7.1 Executive Order 12898, Environmental Justice

Executive Order 12898 directs federal agencies, to the extent practicable, to make the achievement of *environmental justice* part of their mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on *minority* and *low-income populations* in the United States and its territories and possessions. The Order provides that the federal agency responsibilities it establishes are to apply equally to American Indian programs.

11.2.8 ECOLOGY AND HABITAT

11.2.8.1 Endangered Species Act, as Amended (16 U.S.C. 1531 et seq.)

The *Endangered Species Act* provides a program for the conservation of threatened and *endangered species* and the *ecosystems* on which those species rely. If a proposed action of a federal agency could affect threatened or endangered species or their *habitat*, the federal agency must assess the potential impacts and develop measures to minimize those impacts. The agency then must consult formally with the U.S. Fish and Wildlife Service (part of the Department of the Interior) and the National Marine Fisheries Service (part of the Department of Commerce), as required under Section 7 of the Act. The regulations that implement the Act are in 50 CFR Parts 15 and 402.

11.2.8.2 Fish and Wildlife Coordination Act, as Amended (16 U.S.C. 661, 48 Stat. 401)

The *Fish and Wildlife Coordination Act* promotes more effectual planning and cooperation among federal, state, public, and private agencies for the conservation and rehabilitation of the nation's fish and wildlife and authorizes the Department of the Interior to provide assistance.

11.2.8.3 Migratory Bird Treaty Act, as Amended (16 U.S.C. 703 et seq.)

The purpose of the *Migratory Bird Treaty Act* is to protect birds that have common migration patterns between the United States and Canada, Mexico, Japan, and Russia. The Act regulates the take and harvest of migratory birds.

11.2.8.4 Bald and Golden Eagle Protection Act, as Amended (16 U.S.C. 668 Through 668d)

The *Bald and Golden Eagle Protection Act* makes it unlawful to take, pursue, molest, or disturb bald (American) and golden eagles, their nests, or their eggs anywhere in the United States (Sections 668 and 668c). The Department of the Interior regulates activities that might adversely affect bald and golden eagles.

11.2.8.5 Nevada Revised Statutes: Protection and Preservation of Timbered Lands, Trees, and Flora, Chapter 527

These provisions of the Nevada Revised Statutes broadly protect the indigenous flora of the State of Nevada. On determination that a species or subspecies of native flora is threatened with extinction, the state places that species or subspecies on its list of fully protected species. In general, no member of the species or subspecies may be taken or destroyed unless an authorized state official issues a special permit.

11.2.8.6 Nevada Revised Statutes: Hunting, Fishing, and Trapping; Miscellaneous Protective Measures, Chapter 503

These statutes and the provisions in Nevada Administrative Code, Chapter 503, Sections 010 through 104, specify procedures for the classification and protection of wildlife. On determination that an animal species is threatened with extinction, the state places the species on its list of fully protected species. In general, no member of the species may be taken or destroyed unless the Nevada Division of Wildlife issues a special permit.

11.2.8.7 Executive Order 11990, Protection of Wetlands

Executive Order 11990 directs federal agencies to avoid new construction in wetlands unless there is no practicable alternative and unless the proposed action includes all practicable measures to minimize harm to wetlands that might result from such use. DOE requirements for compliance with wetlands activity review procedures are in 10 CFR Part 1022 (Section 11.2.3.6).

11.2.8.8 Executive Order 13112, Invasive Species

Executive Order 13112 directs federal agencies to act to prevent the introduction of or to monitor and control invasive (nonnative) species, provide for restoration of *native species*, conduct research, promote educational activities, and exercise care in taking actions that could promote the introduction or spread of *invasive species*.

11.2.8.9 Executive Order 13186, Responsibilities of Federal Agencies To Protect Migratory Birds

Executive Order 13186 requires federal agencies to avoid or minimize the negative impacts of their actions on migratory birds and to take active steps to protect birds and their habitats. The Order directs each federal agency that takes actions that have or are likely to have a negative impact on migratory bird populations to work with the Fish and Wildlife Service to develop an agreement to conserve those birds. The Order requires environmental analyses of federal actions to evaluate effects of those actions on migratory birds, to control the spread and establishment in the wild of exotic animals and plants that could harm migratory birds and their habitats, and either to provide advance notice of actions that could result in the take of migratory birds or report annually to the Fish and Wildlife Service on the numbers of each species taken during the conduct of agency actions.

11.2.9 USE OF LAND AND WATER BODIES

11.2.9.1 Coastal Zone Management Act (16 U.S.C. 1451 et seq.)

The purpose of the *Coastal Zone Management Act* is to preserve, protect, develop, restore, and enhance the resources of the nation's coastal zones. Resources include wetlands, floodplains, estuaries, beaches, dunes, barrier islands, coral reefs, and fish and wildlife and their habitat. This law provides for (1) management to minimize the loss of life and property from improper development and destruction of natural protective features such as beaches, dunes, wetlands, and barrier islands; and (2) improvement, safeguarding, and restoration of the quality of coastal waters, and for protection of existing uses of those waters. The Act requires priority consideration to coastal-dependent uses and orderly processes for siting major facilities in relation to national defense, energy, fisheries development, recreation, ports and transportation, and the location of new commercial and industrial developments in or adjacent to areas where such development already exists.

Transport of spent nuclear fuel to a repository at Yucca Mountain could require the use of barges for transportation along portions of routes from some storage facilities. In addition, rail *corridors*, roads, and bridges from some storage facilities could require repair or enhancement before they could support shipment of spent nuclear fuel. The regulations that implement the Act are in 15 CFR Part 930.

11.2.9.2 Rivers and Harbors Act (33 U.S.C. 401 et seq.)

The transport of spent nuclear fuel and high-level radioactive waste could require the construction or modification of road or rail bridges that span navigable waters. The *Rivers and Harbors Act* prevents the alteration or modification of the course, location, condition, or capacity of any channel of any navigable water of the United States without a permit from the Army Corps of Engineers. If DOE required construction of a road or rail bridge that would span navigable waters, it would need to obtain a permit from the Corps. Regulations that implement this Act are in 33 CFR Part 323.

11.2.9.3 Materials Act of 1947 (30 U.S.C. 601 Through 603)

The *Materials Act of 1947* authorizes land management agencies, such as the Bureau of Land Management, to make common varieties of sand, stone, and gravel from public lands available to federal and state agencies under free-use permits. The Bureau of Land Management regulations that implement the Act are in 43 CFR Part 3604.

11.2.9.4 Farmland Protection Policy Act (7 U.S.C. 4201 et seq.)

The *Farmland Protection Policy Act* seeks to minimize the extent to which federal programs contribute to the unnecessary and irreversible conversion of farmlands to nonagricultural uses. Compliance with this law requires concurrence from the Natural Resources Conservation Service of the Department of Agriculture that proposed activities would not affect farmlands. Regulations that implement the Act are in 7 CFR Part 658.

11.2.10 HOMELAND SECURITY

11.2.10.1 Energy Policy Act of 2005 (42 U.S.C. 15801)

Subtitle D (Nuclear Security) of the *Energy Policy Act of 2005* requires that NRC establish a system to secure the transfer of nuclear materials, which include spent nuclear fuel and high-level radioactive waste. Subtitle E (Nuclear Energy) directs DOE to conduct research on cost-effective technologies for increasing (1) the safety of nuclear facilities from natural phenomena and (2) the security of nuclear facilities from deliberate attacks.

11.2.10.2 Homeland Security Act of 2002 (6 U.S.C. 101 et seq.)

The *Homeland Security Act of 2002* contains requirements for safekeeping of radioactive materials. Specifically, the Act provides for measures to secure the people, *infrastructures*, property, resources, and systems in the United States from acts of terrorism that involve chemical, biological, radiological, or nuclear weapons or other emerging threats.

11.3 Potential Permits, Licenses, and Approvals

Table 11-1 lists potential permits, licenses, and approvals that DOE could need for construction, operations, monitoring, and closure of a Yucca Mountain Repository.

Table 11-1. Permits, licenses, and approvals for the proposed Yucca Mountain Repository in Nevada.

Activity	Regulatory action	Statute or regulation	Agency(ies)
Disposal of spent nuclear fuel and high-level radioactive waste	Final public health and environmental protection standards	40 CFR Part 197	EPA
Repository construction, operations, and closure	Construction authorization; license to receive and possess source, special nuclear, and byproduct material	10 CFR Part 63	NRC
Repository construction, operations, and closure	Withdrawal of geologic repository operations area from public use	Congressional action needed to authorize withdrawal	Congress, BLM
Air emissions	Approvals for new sources of toxic air pollutants	40 CFR Parts 61 and 63, NAC 445B	NDEP
Air emissions	Air quality operating permit	40 CFR Parts 61 and 63, NAC 445B	NDEP
Air emissions	National Emissions Standards for Hazardous Air Pollutants Subpart H (radionuclides)	40 CFR Part 61	EPA
Air emissions	Standards for protection against radiation	10 CFR Part 20	NRC
Drinking water	Public water system permit	NAC 445A	NDEP
Effluents	Stormwater discharge	40 CFR Part 122, NAC 445A	NDEP

Table 11-1. Permits, licenses, and approvals for the proposed Yucca Mountain Repository in Nevada (continued).

Activity	Regulatory action	Statute or regulation	Agency(ies)
Effluents	National Pollutant Discharge Elimination System	40 CFR Part 122, NAC 445A	NDEP
Effluents	Septic system permit	NAC 444 and 445A	NDEP
Effluents	Underground injection control permit	40 CFR Part 144, NAC 445A	NDEP
Excavation; facility construction	Cultural resources review clearance, Section 106	36 CFR Part 800	Advisory Council on Historic Preservation, State Historic Preservation Office
Excavation; facility construction	Permit to proceed (Objects of Antiquity)	36 CFR Part 296, 43 CFR Parts 3 and 7	DOI
Excavation; facility construction	Permit for excavation or removal of archaeological resources	16 U.S.C. 470 et seq.	DOI, affected American Indian tribes
Facility construction	Free use of mineral materials	43 CFR Part 3604	BLM
Facility construction	Permit for discharge of dredged or fill materials to waters of the United States	*Clean Water Act*, Section 404	U.S. Army Corps of Engineers
TAD canister certification	Requirements for TAD canisters	10 CFR Parts 63, 71, 72	NRC
Transportation casks	Certification of transportation casks	10 CFR Part 71	NRC
Facility construction and operations	Threatened and endangered species consultation	50 CFR Part 402	Fish and Wildlife Service
Materials storage	Hazardous materials storage permit	NAC 459 and 477	Nevada State Fire Marshal
Water appropriations	Water appropriation permit	Nevada Revised Statutes 532, 533, and 534	Nevada State Engineer

Source: DIRS 155970-DOE 2002, p. 11-2.
BLM = Bureau of Land Management.
CFR = Code of Federal Regulations.
DOI = U.S. Department of the Interior.
EPA = U.S. Environmental Protection Agency.
NAC = Nevada Administrative Code.
NDEP = Nevada Division of Environmental Protection.
NRC = U.S. Nuclear Regulatory Commission.
TAD = transportation, aging, and disposal (canister).
U.S.C. = United States Code.

11.4 Department of Energy Orders

This section summarizes, incorporates by reference, and updates Section 11.3 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 11-20 to 11-22).

In the Yucca Mountain FEIS, Table 11-3 listed DOE Orders potentially relevant to the construction, operations, monitoring, and closure of a geologic repository at Yucca Mountain (DIRS 155970-DOE 2002, pp. 11-21 and 11-22). Some DOE Orders overlap or duplicate NRC repository licensing regulations in whole or in part. Recognizing this, DOE issued DOE HQ Order 250.1, *Civilian*

Radioactive Waste Management Facilities - Exemption from Departmental Directives. This Order exempts geologic repository design, construction, operations, and *decommissioning* from compliance with the provisions of DOE Orders that overlap or duplicate NRC requirements in relation to radiation protection, nuclear safety (including quality assurance), and the safeguards and security of nuclear material. The exemption would apply only to the portions of the Proposed Action for which DOE sought an NRC license. DOE Orders would continue to establish requirements for other repository activities that would fall outside the scope of this exemption, such as computer security (DOE Order 205.1A). The mechanism by which DOE Orders give precedence to NRC rules has not changed since completion of the Yucca Mountain FEIS.

Table 11-2 lists DOE Orders potentially relevant to the construction, operations, monitoring, and closure of the proposed Yucca Mountain Repository that have been issued since the completion of the Yucca Mountain FEIS. Table 11-3 updates the revised numbering of relevant DOE Orders in Table 11-3 of the Yucca Mountain FEIS.

Table 11-2. Relevant DOE Orders issued since completion of the Yucca Mountain FEIS.

New DOE Order, date issued, and title	Description
414.1-2A (6/17/2005) *Quality Assurance Management System Guide*	Provides information on principles and practices to establish and implement an effective quality assurance program or quality management system according to the requirements of 10 CFR Part 830.
414.1-5 (3/2/2006) *Corrective Action Program Guide*	Provides guidance to DOE organizations and contractors in the development, implementation, and follow-up of corrective action programs using the feedback and improvement core safety function in DOE's Integrated Safety Management System.
420.1B (12/22/2005) *Facility Safety*	Establishes facility and programmatic safety requirements for DOE facilities, which include nuclear and explosives safety design criteria, fire protection, criticality safety, natural phenomena hazards mitigation, and the System Engineer Program.
426.1-1A (5/18/2004) *Federal Technical Capability Manual*	Provides requirements and responsibilities to ensure recruitment and hiring of technically capable personnel to retain critical technical capabilities within DOE at all times.
440.1B (5/17/2007) *DOE Worker Protection Program*	Establishes the framework for an effective worker protection program that will reduce or prevent injuries, illnesses, and accidental losses by providing DOE workers with a safe and healthful workplace.
231.1A Chg 1 (6/30/2004) *Environment, Safety and Health Reporting*	Ensures timely collection, reporting, analysis, and dissemination of information on environment, safety, and health issues as required by law or regulations or as needed to ensure that DOE is fully informed on a timely basis about events that could adversely affect the health and safety of the public, workers, and the environment.
414.C (6/17/2005) *Quality Assurance*	To ensure that DOE products and services meet or exceed customer expectations. The Order requires each DOE organization to develop and implement a quality assurance program.
433.1A (2/13/2007) *Maintenance Management Program for DOE Nuclear Facilities*	Defines the safety management program required by 10 CFR 830.204(b)(5) for maintenance and the reliable performance of structures, systems, and components that are part of the safety basis required by 10 CFR 830.202.1 at hazard category 1, 2, and 3 DOE nuclear facilities.

Table 11-2. Relevant DOE Orders issued since completion of the Yucca Mountain FEIS (continued).

New DOE Order, date issued, and title	Description
450.1 Admin Chg 1 (1/3/2007) *Environmental Protection Program*	Implements sound stewardship practices that are protective of air, water, land, and other natural and cultural resources that DOE operations affect and by which DOE cost-effectively complies with applicable environmental, public health, and resource-protection laws, regulations, and Departmental requirements.
451.1 (10/6/2006) *National Environmental Policy Act Compliance Program*	Establishes DOE internal requirements and responsibilities for implementing the *National Environmental Policy Act*. Describes procedures to ensure timely public information and the understanding of federal plans and programs with potential environmental impacts, and to obtain the views of interested parties. DOE updated Order 451.1B, to reflect departmental reorganization.
452.2C (6/12/2006) *Nuclear Explosive Safety*	Establishes specific nuclear explosive safety program requirements to implement the DOE standards and other nuclear explosive safety criteria for routine and planned nuclear explosive operations.
460.2A (12/22/2004) *Departmental Materials Transportation and Packaging Management*	Establishes requirements and responsibilities for management of DOE, including the National Nuclear Security Administration, materials transportation, and packaging to ensure the safe, secure, and efficient packaging and transportation of materials, both hazardous and nonhazardous.
226.1A (7/31/2007) *Implementation of Department of Energy Oversight Policy*	Provides direction for implementing DOE Policy 226.1, Department of Energy Oversight Policy (06-10-2005), which establishes DOE policy for assurance systems and processes established by DOE contractors and oversight programs performed by DOE line management and independent oversight organizations.
460.1B (4/4/2003) *Packaging and Transportation Safety*	Establishes safety requirements for the proper packaging and transportation of DOE/National Nuclear Security Administration offsite shipments and onsite transfers of hazardous materials, and for modal transport.
461.1A (4/26/2004) *Packaging and Transfer or Transportation of Materials of National Security Interest*	Establishes requirements and responsibilities for offsite shipments of naval nuclear fuel elements, Category I and Category II special nuclear material, nuclear explosives, nuclear components, special assemblies, and other materials of national security interest.
470.2B (10/31/2002) *Independent Oversight And Performance Assurance Program*	The Independent Oversight Program is designed to enhance the DOE safeguards and security; cyber security; emergency management; and environment, safety, and health programs by providing DOE with an independent evaluation of the adequacy of DOE policy and the effectiveness of line management performance in safeguards and security; cyber security; emergency management; environment, safety, and health.

CFR = Code of Federal Regulations.
DOE = U.S. Department of Energy.

Table 11-3. Revised DOE Orders since completion of the Yucca Mountain FEIS.

Previous number and title		Revised number and title	
1300.2A	Department of Energy Technical Standards Program	252.1	Technical Standards Program
425.1	Facility Startup and Restart	425.1C	Startup and Restart of Nuclear Facilities
151.1	Comprehensive Emergency Management System	151.C	Comprehensive Emergency Management System
1360.2B	Unclassified Computer Security Program	205.1A	Department of Energy Cyber Security Management

Table 11-3. Revised DOE Orders since completion of the Yucca Mountain FEIS (continued).

Previous number and title		Revised number and title	
3790.1B	Federal Employee Occupational Safety and Health Program	440.1B	Worker Protection Program for DOE (Including the National Nuclear Security Administration) Federal Employees
5400.1	General Environmental Protection Program	231.1A Chg. 1	Environment, Safety and Health Reporting
5400.5	Radiation Protection of the Public and the Environment	231.1A Chg. 1	Environment, Safety and Health Reporting
5484.1	Environmental Protection, Safety, and Health Protection Information Reporting Requirements	231.1A Chg. 1	Environment, Safety and Health Reporting
5610.14	Transportation Safeguards System Program Operations	461.1A	Packaging and Transfer or Transportation of Nuclear Materials of National Security Interest
5632.1C	Protection and Control of Safeguards and Security Interests	470.4A	Safeguards and Security Program

Chg = Change.
DOE = U.S. Department of Energy.

11.5 Other Potentially Applicable Federal Regulations

This section incorporates by reference Table 11-4 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 11-23 to 11-25). That table listed federal regulations and DOE Orders potentially applicable to the construction, operations, monitoring, and closure of a geologic repository.

11.6 Statutes, Regulations, Requirements, and Orders Specific to the Proposed Nevada Railroad

Based on its obligations under the NWPA and its decision to select the mostly rail scenario for the transportation of spent nuclear fuel and high-level radioactive waste (69 FR 18557; April 8, 2004), DOE would ship spent nuclear fuel and high-level radioactive waste by rail in Nevada. To meet this need, DOE is proposing to construct and operate a railroad to connect the repository to an existing rail line in Nevada. Many of the statutes and regulations in the preceding sections of Chapter 11 are applicable to both the repository and the railroad. Chapter 6 of the Rail Alignment EIS discusses the potentially requirements relevant to the proposed Nevada railroad.

11.7 Interagency and Intergovernmental Interactions

In the course of preparing this Repository SEIS, DOE has interacted with a number of government agencies and other organizations. Nye County requested cooperating agency status, which DOE granted. No other agency or government requested cooperating agency status during preparation of this Repository SEIS.

The purposes of DOE interactions with government agencies and other organizations are as follows:

- To discuss issues of concern with organizations having an interest in or authority over land that the Proposed Action (to construct, operate, monitor, and eventually close a geologic repository at Yucca Mountain) would directly affect, or organizations having other interests that some aspect of the Proposed Action could affect;
- To obtain information pertinent to the environmental impacts analysis of the Proposed Action;
- To initiate consultations or permitting processes, including providing data to agencies with oversight, review, or approval authority over some aspect of the Proposed Action;
- To provide information relevant to the development of responses to public comments on the Draft documents.

Table 11-4 presents the ongoing consultations with agencies and Indian tribes that have relevant expertise or organizational interests that the Proposed Action may affect.

Table 11-4. Ongoing consultations with agencies and American Indian tribes.

Agency	Summary of interaction
National Nuclear Security Administration/Nevada Site Office	DOE continues to work closely with the National Nuclear Security Administration/Nevada Site Office regarding site maintenance, security, use of resources, air space and future actions.
U.S. Department of the Navy	DOE continues to consult closely with the Navy regarding inventory and transportation.
U.S. Department of the Air Force	DOE continues to consult closely with the Air Force regarding air space and overflights.
Bureau of Land Management	DOE met routinely with the BLM to discuss project direction and coordination. DOE has held numerous briefings and working meetings with the BLM, regarding the status of the NEPA analyses. In addition, a BLM staff member occupied DOE offices during the development of this Repository SEIS, the Nevada Rail Corridor SEIS, and the Rail Alignment EIS to facilitate communications and interactions between DOE and the BLM.
U.S. Fish and Wildlife Service	DOE met with staff from the U.S. Fish and Wildlife Service on January 27, 2005, March 2, 2006, and December 13, 2006, to discuss how changes in the repository design could affect compliance with the Endangered Species Act for construction and operation of the proposed repository.
U.S. Army Corps of Engineers	Between November 4, 2004 and October 25, 2007, DOE met with the U.S. Army Corps of Engineers to provide an overview of the plans for constructing a railroad to Yucca Mountain and to obtain initial information from the U.S. Army Corps of Engineers on the permitting process for Section 404 of the *Clean Water Act*. These meetings included discussions on jurisdictional determinations for the repository.

Table 11-4. Ongoing consultations with agencies and Indian tribes (continued).

Agency	Summary of interaction
U.S. Environmental Protection Agency	On February 20, 2008, DOE met with staff of the U.S. Environmental Protection Agency to discuss that agency's comments on the NEPA analyses.
State of Nevada	DOE met with personnel from the Nevada Department of Wildlife, the Nevada Division of Forestry, the Nevada Department of Transportation, the Nevada Bureau of Air Quality, and the Nevada Division of Water Resources. Discussions with the U.S. Department of Transportation included the mitigation of potential traffic congestion by widening U.S. Highway 95 as presented in this Repository SEIS. DOE, the Advisory Council on Historic Preservation, and the Nevada State Historic Preservation Office, continue to work together to develop the programmatic agreement for the repository.
Local agencies	Nye County has established cooperating agency status and has been actively involved in the preparation of this Repository SEIS.
American Indian tribes	DOE has met several times in 2005 and 2006 with the Consolidated Group of Tribes and Organizations. After each meeting between DOE and the Consolidated Group of Tribes and Organizations or the designated American Indian Writers Subgroup, the tribal representatives prepared a series of recommendations for DOE consideration.
Nuclear Waste Technical Review Board	The Technical Review Board's primary responsibility is to evaluate (1) the site characterization phase of the Yucca Mountain Project and the activities associated with determining whether the Yucca Mountain site is suitable for further development as a geologic repository, and (2) the packaging and transportation of spent nuclear fuel and high-level radioactive waste. DOE has ongoing interactions with the Board.
U.S. Nuclear Regulatory Commission	DOE has met periodically with the U.S. Nuclear Regulatory Commission for technical exchanges. DOE submitted the application for construction authorization to NRC in June 2008.

BLM = Bureau of Land Management.
DOE = U.S. Department of Energy.
NEPA = National Environmental Policy Act.
STB = Surface Transportation Board.

REFERENCES

179968 DeBurle 2006 DeBurle, M.A. 2006. "Re: Class II General Air Quality Operation Permit Renewal, #AP9199-0573.02, FIN #A0023." Letter from M.A. DeBurle (NDEP) to W.J. Arthur, III (DOE/OCRWM), August 8, 2006, 0814065554, MAD/tu, with enclosure. ACC: MOL.20070316.0087.

155970	DOE 2002	DOE (U.S. Department of Energy) 2002. *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*. DOE/EIS-0250F. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20020524.0314; MOL.20020524.0315; MOL.20020524.0316; MOL.20020524.0317; MOL.20020524.0318; MOL.20020524.0319; MOL.20020524.0320.

12

Glossary

12. GLOSSARY

The U.S. Department of Energy (DOE or the Department) has provided this glossary to assist readers in the interpretation of this *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F-S1) (Repository SEIS). The Glossary includes definitions of technical and regulatory terms common to DOE *National Environmental Policy Act* (NEPA) documents and explains these terms with their most likely meanings in the context of DOE NEPA documents, and in particular this Repository SEIS. To better aid the reader, a number of terms in this glossary emphasize their project-specific relationship to the Yucca Mountain Repository (*italicized* words are defined in the glossary). DOE derived the definitions in this glossary from the most authoritative sources available (for example, a statute, regulation, DOE directive, dictionary, or technical reference book) and checked each definition against other authorities.

100-year flood — A flood *event* of such magnitude that it occurs, on average, every 100 years; this equates to a 1-percent chance of its occurring in a given year. A base flood may also be referred to as a 100-year storm. The area inundated during the base flood is sometimes called the 100-year *floodplain*.

accessible environment — For this Repository SEIS, all points on Earth outside the surface and *subsurface* area controlled over the long term for the proposed *repository*, including the atmosphere above the *controlled area*.

accident — An unplanned sequence of events that results in undesirable consequences. Examples in this Repository SEIS include an inadvertent release of *radioactive* or hazardous materials from their containers or confinement to the environment, vehicular accidents during the transportation of highly radioactive materials, and industrial accidents that could affect workers in the facilities.

actinide — Any one of a series of chemically similar elements of *atomic numbers* 89 (actinium) through 103 (lawrencium). All actinides are *radioactive*.

affected environment — The physical, biological, and human-related environment that is sensitive to changes resulting from the *Proposed Action*. The extent of the affected environment may not be the same for all potentially affected resource areas. For example, traffic may increase within 4 miles of a hypothetical site from which waste would be removed to a nearby landfill (the extent of the affected environment with respect to transportation impacts). In contrast, *groundwater* extending 2 miles from the hypothetical site may be affected (the extent of the affected environment with respect to groundwater impacts).

aging — The retention of *commercial spent nuclear fuel* on the surface in *dry storage* for the purpose of reducing its thermal output as necessary to meet *repository* thermal management goals.

Aging Facility	Facility that provides the capability to age *commercial spent nuclear fuel* as necessary to meet *waste package* thermal limits.
aging overpack	A *cask* specifically designed for aging *spent nuclear fuel*. *Transportation, aging, and disposal* (*TAD) canisters* and *dual-purpose canisters* would be placed in aging overpacks for *aging* on the aging pad.
Agreement State	A state that reaches an agreement with the U.S. Nuclear Regulatory Commission (NRC) to assume regulatory authority to license and regulate *radioactive* materials.
air quality	A measure of the concentrations of pollutants, measured individually, in the air.
alcove	A small excavation (room) off the main tunnel of a *repository* used for scientific study or for the installation of equipment.
aleatory	An inherent variation associated with the physical system or environment. Also referred to as variability, irreducible uncertainty, stochastic uncertainty, and random uncertainty.
alien species	With respect to a particular *ecosystem*, any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem.
alignment	As used in the transportation analysis in this Repository SEIS, an engineered refinement of a rail corridor in which DOE would identify the location of a rail line.
Alloy 22	A corrosion-resistant, high-nickel alloy DOE would use for the outer shell of the *waste package*, for rails that support the *drip shields*, and for the parts of the *emplacement* pallet that would contact the *waste package*.
alluvium	A general term for the sedimentary material deposited by flowing water.
alpha particle	A positively charged particle ejected spontaneously from the *nuclei* of some *radioactive* elements. It is identical to a helium *nucleus* and has a mass number of 4 and an electrostatic charge of +2. It has low penetrating power and a short range (a few centimeters in air). See *ionizing radiation.*

alternative — One of two or more actions, processes, or propositions from which a *decisionmaker* will determine the course to be followed. The *National Environmental Policy Act* states that in the preparation of an *environmental impact statement*, an agency "shall ... study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources" [42 U.S.C. 4321, Title I, Section 102 (E)]. The regulations of the Council on Environmental Quality that implement the National Environmental Policy Act indicate that the alternatives section is "the heart of the environmental impact statement" (40 CFR 1502.14), and include rules for presentation of the alternatives, including no action, and their estimated *impacts*.

This Repository SEIS has two alternatives: the *Proposed Action*, under which DOE would construct, operate and monitor, and eventually close a *geologic repository* for the *disposal* of *spent nuclear fuel* and *high-level radioactive waste* at Yucca Mountain, and the *No-Action Alternative* under which DOE would terminate activities at Yucca Mountain and undertake site reclamation to mitigate significant adverse environmental impacts and commercial utilities The *Nuclear Waste Policy Act, as amended* states that this Repository SEIS does not have to discuss alternatives to *geologic* disposal or alternative sites to Yucca Mountain; DOE included the analysis of the No-Action Alternative to provide a basis for comparison with the Proposed Action.

alternative segments — Within a *rail alignment*, alternative segments are multiple routes DOE has selected for consideration. DOE would select one of them for the final *rail line*.

Amargosa Desert — The basin area south of Beatty, Nevada, and extending southeast about 80 kilometers (50 miles) to the area of Alkali Flat in California. The unincorporated town of Amargosa Valley, Nevada, is in the central portion of the Amargosa Desert. Amargosa Desert is also the name of *hydrographic area* number 230, which is part of the Death Valley Groundwater Region; both are designations used by the State of Nevada in its water planning and appropriations efforts. The boundaries of the Amargosa Desert hydrographic area closely resemble those of the geographic area.

Amargosa River — The main drainage system of the *Amargosa Desert*. The Amargosa River drainage basin originates in the Pahute Mesa-Timber Mountain area north of Yucca Mountain and includes the main tributary systems of *Beatty Wash* and *Fortymile Wash*. The river, which is frequently dry along much of its length, flows southeast through the Amargosa Desert and ends in the internal drainage system of Death Valley.

ambient

- Undisturbed natural conditions such as ambient temperature caused by climate or natural *subsurface* thermal gradients.
- Surrounding conditions.

ambient air — The surrounding atmosphere, usually the outside air, as it exists around people, plants, and structures. It is not the air in the immediate proximity to emission sources.

ambient air quality standards — Standards established on a federal or state level that define the limits for airborne concentrations of designated *criteria pollutants* to protect public health with an adequate margin of safety (primary standards) and to protect public welfare, including plant and animal life, visibility, and materials (secondary standards). National Ambient Air Quality Standards have been established for *nitrogen dioxide*, *sulfur dioxide*, *carbon monoxide*, *particulate matter* with aerodynamic diameters less than 10 microns (PM_{10}), particulate matter with aerodynamic diameters less than 2.5 microns ($PM_{2.5}$), *ozone*, and lead. See *criteria pollutants*.

analytical periods — See *Repository SEIS analytical periods.*

analyzed land withdrawal area — An area of approximately 600 square kilometers (230 square miles or 150,000 acres) at Yucca Mountain. Because the land has not yet been withdrawn, in this Repository SEIS it is referred to as the analyzed land withdrawal area. DOE uses the same analyzed land withdrawal area for the analyses in this Repository SEIS it used in the Yucca Mountain FEIS.

aquifer — A *subsurface* saturated rock unit (formation, group of formations, or part of a formation) of sufficient *permeability* to transmit *groundwater* and yield usable quantities of water to wells and springs.

atomic mass — The mass of a neutral atom, based on a relative scale, usually expressed in atomic mass units. See *atomic weight.*

atomic number — The number of *protons* in an atom's *nucleus*.

atomic weight — The relative mass of an atom based on a scale in which a specific carbon atom (carbon-12) has a mass value of 12. Also known as relative *atomic mass*.

A-weighted decibel — See *decibel, A-weighted.*

backfill — The general fill that would be placed in the excavated areas of an *underground facility*. Backfill for the proposed *repository* could be *tuff* or other material.

background radiation — *Radiation* from cosmic and cosmogenic sources, external terrestrial sources, radon in homes, and internally deposited radionuclides..

barrier	Any material, structure, or condition (as a thermal barrier) that prevents or substantially delays the movement of water or *radionuclides*. See *natural barrier*.
Beatty Wash	A tributary drainage to the *Amargosa River*; drains the west and north sides of the Yucca Mountain area.
best management practices	The processes, techniques, procedures, or considerations that DOE would employ to avoid or reduce the potential environmental *impacts* of its *Proposed Action* in a cost-effective manner while meeting the *Yucca Mountain Repository* project objectives.
beta particle	A negatively charged *electron* or positively charged positron emitted from a *nucleus* during *decay*. Beta decay usually refers to a *radioactive* transformation of a *nuclide* by electron emission in which the *atomic number* increases by 1 and the mass number remains unchanged. In positron emission, the atomic number decreases by 1 and the mass number remains unchanged. See *ionizing radiation.*
biosphere	The *ecosystem* of the Earth and the living *organisms* that inhabit it.
boiling-water reactor	A *nuclear reactor* that uses boiling water to produce steam to drive a turbine.
borehole	For this Repository SEIS, a hole drilled to collect *site characterization* data or to supply water.
borosilicate glass	*High-level radioactive waste matrix* material in which boron takes the place of the lime used in ordinary glass mixtures. See *vitrification*.
buffer area	Area where railcars or trucks with *transportation casks* would wait until DOE moved them to a waste handling facility or shipped them off the site, and where the Department would store empty *waste packages* on site rail transfer carts until needed.
buffer car	A railcar that DOE would place at the front of a *cask* train between the locomotive and the first cask car and at the back of the train between the last cask car and the *escort car*. Federal regulations require the separation of a railcar that carries *spent nuclear fuel* and *high-level radioactive waste* from a locomotive, occupied caboose, carload of undeveloped film, or a railcar that carries another class of hazardous material by at least one buffer car. These could be DOE railcars or, in the case of general freight service, commercial railcars.
cancer	A group of diseases that are characterized by uncontrolled growth and spread of abnormal cells.

candidate species	Species for which the U.S. Fish and Wildlife Service has enough substantive information on biological status and threats to support proposals to list them as threatened or endangered under the Endangered Species Act. Listing is anticipated but has been precluded temporarily by other listing activities.
canister	An unshielded metal container used as: • A pour mold in which molten vitrified *high-level radioactive waste* could solidify and cool. • A container in which DOE and electric utilities would place intact *spent nuclear fuel*, loose rods, or nonfuel components for shipping or storage. • In general, a container that provides *radionuclide* confinement. Canisters would be used in combination with specialized overpacks that provide structural support, *shielding*, or confinement for storage, transportation, and *emplacement*. Overpacks used for transportation are usually referred to as *transportation casks*; those used for emplacement in a *repository* are referred to as *waste packages*.
Canister Receipt and Closure Facility	Facility that would receive DOE *disposable canisters* and *TAD canisters*, load canisters into *waste packages*, and close the waste packages.
carbon monoxide	A colorless, odorless, poisonous gas produced by incomplete fossil-fuel combustion; one of the six *criteria pollutants* for which there is a National *Ambient Air Quality Standard*.
carcinogen	An agent capable of producing or inducing *cancer*.
cask	• A heavily shielded container that meets applicable regulatory requirements used to ship *spent nuclear fuel* or *high-level radioactive waste*; • A heavily shielded container used by DOE and utilities for the *dry storage* of spent nuclear fuel; usable only for storage, not for transport to or *emplacement* in a *repository*; or • A heavily shielded container that would be used by DOE to transfer *canisters* among waste handling facilities at the repository.
Cask Receipt Security Station	Facility that would perform initial waste receipt and inspection.
central operations area	The central operations area is an area approximately 0.8 kilometer (0.5 mile) southwest of the *geologic repository operations area* that DOE would develop for all operations, to include support and replacement of *subsurface infrastructure* in the *Exploratory Studies Facility*.

chain reaction	A process in which some *neutrons* released in one *fission* event cause other fission events that in turn release neutrons.
cladding	The metallic outer sheath of a fuel element generally made of stainless steel or a *zirconium alloy*. Its purpose is to isolate the fuel element from the *accessible environment.*
clastic	Describing a rock or sediment that consists mainly of broken fragments of preexisting minerals or rocks that have been transported from their places of origin.
closure	See *closure analytical period*.
closure analytical period	10 years – Overlaps the last 10 years of the *monitoring analytical period* and includes activities that would begin upon receipt of a license amendment to close the repository. Activities would include *decommissioning* and demolishing surface facilities, emplacing *drip shields, backfilling*, restoring the surface to its approximate condition before *repository* construction, and constructing monuments to mark the site. See *Repository SEIS analytical periods*.
cloudshine	*Irradiation* of the human body by *neutrons* and *gamma rays* emitted by the passing plume of *radioactive* material.
commercial spent nuclear fuel	Commercial nuclear fuel rods that have been removed from *reactor* use at commercial nuclear power plants. See *spent nuclear fuel* and *DOE spent nuclear fuel.*
common segment	Portions of the *rail alignment* for which DOE has selected a single route for the *rail line*.
composite employment	Sum of *direct* and *indirect employment*.
construction	See *construction analytical period.*
construction analytical period	5 years – Begins upon receipt of *construction* authorization from NRC and ends prior to receipt of a license to receive and possess radiological materials. Activities would include site preparation, surface construction, and *subsurface* development. See *Repository SEIS analytical period.*
construction right-of-way	As used in the analysis for the Rail Alignment EIS, nominally 150 meters (500 feet) on either side of the centerline of the *rail alignment*, with some variability. The right-of-way is generally linear but includes areas for support facilities such as quarries, water wells, and access roads.

contaminant	A substance that contaminates (pollutes) air, soil, or water. Also a hazardous substance that does not occur naturally or that occurs at levels greater than those that occur naturally in the surrounding *environment*.
contamination	The intrusion of undesirable elements (unwanted physical, chemical, biological, or radiological substances, or matter that has an adverse effect) to air, water, or land.
controlled area	The area restricted for the long term for the proposed *repository*, as identified by passive *institutional controls* DOE would install at *closure*. The controlled area would be 300 square kilometers (about 120 square miles) maximum surface and *subsurface* area that extended in the predominant direction of *groundwater* flow no farther south than 36 degrees, 40 minutes, 13.6661 seconds north latitude (the present southwest corner of the Nevada Test Site), and no more than 5 kilometers (3 miles) from the repository footprint in any other direction (see 40 CFR 197.12).
corridor	As used in the transportation analysis in this Repository SEIS, a strip of land, approximately 400 meters (0.25 mile) wide, that encompasses one of several possible routes through which DOE could build a *rail line* to transport *spent nuclear fuel*, *high-level radioactive waste*, and other materials to and from the proposed *Yucca Mountain Repository*.
corrosion	The process of dissolving or wearing away gradually, especially by chemical action.
corrosion products	Materials produced by corrosion process.
corrosion-resistant material	Outer *waste package* material, such as *Alloy 22*, that corrodes slowly in a corrosive environment.
criteria pollutants	Six common pollutants (*ozone, carbon monoxide, particulate matter, sulfur dioxide*, lead, *and nitrogen dioxide*) known to be hazardous to human health and the environment and for which the U.S. Environmental Protection Agency (EPA) sets National *Ambient Air Quality Standards* under the Clean Air Act. See *toxic air pollutants*.
crud	A colloquial term for corrosion and wear products (rust particles, etc.) that become radioactive (i.e., neutron activated) when exposed to radiation.
cumulative impact	An *impact* on the environment that results from the incremental impact(s) of an action added to impacts from other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions that take place over a period of time.

curie	A unit of *radioactivity* equal to 37 billion disintegrations per second; also a quantity of any *nuclide* or mixture of nuclides having 1 curie of radioactivity.
day-night average sound level	The energy average of the *A-weighted decibel* sound levels over a 24-hour period. It includes an adjustment factor for noise between 10 p.m. and 7 a.m. to account for the greater sensitivity of most people to noise during the night.
decay (radioactive)	The process in which one *radionuclide* spontaneously transforms into one or more different radionuclides called decay products.
decibel	A standard unit for measuring sound pressure levels based on a reference sound pressure of 0.0002 dyne per square centimeter. This is the smallest sound a human can hear.
decibel, A-weighted (dBA)	A measurement of sound that approximates the sensitivity of the human ear, which is used to characterize the intensity or loudness of sound.
decisionmaker	The group or individual who would be responsible for making a decision on the *construction* and *operation* of a *geologic repository* for the *disposal* of *spent nuclear fuel* and *high-level radioactive waste* at Yucca Mountain.
decommissioning	The process of removal from service a facility in which the handling of nuclear materials occurs. If nuclear materials have been handled at the facility, decommissioning includes decontamination of the facility so it can be dismantled or dedicated to other purposes.
dedicated train	A train that handles only one commodity. For the proposed *railroad*, this separate train with its own crew would limit switching between trains of the railcars carrying *spent nuclear fuel* and *high-level radioactive waste*.
detention pond	A low-lying area that is designed to temporarily hold a set amount of water while slowly draining to another location. Detention ponds exist for flood control when large amounts of rain could cause flash flooding if not dealt with properly. The pond acts to reduce the peak runoff downstream by spreading the discharge over a longer period.
direct employment	Jobs that are expressly associated with project activity.
direct impact	An effect that would result solely from the *Proposed Action* without intermediate steps or processes. Examples include *habitat* destruction, soil disturbance, air emissions, and water use.
disintegration	Any transformation of a *nucleus*, whether spontaneous or induced by *irradiation*, in which the nucleus emits one or more particles or *photons*.

disposable canister	A metal vessel for *DOE spent nuclear fuel* assemblies (including *naval spent nuclear fuel*) or solidified *high-level radioactive waste* suitable for storage, shipping, and *disposal*. At the *repository*, DOE would remove the disposable canister from the *transportation cask* and place it directly in a *waste package*. There are a number of types of disposable canisters, including standard canisters, multicanister overpacks, and *TAD canisters*.
disposal	For this Repository SEIS, the *emplacement* in a *repository* of *high-level radioactive waste, spent nuclear fuel*, or other highly *radioactive* material with no foreseeable intent of recovery, whether or not such emplacement would permit the recovery of such waste, and the *isolation* of such waste from the *accessible environment*.
distribution	As used in analyses of long-term performance, a range of values and probabilities associated with each value (or subrange of values) within the range. This can be in the form of a mathematical function or a table of values. See *normal distribution.*
DOE spent nuclear fuel	Nuclear fuel that has been withdrawn from a *nuclear reactor*, provided the constituent elements of the fuel have not been separated by reprocessing, that DOE manages from its defense production reactors, U.S. naval reactors, and DOE test and experimental reactors, as well as from university and other research reactors, commercial reactor fuel acquired by DOE for research and development, and from foreign research reactors.
dose (radioactive)	The amount of *radioactive* energy taken into (absorbed by) living tissues.
dose equivalent	The product of absorbed dose in tissue multiplied by a quality factor and then sometimes multiplied by other necessary modifying factors at the location of interest. It is expressed numerically in *rem*. The dose equivalent quantity is used to compare the biological effectiveness of different kinds of *radiation* (based on the quality of radiation and its spatial distribution in the body) on a common scale.
drift	From mining terminology, a horizontal underground passage. In relation to the proposed *repository*, this includes excavations for *emplacement* (emplacement drifts), ventilation exhaust mains, access (access mains), and *performance confirmation* (observation drift).
drip shield	A corrosion-resistant *engineered barrier* that DOE would place above a *waste package* to prevent seepage water from direct contact with the waste package for thousands of years. The drip shield would also protect the waste package from rock fall.

dry storage	Storage of *spent nuclear fuel* without *immersion* of the fuel in water for cooling or *shielding*; it involves the encapsulation of spent nuclear fuel in a steel cylinder that might be in a concrete or massive steel *cask* or structure.
dual-purpose canister	A metal vessel suitable for storing (in a storage facility) and shipping (in a *transportation cask*) *commercial spent nuclear fuel* assemblies. At the *repository*, DOE would remove dual-purpose canisters from the transportation cask and open them. DOE would remove the spent nuclear *fuel assemblies* from the dual-purpose canister and place them in a *TAD canister* before placement in a *waste package*. The opened canister would be recycled or disposed of off the site as *low-level radioactive waste*.
duripan	A *subsurface* layer held together (cemented) by silica, usually containing other accessory cements.
earthquake	A series of elastic waves in the crust of the Earth caused by abrupt movement that eases strains built up along *geologic faults* or by volcanic action and that results in movement of the Earth's surface.
ecoregion	A relatively discrete set of *ecosystems* characterized by certain plant communities or assemblages.
ecosystem	A community of *organisms* and their physical environment interacting as an ecological unit.
electron	A stable elementary particle that is the negatively charged constituent of ordinary matter.
emplacement	The placement and positioning of *waste packages* in the proposed *repository*.
emplacement panels	Isolated areas in the proposed *repository* that DOE would set aside for waste *disposal*.
endangered species	An animal or plant species that is in danger of extinction throughout all or a significant part of its range.
engineered barrier	The designed, or engineered, components of the proposed *underground facility* at Yucca Mountain, which would include the *waste packages* and other *barriers*.

environmental impact statement (EIS)	A detailed written statement that describes: ...the environmental impact of the proposed action; any adverse environmental effects which cannot be avoided should the proposal be implemented; alternatives to the proposed action (although the Nuclear Waste Policy Act, as amended, precludes consideration of certain alternatives); the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity; and any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented. Preparation of an environmental impact statement requires a public process that includes public meetings, reviews, and comments, as well as agency responses to the public comments.
environmental justice	The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including racial, ethnic, or socioeconomic groups, should bear a disproportionate share of the negative environmental *impacts* that result from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs and policies. Executive Order 12898, Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations, directs federal agencies to make the achievement of environmental justice part of their missions by identifying and addressing disproportionately high and adverse effects of agency programs, policies, and activities on *minority populations* and *low-income populations*.
epistemic	Lack of knowledge of quantities or processes of the system or the environment. Also referred to as subjective uncertainty, reducible uncertainty, and model form uncertainty.
erionite	Erionite is an uncommon zeolite mineral that forms wool-like fibrous masses and is listed as a known human *carcinogen* by recognized international agencies such as the International Agency for Research on Cancer. Based on geologic studies to characterize the repository horizon, erionite appears to be absent or rare at the proposed repository depth and location.
escort car	Railcar in which escort personnel would travel on a train that carried *spent nuclear fuel* or *high-level radioactive waste*.
evaporation pond	A containment pond with impermeable bottom and sides designed to hold liquid wastes and to concentrate the waste through evaporation.

evapotranspiration	The combined processes of evaporation and plant *transpiration* that remove water from the soil and return it to the air.
event	Any thing that happens discretely at a particular time; for example, an *earthquake* is an event.
Exploratory Studies Facility	An underground laboratory at Yucca Mountain that comprises an 8-kilometer (5-mile) main loop (tunnel), a 3-kilometer (2-mile) cross *drift*, and a research *alcove* system for the performance of underground studies. The proposed *repository* could incorporate some or all of the Exploratory Studies Facility.
exposed	See *exposure (to radiation)*.
exposure (to radiation)	The incidence of *radiation* on living or inanimate material by *accident* or intent. Background exposure is the exposure to natural *ionizing radiation*. Occupational exposure is the exposure to ionizing radiation that occurs during a person's working hours. Population exposure is the exposure to a number of persons who inhabit an area.
exposure pathway	The course a chemical or physical agent takes from the source to the exposed *organism*; it describes a unique mechanism by which an individual or population can become *exposed* to chemical or physical agents at or originating from a release site. Each exposure pathway includes a source or a release from a source, an exposure point, and an exposure route.
fault	A *fracture* or a fracture zone in crustal rocks along which there has been movement of the fracture's two sides in relation to one another, so what were once parts of one continuous rock *stratum* or vein are now separated.
fault-gouge material	Crushed and ground-up rock produced by friction between two sides of a *fault* when there is movement along the fault.
fission	The splitting of a *nucleus* into at least two other nuclei, which results in the release of two or three *neutrons* and a relatively large amount of energy.
floodplain	The lowlands adjoining inland and coastal waters and relatively flat areas and flood-prone areas of offshore islands. Executive Order 11988 requires federal facilities to assess, at a minimum, actions in areas inundated by a 1-percent or greater chance of flood in any given year. By DOE regulation (40 CFR Part 1022), the base floodplain is defined as the 100-year (1.0-percent) floodplain, and the critical action floodplain is defined as the 500-year (0.2-percent) floodplain (see *100-year flood*).
Fortymile Wash	A major tributary to the *Amargosa River*; drains the east side of Yucca Mountain, *Jackass Flats* to the east of Yucca Mountain, and the Fortymile Canyon area to the north. Fortymile Wash is usually dry along most of its length.

fracture	A general term for any break in a rock, whether or not it causes displacement, caused by mechanical failure from stress. Fractures include cracks, joints, and *faults*. Fractures can act as *pathways* for rapid *groundwater* movement.
fuel assembly	A number of fuel elements held together by structural materials for use in a *nuclear reactor*.
fugitive dust	*Particulate matter* composed of soil; can include emissions from haul roads, wind erosion of exposed soil surfaces, and other activities in which soil is removed or redistributed.
full-time equivalent worker years	The number of employees who would be involved in an activity calculated from work hours. Each full-time equivalent worker year consists of 2,000 work hours (the number of hours DOE assumed for one worker in a normal work year).
gamma ray	High-energy, short wavelength, electromagnetic *radiation* emitted from the *nucleus*. Gamma rays are very penetrating and are best stopped or shielded by dense materials, such as lead or depleted uranium.
geologic	Of or related to a natural process that acts as a dynamic physical force on the Earth (such as, faulting, erosion, and mountain-building resulting in rock formations).
geologic repository	A system for disposing of *radioactive* waste in excavated *geologic* media, which includes surface and *subsurface* areas of operation and the adjacent part of the geologic setting that provides *isolation* of radioactive waste in a *controlled area*.
geologic repository operations area	As defined at 10 CFR 63.2, the geologic repository operations area is "a *high-level radioactive waste* facility that is part of a *geologic repository*, including both surface and *subsurface* areas, where waste handling activities are conducted."
Great Basin	A subprovince of the Basin and Range Province, generally characterized by north-trending mountain ranges and intervening basins, that stretches north to south from eastern Oregon to southern California, includes most of Nevada, and extends into western Utah.
Greater-Than-Class-C waste	*Low-level radioactive waste* generated by the commercial sector that exceeds NRC concentration limits for Class-C *low-level radioactive waste*, as specified in 10 CFR Part 61. DOE is responsible for disposing of this type of waste pursuant to the Low-Level Radioactive Waste Policy Amendments Act of 1985.
Gross Regional Product	The value of all final goods and services produced in the *region of influence.*

groundshine	The *radiation dose* received from an area on the ground where a *radioactive* plume or cloud has deposited *radioactivity*.
groundwater	Water in pores or fractures in either the *unsaturated zone* or *saturated zone* below ground level.
habitat	Area in which a plant or animal lives and reproduces.
hazardous pollutant	Hazardous chemical that can cause serious health and environmental hazards, and that is listed on the federal list of hazardous air pollutants (42 U.S.C. Part 7412). See *toxic air pollutants.*
hazardous waste	Waste is designated as hazardous if it appears on the list of hazardous materials prepared by the EPA or a state or local regulatory agency, or if it has characteristics defined as hazardous by such agency. If the EPA does not list a material as hazardous, it still may be considered a hazardous waste if it exhibits one of the four characteristics defined in 40 CFR 261 Subpart C: ignitability, corrosivity, reactivity, or toxicity.
heavy-haul truck	An *overweight, overdimension truck* that must have permits from state highway authorities to use public highways; a vehicle DOE would use on public highways to move *spent nuclear fuel* or *high-level radioactive waste shipping casks* designed for a railcar.
heavy metal	In the context of this Repository SEIS, all uranium, plutonium, and thorium used or generated in a manmade *nuclear reactor*.
high-level radioactive waste	1. The highly *radioactive* material that resulted from the reprocessing of *spent nuclear fuel*, which includes liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains *fission* products in sufficient concentrations. (Note: DOE would vitrify liquid high-level radioactive waste before shipping it to the proposed *repository*.) 2. Other highly radioactive material that the NRC, consistent with existing law, determines by rule requires permanent *isolation*.
human intrusion	The inadvertent penetration into the *repository* by people.
hydric	Describes soils that are characterized by the presence of considerable moisture.
hydrographic area	In reference to Nevada *groundwater*, divisions of the state into groundwater basins and subbasins based primarily on topographic features such as mountains and valleys. The state uses the map of hydrographic areas as the basis for water planning, management, and administration. (Because they are based heavily on topographic features, hydrographic area boundaries sometimes differ from groundwater basin designations developed from studies of inferred or measured groundwater flow patterns.)

hydrology	1. The study of water characteristics, especially the movement of water. 2. The study of water, involving aspects of geology, oceanography, and meteorology.
immersion	See *cloudshine*.
impact	The positive or negative effect of an action (past, present, or future) on the natural environment (land use, *air quality*, water resources, geological resources, ecological resources, aesthetic and scenic resources) and the human environment *(infrastructure*, economics, social, and cultural).
in situ	In its natural position or place. The phrase distinguishes in-place experiments, that is, conducted in the field or *underground facility*, from those conducted in the laboratory.
incident-free	Routine transportation in which cargo travels from origin to destination without being involved in an *accident*.
indirect employment	Jobs that are created as a result of expenditures by directly employed project workers (for example, restaurant workers or childcare providers) or jobs that are created by project-related purchases of goods and services (for example, sales manager of a concrete supply store).
indirect impact	An effect that is related to but removed from a *proposed action* by an intermediate step or process. Examples include surface-water quality changes resulting from soil erosion at construction sites, and reductions in productivity resulting from changes in soil temperature.
indurated	Hardened, as in a *subsurface* layer that has become hardened.
industrial waste	*Solid waste* that is neither hazardous nor *radioactive* such as construction and demolition debris, rubber, and miscellaneous plastic products. Examples of construction and demolition debris include soil, rock, masonry materials, and lumber.
industrial wastewater	Liquid wastes from industrial processes that do not include *sanitary sewage*. *Repository* industrial wastewater would include water for dust suppression, rinse water from concrete production and transport, and process water from building heating, ventilation, and air conditioning systems.
infrastructure	Basic facilities, services, and installations for the functioning of a community or society, such as transportation and communication systems. For the proposed *repository*, these would include surface and *subsurface facilities* (for example, service *drifts*, transporters, electric power supplies, waste handling buildings, and administrative facilities).

Initial Handling Facility	A facility that would receive *high-level radioactive waste* and *naval spent nuclear fuel* canisters, load *canisters* into *waste packages*, and close the waste packages.
institutional control	*Monitoring* and maintenance of storage facilities to ensure that radiological releases to the environment and *radiation doses* to workers and the public remain within federal limits and DOE Order requirements, as applicable. For the proposed *repository*, active institutional control would require the presence of humans to safeguard and maintain the site; passive institutional control would include such devices as permanent markers and land records to warn future generations of dangers.
invasive species	An *alien species* whose introduction does or is likely to cause economic or environmental harm or harm to human health.
invert	The structure constructed in a *drift* to provide the floor of that drift. Drifts are made by boring machines and have a round bottom. The invert makes the bottom of the drift flat.
involved worker	Nonradiological impacts: A worker who would be doing the physical work involved with constructing, operating, monitoring, and closing the *repository*. Radiological impacts: A worker who would be directly engaged in the activities related to *subsurface* construction and *operations* at the proposed repository, which would include subsurface excavation activities; receipt, handling, packaging, and *emplacement* of waste materials; and *monitoring* of the condition and performance of the *waste packages*. See *noninvolved worker*.
ion	1. An atom that contains excess *electrons* or is deficient in electrons, which causes it to be chemically active. 2. An electron not associated with a *nucleus*.
ionizing radiation	1. *Alpha particles*, *beta particles*, *gamma rays*, *x-rays*, *neutrons*, high-speed *electrons*, high-speed *protons*, and other particles capable of producing *ions*. 2. Any *radiation* capable of the displacement of electrons from an atom or molecule, thereby producing ions.
irradiation	*Exposure* to *radiation.*
isolation	Inhibition of the transport of *radioactive* material so the amounts and concentrations of the material that enters the *accessible environment* stay within prescribed limits.

Jackass Flats	A broad asymmetric basin 8 to 10 kilometers (5 to 6 miles) wide and 20 kilometers (12 miles) long that is east of Yucca Mountain and is drained by *Fortymile Wash*. Also the name of the *hydrographic area* (Area 227A) overlapping the same general land area and from which DOE would withdraw *groundwater* to support the *Proposed Action.*
latent cancer fatality	A death that results from *cancer* that *exposure* to *ionizing radiation* caused. There typically is a latent, or dormant, period between the time of the *radiation* exposure and the time the cancer cells become active.
lost workday case	A case that involves days away from work or days of restricted work activity, or both. Equivalent to Days Away, Restricted, or On Job Transfer case in the CAIRS database.
low-income	Below the poverty level, as defined by the Bureau of the Census.
low-income population	A population in which 20 percent or more of the persons live in poverty, as reported by the Bureau of the Census in accordance with Office of Management and Budget requirements.
low-level radioactive waste	*Radioactive* waste that is not classified as *high-level radioactive waste*, *transuranic waste*, byproduct material containing uranium or thorium from processed ore, or naturally occurring *radioactive* material. The *repository* low-level radioactive waste would include personal-protective clothing, air filters, solids from the liquid low-level waste treatment process, radiological control and survey waste, and used *dual-purpose canisters*.
mapping zone	Biogeographically unique areas the Southwest Regional Gap Analysis Project derived from existing ecoregion maps using a combination of topographic and soil information, which it then truncated at state boundaries. Mapping zones are subunits of *ecoregions*.
matrix	The solid, but porous, portion of the rock.
maximally exposed offsite individual	For public health and safety impact analysis, a hypothetical individual who would reside continuously for 70 years at the unrestricted public access area in the prevailing downwind direction from the repository that would receive the highest radiation exposure. For accident analysis, a hypothetical member of the public at a point on the site boundary who would be likely to receive the maximum radiation dose.
maximum contaminant level	Under the Safe Drinking Water Act, the maximum permissible concentrations of specific constituents in drinking water that is delivered to any user of a public water system that serves 15 or more connections and 25 or more people; the standards established as maximum contaminant levels consider the feasibility and cost of attaining the standard.

mesosphere	Belt of atmosphere, just above the *stratosphere*, from 50 to 80 kilometers (30 to 50 miles) above the Earth's surface.
metric tons of heavy metal (MTHM)	Quantities of *spent nuclear fuel* are traditionally expressed in terms of MTHM (typically uranium, but including plutonium and thorium), without the inclusion of other materials such as *cladding* and structural materials. A metric ton is 1,000 kilograms (1.1 short tons or 2,200 pounds). Uranium and other metals in spent nuclear fuel are called *heavy metals* because they are extremely dense; that is, they have high weights per unit volume. One MTHM disposed of as spent nuclear fuel would fill a space approximately the size of the refrigerated storage area in a typical household refrigerator.
midpillar	The rock section between adjacent *emplacement drifts*.
millirem	One one-thousandth (0.001) of a *rem*.
minority	Hispanic, Black, Asian/Pacific Islander, American Indian/Eskimo, Aleut, and other nonwhite person.
minority population	A community in which the percent of the population of a racial or ethnic minority is 10 points higher than the percent found in the population as a whole.
mitigation	Actions and decisions that: • Avoid *impacts* altogether by not taking a certain action or parts of an action; • Minimize impacts by limiting the degree or magnitude of an action; • Rectify the impact by repairing, rehabilitating, or restoring the *affected environment*; • Reduce or eliminate the impact over time by preservation and maintenance operations during the life of the action; or • Compensate for an impact by replacing or providing substitute resources or environments.
mixed-oxide fuel	A mixture of uranium oxide and plutonium oxide that could be used to power commercial *nuclear reactors*.
mixed waste	Waste that exhibits the characteristics of both *hazardous* and *low-level radioactive wastes.*
monitoring	Activities during the *repository operations* and *monitoring analytical periods* that would include the surveillance and testing of *waste packages* and the repository for *performance confirmation*. See *monitoring analytical period.*

monitoring analytical period	50 years – Begins upon *emplacement* of the final *waste package*. Activities would include maintaining active ventilation of the *repository* for as long as 50 years, remotely inspecting waste packages, and continuing investigations in support of predictions related to *postclosure* performance. See *Repository SEIS analytical periods.*
Monte Carlo sampling technique	Technique for the random generation of inputs from *probability distributions* to simulate the process of sampling from the actual population.
native species	With respect to a particular *ecosystem*, a species that, other than as a result of an introduction, historically occurred or currently occurs in that ecosystem.
natural barrier	The physical components of the *geologic* environment that individually and collectively act to limit the movement of water or, in relation to this Repository SEIS, *radionuclides*. See *barrier*.
naval spent nuclear fuel	*Spent nuclear fuel* discharged from *reactors* in surface ships, submarines, and training reactors operated by the U.S. Navy.
neutron	An atomic particle with no charge and an *atomic mass* of 1; a component of all atoms except hydrogen; frequently released as *radiation*.
nitrogen dioxide	See *nitrogen oxides:* one of the six *criteria pollutants* for which there is a National *Ambient Air Quality Standard*.
nitrogen oxides	Gases formed in great part from atmospheric nitrogen and oxygen when combustion occurs under conditions of high temperature and high pressure; a major air pollutant. Two primary nitrogen oxides, nitric oxide and *nitrogen dioxide*, are important airborne *contaminants*. Nitric oxide combines with atmospheric oxygen to produce nitrogen dioxide. Both nitric oxide and nitrogen dioxide can, in high concentration, cause lung *cancer*. Nitrogen dioxide is a *criteria pollutant*.
noise-sensitive receptors	As used in this Repository SEIS, any specific resource (population or facility) that would be more susceptible to the effects of the noise impact of implementing the Proposed Action than would otherwise be.
No-Action Alternative	DOE included the analysis of the No-Action Alternative to provide a basis for comparison with the *Proposed Action*. For this SEIS, under the No-Action Alternative DOE would terminate activities at Yucca Mountain and undertake site reclamation to mitigate significant adverse environmental *impacts*. Commercial utilities and DOE would continue to store and manage *spent nuclear fuel* and *high-level radioactive waste* at 76 sites in the United States in a manner that protected public health and safety and the environment. See *alternative*.

nonattainment area — An area that does not meet the National *Ambient Air Quality Standard* for one or more *criteria pollutants*. Further designations (for example, serious, moderate) describe the magnitude of the nonattainment.

noninvolved worker — A worker who would perform managerial, technical, supervisory, or administrative activities but would not be directly involved in *construction*, excavation, or *operations* activities. Noninvolved workers include DOE Nevada Test Site workers. See *involved worker*.

nonnative species — A species found in an area where it has not historically been found.

normal distribution — As used in analyses of long-term performance, a special type of symmetrical distribution known in the science of statistics as the Gaussian distribution and commonly known as the "bell-shaped curve." See *distribution.*

North Construction Portal — *Portal* that would be used for construction of the *subsurface* facility.

North Portal — An existing *portal (*current northern access to the *Exploratory Studies Facility*) that DOE would use initially for *subsurface* construction and to emplace *waste packages* in the *subsurface facility*.

North Ramp — An existing, gently sloping incline that begins at the *North Portal* on the surface and extends through the *subsurface* to the edge of the *subsurface facility*. It would support *waste package emplacement* operations.

noxious weed — Any species of plant which is, or is likely to be, detrimental or destructive and difficult to control or eradicate.

nuclear reactor — A device in which a nuclear *fission chain reaction* can be initiated, sustained, and controlled to generate heat or to produce useful *radiation*.

Nuclear Waste Technical Review Board — An independent body in the executive branch created by the *Nuclear Waste Policy Amendments Act of 1987* to provide independent scientific and technical oversight of DOE's program for managing and disposing of *high-level radioactive waste* and *spent nuclear fuel*. The President appoints Board members from a list prepared by the National Academy of Sciences.

nucleus (nuclei) — The central, positively charged, dense portion of an atom. Also known as atomic nucleus.

nuclide — An atomic *nucleus* specified by its *atomic weight*, *atomic number*, and energy state; a *radionuclide* is a *radioactive* nuclide.

operations — See *operations analytical period.*

operational phases	Four stages used in the license application to indicate when specific facilities are expected to be operational under the planned phased construction. Operational phases are Phase 1, Phase 2, Phase 3, and Phase 4.
operations analytical period	50 years – Begins upon receipt of a license to receive and possess radiological materials and ends upon *emplacement* of the final *waste package*. Activities would include receipt, handling, *aging*, emplacement, and *monitoring* of waste, as well as continued construction of surface and *subsurface facilities*. See *Repository SEIS analytical periods.*
organism	An individual living system, such as animal, plant or micro-organism, that is capable of reproduction, growth and maintenance.
overweight, overdimension truck	Semi- and tandem tractor-trailer trucks with gross weights over 80,000 pounds that must obtain permits from state highway authorities to use public highways.
ozone	The triatomic form of oxygen; in the *stratosphere*, ozone protects the Earth from the Sun's *ultraviolet radiation*, but in lower levels of the atmosphere, it is an air pollutant; one of the six *criteria pollutants* for which there is a National *Ambient Air Quality Standard*.
particulate matter	Fine liquid or solid particles such as dust, smoke, mist, fumes, or smog, found in air or emissions; one of the six *criteria pollutants* for which there is a National *Ambient Air Quality Standard*. See $PM_{2.5}$ and PM_{10}.
pathway	A potential route by which *radionuclides* might reach the *accessible environment* and pose a threat to humans.
perceived risk	How an individual perceives, or senses, the amount of risk from a certain activity.
perched water	A *saturated zone* condition that is not continuous with the *water table* because an impervious or semipervious layer underlies the perched zone or a *fault* zone and creates a *barrier* to water movement and perches water. See *permeable.*
performance confirmation	The program of tests, experiments, and analyses DOE conducted to evaluate the accuracy and adequacy of the information it used to determine with reasonable assurance that the *repository* would meet the performance objectives for the period after *permanent closure*.
permanent closure	Final sealing of *shafts* and *boreholes* of the *underground facility*, which would include the installation of permanent monuments to mark the location and boundaries of the *repository*.

permeability	In general terms, the capacity of such mediums as rock, sediment, and soil to transmit liquid or gas. Permeability depends on the substance transmitted (such as oil, air, and water) and on the size and shape of the pores, joints, and *fractures* in the medium and the manner in which they interconnect. "Hydraulic conductivity" is equivalent to "permeability" in technical discussions of *groundwater*.
permeable	Pervious; a permeable rock is one that is either porous or cracked and that allows water to soak into and pass through freely.
person-rem	A unit to measure the *radiation exposure* to an entire group for comparison of the effects of different amounts of radiation on groups of people; it is the product of the average *dose equivalent* (in rem) to a given organ or tissue multiplied by the number of persons in the population of interest.
petrocalcic	A *subsurface* layer in which calcium carbonate or other carbonates have accumulated to the extent that the layer is cemented or *indurated*.
photon	A massless particle; the quantum of an electromagnetic field that carries energy, momentum, and angular momentum.
picocurie per liter (or gram)	A unit of concentration measure that describes the amount of *radioactivity* (in picocuries) in volume (or mass) of a given substance [typically, air or water (by volume) or soil (by mass)]. A picocurie is one-trillionth of a *curie*.
$PM_{2.5}$	*Particulate matter* with an aerodynamic diameter of 2.5 micrometers or less (about 0.0001 inch). This fine particulate matter is able to penetrate to the deepest part of the lungs and poses a risk to human health.
PM_{10}	*Particulate matter* with an aerodynamic diameter less than or equal to a nominal 10 micrometers (about 0.0004 inch). Particles smaller than this diameter are small enough to be breathable and could be deposited in lungs.
population dose	A summation of the *radiation doses* received by individuals in an exposed population; equivalent to collective dose. Expressed in *person-rem*.
portal	A portal is the opening to the *subsurface facility* that would provide access for construction, equipment, rock removal, and waste *emplacement.*
postclosure	The timeframe after *repository-closure* of the *repository* through the 1 million years analyzed in this Repository SEIS.
preclosure	The timeframe from construction authorization to *repository-closure*.
pressurized-water reactor	A nuclear power *reactor* that uses water under pressure as a coolant. The water boiled to generate steam is in a separate system.

primarily canistered approach	The packaging of most (a goal of 90 percent) *commercial spent nuclear fuel* at the commercial sites in multipurpose *TAD canisters*. The remaining commercial spent nuclear fuel (about 10 percent) would arrive at the *repository* as *uncanistered spent nuclear fuel* or in *dual-purpose canisters*.
prime farmland	Land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops, and is available for these uses (urban areas are not eligible). It has the soil quality, growing season, and moisture supply necessary for the economic production of sustained high yields of crops when treated and managed (including water management) in accordance with acceptable farming methods.
probabilistic	1. Based on or subject to *probability*. 2. Involving a variable factor, such as temperature or porosity. At each instance of time, the factor can take on any of the values of a specified set with a certain probability. Data from a probabilistic *process* are an ordered set of observations, each of which is one item in a probability *distribution*.
probability	The relative frequency at which an *event* can occur during a defined period. Statistical probability is about what happens in the real world and is verifiable by observation or sampling. Knowledge of the exact probability of an event is usually limited by the inability to know, or compile the complete set of, all possible outcomes over time or space. Probability is measured on a scale of 0 (event will not occur) to 1 (event will occur).
process	Any phenomenon that occurs over a relatively long period, as opposed to an *event*, which occurs relatively instantaneously. An example of a process is general corrosion of metal.
proposed action	The activity proposed to accomplish a federal agency's purpose and need. An *environmental impact statement* analyzes the environmental *impacts* of the proposed action. A proposed action includes the project and its related support activities (preconstruction, construction, and operation, along with postoperational requirements). The Proposed Action for this Repository SEIS is the *construction*, *operation* and *monitoring*, and eventual *closure* of a *geologic repository* for *spent nuclear fuel* and *high-level radioactive waste* at Yucca Mountain in Nevada.
Proposed Action inventory	Materials planned for *disposal* at the *Yucca Mountain Repository.*
proton	An elementary particle that is the positively charged component of ordinary matter and, together with the *neutron*, is a building block of all atomic *nuclei*.

pyroclastic	Of or related to individual particles or fragments of *clastic* rock material of any size formed by volcanic explosion or ejected from a volcanic vent.
qualitative	In relation to a variable, a parameter, or data, an expression or description of an aspect in terms of nonnumeric qualities or attributes. See *quantitative*.
quantitative	A numeric expression of a variable. See *qualitative.*
rad	A unit of absorbed *radiation dose* in terms of energy. One rad equals 100 ergs of energy absorbed per gram of tissue. (The word derives from radiation absorbed dose.)
radiation	The emitted particles or *photons* from the *nuclei* of *radioactive* atoms. Some elements are naturally radioactive; others are induced to become radioactive by *irradiation* in a *reactor*. Naturally occurring radiation is indistinguishable from induced radiation.
radioactive	Emitting *radioactivity*.
radioactivity	The property possessed by some elements (for example, uranium) of spontaneously emitting alpha, beta, or *gamma rays* by the *disintegration* of atomic *nuclei*.
radionuclide	An unstable *nuclide* capable of spontaneous transformation into an other nuclide by emitting photons or particles, thus changing its nuclear configuration or energy level.
rail alignment	A strip of land less than 400 meters (0.25 mile) wide within a corridor within which DOE would specify the location of a *rail line*.
rail corridor	A strip of land 400 meters (0.25 mile) wide through which DOE would identify an *alignment* for the construction of a *rail line*.
rail line	An engineered feature that consists of the track, ties, ballast, and subballast at a specific location.
railroad	A transportation system that incorporates the *rail line*, rail line operations support facilities, railcars, locomotives, and other related property and *infrastructure*.
reactor	See *nuclear reactor*.
real disposable personal income	The dollar income, including the value of transfer payments, available to individuals after taxes have been paid.

reasonably maximally exposed individual	A hypothetical person who is exposed to environmental *contaminants* (in this case *radionuclides*) in such a way (that is, by a combination of factors that include location, lifestyle, and dietary habits) that this individual is representative of the *exposure* of the general population. DOE used this hypothetical individual to evaluate long-term *repository* performance. The receptor represents the *reasonably maximally exposed individual* defined in 40 CFR Part 197. See *maximally exposed individual.*
Receipt Facility	A facility for the transfer of *TAD canisters* and *dual-purpose canisters*, as appropriate, to the *Wet Handling Facility*, a *Canister Receipt and Closure Facility*, and the *aging pads*.
Record of Decision	A document that provides a concise public record of a decision made by a government agency.
recordable cases	Occupational injuries or occupation-related illnesses that result in: 1. A fatality, regardless of the time between the injury or the onset of the illness and death, 2. *Lost workday cases* (nonfatal), or 3. The transfer of a worker to another job, termination of employment, medical treatment, loss of consciousness, or restriction of motion during work activities.
region of influence	A specialized term that indicates a specific area of study for each of the resource areas that this Repository SEIS analysis addresses.
release fraction	The fraction of each *radionuclide* in *spent nuclear fuel* or *high-level radioactive waste* that could be released from a containment in an *accident*.
rem	The unit of effective *dose equivalent* from *ionizing radiation* to the human body. It is an expression of the amount of *radiation* to which a person has been exposed. The effective dose equivalent in rem is equal to the absorbed *dose* in *rad* multiplied by quality and weighting factors that are necessary because biological effects can vary both by the type of radiation (even of the same deposited energy) and by the specific tissue exposed. (The word derives from roentgen equivalent in man).
repository	A burial vault. See *Yucca Mountain Repository.*
repository-closure	The point in time when activities associated with the closure analytical period, such as decommissioning and demolishing surface facilities and backfilling subsurface-to-surface openings, have been completed. Permanent closure of the repository would be complete; postclosure timeframe would begin.

Repository SEIS analytical periods — Four timeframes DOE defined for use in this Repository SEIS to best evaluate potential preclosure environmental impacts:

- *Construction analytical period*: 5 years – Begins upon receipt of the *construction* authorization from the NRC and ends prior to receipt of a license to receive and possess radiological materials. Activities would include site preparation, surface construction, and *subsurface* development.

- *Operations analytical period*: 50 years – Begins upon receipt of a license to receive and possess radiological materials and ends upon *emplacement* of the final waste package. Activities would include receipt, handling, *aging*, emplacement, and *monitoring* of waste, as well as continued construction of surface and *subsurface facilities*.

- *Monitoring analytical period*: 50 years – Begins upon emplacement of the final waste package. Activities would include maintaining active ventilation of the repository for as long as 50 years, remotely inspecting waste packages, and continuing investigations in support of predictions related to *postclosure* performance.

- *Closure analytical period*: 10 years – Overlaps the last 10 years of the monitoring analytical period and includes activities that would begin upon receipt of a license amendment to close the repository. Activities would include *decommissioning* and demolishing surface facilities, emplacing *drip shields*, *backfilling*, sealing subsurface-to-surface openings, restoring the surface to its approximate condition before repository construction, and constructing monuments to mark the site.

Resource area — For this Repository SEIS, a resource area, also known as a subject area, is one of the 13 areas evaluated to determine potential impacts to human health and welfare and the environment if the *Proposed Action* was implemented.

restricted area — As defined at 10 CFR 20.1003 and 10 CFR 63.2, an area in which DOE would separate waste handling operations from other activities in the *geologic repository operations area.* During phased *construction*, the restricted area would separate operational waste handling facilities from waste handling facilities under construction. DOE would monitor the restricted area to ensure adequate safeguards and security for *radioactive* materials.

resuspension — The renewed suspension into the atmosphere of material that had once settled to the ground.

retention pond — A pond designed to hold up to a specific amount of water indefinitely.

retrieval	The act of removing *radioactive* waste from the underground location at which the waste had been previously emplaced for *disposal*. Retrieval would be a contingency action, performed only if the waste needed to be retrieved in order to protect the public health and safety or the environment or to recover resources from *spent nuclear fuel*.
riprap	Broken stones or chunks of concrete used as foundation material or in embankments to control water flow or prevent erosion.
risk	The product of the *probability* that an undesirable *event* will occur multiplied by the consequences of the undesirable event.
sanitary sewage	Domestic wastewater from, sinks, showers, kitchens, floor drains, restrooms, change rooms, and food preparation and storage areas.
sanitary waste	*Solid waste* that is neither hazardous nor *radioactive*. Sanitary waste streams include paper, glass, and discarded office material. (State of Nevada waste regulations define this waste stream as household waste.)
saturated zone	The region below the *water table* where water completely fills all spaces (*fractures* and rock pores).
sedimentary rock	Rock formed by the accumulation and consolidation of sediment in water or land, usually in layered deposits. Sandstone, limestone, dolomite, and shale are types of sedimentary rocks DOE has identified in this Repository SEIS. They are differentiated by chemistry, deposition, and texture.
seismic	Pertaining to, characteristic of, or produced by *earthquakes* or earth vibrations.
sensitive species	As designated by the Bureau of Land Management, *native species* other than federally listed, proposed, or *candidate species* that the State Director deems to be in need of protection to ensure that actions authorized, funded, or carried out do not contribute to the need for the species to become listed under the Endangered Species Act. Bureau of Land Management Manual 6840.06 E provides the factors by which a native species may be listed as sensitive.
shaft	For the *Yucca Mountain Repository*, an excavation or vertical passage of limited area, in comparison with its depth, DOE would use to ventilate underground facilities.
shielding	Any material that provides *radiation* protection.
shielded transfer cask	A metal vessel used to transfer *canisters* among waste handling facilities.
shipment	The movement of a properly prepared (loaded, unloaded, or empty) *cask* from one site to another and associated activities to ensure compliance with applicable regulations.

shipping cask	A massive container with heavy *shielding* that would meet regulatory requirements for the shipment of *spent nuclear fuel* or *high-level radioactive waste*. See *cask*.
site characterization	Activities associated with the determination of the suitability of the *Yucca Mountain site* as a *geologic repository*. DOE constructed the *Exploratory Studies Facility*, which included surface facilities and *subsurface* ramps and *drifts*, to support the following activities related to the determination of site suitability: • Gather and evaluate surface and subsurface site data, • Predict the performance of the *repository*, • Prepare the repository design, and • Assess the performance of the system against the required regulations and program performance criteria.
soil map unit	A conceptual group of one or more map delineations identified by the same name in a soil survey that represent similar landscape areas that consist of either: 1. The same kind of component soils, with inclusions of minor or erratically dispersed soils; or 2. Two or more kinds of component soils that might or might not occur together in various delineations but that have similar special use and management properties.
soil order	The broadest category of soil classification, identified by the presence or absence of diagnostic layers, or horizons, which have specific physical, chemical, and biological properties.
soil series	The lowest category of soil taxonomy with the most restrictive classification of soil properties.
solid cancer	Solid *cancers* include all neoplasms other than those of the lymphatic and hematopoietic tissue.
solid waste	For this Repository SEIS analysis, non-liquid, nonsoluble materials ranging from municipal garbage to industrial wastes that contain complex, and sometimes hazardous, substances. Solid wastes also include sewage sludge, agricultural refuse, demolition wastes, and mining residues.
source term	Types and amounts of *radionuclides* that are the source of a potential release of *radioactivity*.

South Portal development area	An existing *portal* and ramp (current southern access to the *Exploratory Studies Facility*) that DOE would use for construction of the *subsurface facility*.
Southwest Regional Gap Analysis Project	This 2004 project was a multi-institutional effort to map and assess biodiversity for approximately 1.45 million square kilometers (560,000 square miles) in the southwestern United States. One task of this project was the development of a land cover map for the region.
Special-Performance-Assessment-Required wastes	*Low-level radioactive wastes* generated in DOE production *reactors,* research reactors, reprocessing facilities, and research and development activities that exceed the NRC Class C shallow-land burial *disposal* limits.
spent nuclear fuel	1. *Nuclear reactor* fuel that has been used to the extent that it can no longer effectively sustain a *chain reaction*. 2. Fuel that has been withdrawn from a nuclear reactor after *irradiation*, the component elements of which have not been separated by reprocessing. For this Repository SEIS, this refers to: a. Intact, nondefective *fuel assemblies*, b. Failed fuel assemblies in *canisters*, c. Fuel assemblies in canisters, d. Consolidated fuel rods in canisters, e. Nonfuel assembly hardware inserted in *pressurized-water reactor* fuel assemblies, f. Fuel channels attached to *boiling-water reactor* fuel assemblies, and g. Nonfuel assembly hardware and structural parts of assemblies resulting from consolidation in canisters.
stigma	An undesirable attribute that blemishes or taints an area or locale.
stratigraphic units	A layer or body of rock, distinct from that above or below, based on a specific property or characteristic of the rock. (A stratigraphic unit based on one rock property may not coincide with the unit designation based on another property.)
stratigraphy	The branch of geology that deals with the definition and interpretation of rock strata, the conditions of their formation, character, arrangement, sequence, age, distribution, and especially their correlation by the use of fossils and other means of identification. See *stratum*.

stratosphere	The atmospheric shell above the *troposphere* and below the *mesosphere*. It extends from 10 to 20 kilometers (6 to 12 miles) to about 53 kilometers (33 miles) above the surface.
stratum	A sheet-like mass of *sedimentary rock* or earth of one kind between beds of other kinds.
subsurface	A zone below the surface of the Earth, the *geologic* features of which are principally layers of rock that have been tilted or faulted and are interpreted on the bases of drill hole records and geophysical (*seismic* or rock vibration) evidence. In general, it is all rock and solid materials lying beneath the Earth's surface.
subsurface facility (subsurface geologic repository operations area)	The structure, equipment and systems (such as ventilation), *backfill* materials if any, and openings that penetrate underground (for example, ramps, *shafts*, and *boreholes*, including their seals).
sulfur dioxide	A pungent, colorless gas produced during the burning of sulfur-containing fossil fuels; one of the six *criteria pollutants* for which there is a National *Ambient Air Quality Standard*. It is the main pollutant involved in the formation of acid rain. Coal- and oil-burning electric utilities are the major source of sulfur dioxide in the United States. Inhaled sulfur dioxide can damage the human respiratory tract and severely damage vegetation. See *criteria pollutants, ambient air quality standards*.
TAD canister	See *transportation, aging, and disposal (TAD) canister*.
threatened species	A species that is likely to become endangered in the foreseeable future throughout all or a significant part of its range.
threshold limit values	The airborne concentration of a material to which nearly all persons can be exposed day after day, for a normal 8-hour workday or 40-hour workweek, without adverse effects; term used by the American Conference of Governmental Industrial Hygienists.
total employment	The sum of *direct* and *indirect employment* resulting from initiation of an activity. Direct employment consists of jobs performing the activity. Indirect employment consists of jobs in other activities supporting the direct employees. Also defined as *composite employment*.
total recordable cases	The total number of work-related deaths, illnesses, or injuries that resulted in the loss of consciousness, restriction of work or motion, transfer to another job, or that required medical treatment beyond first aid.

total effective dose equivalent	An expression of the *radiation* dose received by an individual from external radiation and from *radionuclides* internally deposited in the body; often generically referred to as *dose*. All doses presented in this Repository SEIS are in terms of total effective dose.
Total System Performance Assessment	A *risk* assessment that *quantitatively* estimates how the proposed *Yucca Mountain Repository* system could perform under the influence of specific features, *events*, and processes, incorporating uncertainty in the models and data.
toxic air pollutant	A hazardous air pollutant not listed as a *criteria pollutant* or a hazardous pollutant.
transpiration	The process by which water enters a plant through its root system, passes through its vascular system, and releases into the atmosphere through openings in its outer covering. It is an important process for removal of water that has infiltrated below the zone where it could be removed by evaporation.
transportation, aging, and disposal (TAD) canister	A *canister* suitable for storage, shipping, and *disposal* of *commercial spent nuclear fuel*. Commercial spent nuclear fuel would be placed directly into a TAD canister at the commercial *reactor*. At the *repository*, DOE would remove the TAD canister from the *transportation cask* and place it directly into a *waste package* or an *aging overpack*. The TAD canister is one of a number of types of *disposable canisters*.
transportation cask	A vessel that meets applicable regulatory requirements for the transport of *spent nuclear fuel* or *high-level radioactive waste* via public transportation routes.
transuranic waste	Waste materials (excluding *high-level radioactive waste* and certain other waste types) contaminated with alpha-emitting *radionuclides* that are heavier than uranium with half-lives greater than 20 years and that occur in concentrations greater than 100 nanocuries per gram. Transuranic waste results primarily from treatment and fabrication of plutonium and from research activities at DOE defense installations.
troposphere	The lowest layer of the atmosphere; it contains about 95 percent of the mass of air in the Earth's atmosphere. The troposphere extends from the Earth's surface up to about 10 to 15 kilometers (6 to 9 miles).
tuff	Igneous rock formed from compacted volcanic fragments from *pyroclastic* (explosively ejected) flows with particles generally smaller than 4 millimeters (about 0.16 inch) in diameter; the most abundant type of rock at the *Yucca Mountain site*. Nonwelded tuff results when volcanic ash cools in the air sufficiently so it does not melt together, yet later becomes rock through compression. See *welded tuff*.

ultraviolet radiation	Electromagnetic *radiation* with wavelengths from 4 to 400 nanometers. This range begins at the short wavelength limit of visible light and overlaps the wavelengths of long *x-rays* (some scientists place the lower limit at higher values, up to 40 nanometers). Also known as ultraviolet light.
uncanistered spent nuclear fuel	*Commercial spent nuclear fuel* placed directly into *transportation casks*. At the *repository*, DOE would remove spent nuclear fuel assemblies from the transportation cask and place them in a *TAD canister* before placement in a *waste package* or site *aging overpack.*
underground facility	In relation to the proposed *repository*, the underground structure, backfill materials, if any, and openings that penetrate the underground structure (for example, ramps, *shafts*, and *boreholes*).
unsaturated zone	The region between the surface and the *water table* where water fills only some of the spaces (*fractures* and rock pores).
vibration velocity decibels (VdB)	Vibration velocity in decibels with respect to 1 microinch per second. A measurement of root-mean-square velocity for the evaluation of ground vibration as an average or smoothed vibration amplitude on a logarithmic scale.
visual resource management class	The Bureau of Land Management classification of visual resource values.

Class I	Preserve the existing character of the landscape.	Provides for natural ecological changes but does not preclude limited management activity. Changes to the land must be small and must not attract attention.
Class II	Retain the existing character of the landscape.	Management activities may be seen but should not attract the attention of the casual observer. Changes must repeat the basic elements of form, line, color, and texture of the predominant natural features of the characteristic landscape.
Class III	Partially retain the existing character of the landscape.	Management activities may attract attention but may not dominate the view of the casual observer. Changes should repeat the basic elements in the predominant natural features of the characteristic landscape.
Class IV	Provide for management activities that require major modifications of the existing character of the landscape.	Management activities may dominate the view and be the major focus of viewer attention. An attempt should be made to minimize the impact of activities through location, minimal disturbance, and repeating the basic elements.

vitrification	A waste treatment process that uses glass (for example, *borosilicate glass)* to encapsulate or immobilize *radioactive* wastes.
waste package	Consists of the corrosion-resistant outer container, the waste form and any internal containers (such as the *TAD canister*), spacing structure or baskets, and *shielding* integral to the container. The waste package would be ready for *emplacement* in the *repository* when the outer lid welds were completed and accepted.
water table	1. The upper limit of the *saturated zone* (the portion of the ground wholly saturated with water). 2. The upper surface of a zone of saturation above which the majority of pore spaces and *fractures* are less than 100 percent saturated with water most of the time (*unsaturated zone*) and below which the opposite is true (saturated zone).
welded tuff	A *tuff* deposited under conditions where the particles that make up the rock were heated sufficiently to cohere. In contrast to nonwelded tuff, welded tuff is denser, less porous, and more likely to be fractured (which increases *permeability*).
Wet Handling Facility	A facility designed to handle uncanistered *commercial spent nuclear fuel* and to open and unload *dual-purpose canisters*; its essential purpose is to load *TAD canisters.*
wetland	• A shoreline or other area, such as a marsh or swamp, that is saturated with moisture, especially when it is the natural *habitat* of wildlife. • An area that is inundated or saturated by surface or *groundwater* at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.
x-rays	Penetrating electromagnetic *radiation* with a wavelength much shorter than that of visible light. X-rays are identical to *gamma rays* but originate outside the *nucleus*, either when the inner orbital *electrons* of an excited atom return to their normal state or when a metal target is bombarded with high-speed electrons.
Yucca Mountain Repository (repository)	Inclusive term for all areas in the *Yucca Mountain site* where DOE would construct the proposed facilities to support the proposed *repository,* including roads.
Yucca Mountain site	The area inside the site boundary over which DOE has control.

Yucca Mountain site boundary	That line beyond which DOE does not own, lease, or otherwise control the land or property for the purposes of the *repository*.
zirconium alloy	An alloy material that contains the element zirconium and that can have several compositions. For this Repository SEIS, it is a *cladding* material.

13

Preparers, Contributors, and Reviewer

13. PREPARERS, CONTRIBUTORS, AND REVIEWERS

13.1 Preparers and Contributors

This chapter lists the individuals who filled primary roles in the preparation of this *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F-S1) (Repository SEIS). Jane R. Summerson, Ph.D., of the U.S. Department of Energy (DOE) Office of Civilian Radioactive Waste Management directed the preparation of the Repository SEIS. The Repository SEIS Team, led by Joseph W. Rivers, Jr., of Jason Associates Corporation provided primary support and assistance to DOE; other members of the team include AGEISS Environmental, Inc., Dade Moeller & Associates, Inc., Tetra Tech NUS Inc., HRA Inc., and Battelle Memorial Institute.

DOE provided direction to the Repository SEIS Team, which was responsible for developing the analytical methodology and alternatives, coordinating the work tasks, performing the impact analyses, and producing the document. DOE was responsible for data quality, the scope and content of the Repository SEIS, and issue resolution and direction. The DOE Office of Civilian Radioactive Waste Management Technical Support Services contractor, Booz Allen Hamilton, assisted DOE in managing information flow and work priorities.

In addition, the Management and Operating contractor to the Office of Civilian Radioactive Waste Management (Bechtel SAIC Corporation and its subcontractors) assisted in the preparation of supporting documentation and information for this Repository SEIS, as did Sandia National Laboratories and the Nye County Nuclear Waste Project Office. These organizations, along with Potomac-Hudson Engineering, worked with the Repository SEIS Team to coordinate data and technologies for the simultaneous preparation of this Repository SEIS, the Rail Alignment EIS, and the application for an authorization to construct a repository.

DOE independently evaluated all supporting information and documentation prepared by these organizations. Further, DOE retained the responsibility for determining the appropriateness and adequacy of incorporating any data, analyses, and results of other work performed by these organizations in this Repository SEIS. The Repository SEIS Team was responsible for integrating such work in this Repository SEIS document.

As required by federal regulations [40 CFR 1506.5(c)], Jason Associates Corporation and its subcontractors have signed *National Environmental Policy Act* (NEPA) disclosure statements in relation to the work they performed on this Repository SEIS. These statements appear at the end of this chapter.

Name	Education	Experience	Responsibility
U.S. Department of Energy			
Jane R. Summerson	Ph.D., Geology, 1991 M.S., Geobiology, 1985 M.A., Anthropology, 1978 B.A., Anthropology, 1977	16 years – waste management projects with the DOE office of Civilian Radioactive Waste Management	DOE Document Manager
Repository SEIS Team			
Joseph W. Rivers, Jr. Jason Associates Corporation	B.S., Mechanical Engineering, 1982	25 years – commercial and DOE nuclear projects, NEPA and regulatory compliance, systems engineering, and safety analysis.	Project Manager
James “Pat” Barker HRA Inc., Conservation Archaeology	Ph.D., Anthropology, 1982	20 years – Bureau of Land Management Cultural Resources Management Program archaeologist, 18 in Nevada	Lead Analyst: Cultural Resources
Tonya Bartels AGEISS Environmental, Inc.	M.S., Analytical Chemistry, 1994 B.S., Chemistry, 1991	8 years – NEPA project support.	Lead Analyst: Land Use, Noise and Vibration, Aesthetics
Pixie Baxter Tetra Tech NUS Inc.	M.B.A., Economics, 1981 B.A., Art History	20 years – multidisciplinary economic and business experience including 15 years as economics college faculty member.	Lead Analyst: Socioeconomics
William J. Craig Dade Moeller & Associates	M.S., Planning, 1977 B.S., Forestry, 1972	27 years – power plant siting, nuclear fuel management, NEPA, project management, and public participation.	Comment Response Team; Lead Analyst: Similar Actions, Unavoidable Impacts, Appendix A
David Crowl Dade Moeller & Associates	B.A., Computer Science, 1985	23 years – NEPA documentation, technical writing and editing, publications management.	Production Team: technical editor

Name	Education	Experience	Responsibility
Keith D. Davis, PE Jason Associates Corporation	M.S., Civil/Environmental Engineering, 1976 B.S., Civil Engineering, 1973	30 years – civil and environmental engineering; waste management; facility permitting and closure; site investigations, feasibility studies, and remedial action planning; 13 years – NEPA documentation.	Lead Analyst: Geology, Hydrology, Manufacturing Repository Components, and Floodplain/Wetlands Assessment (Appendix C)
Peter R. Davis Jason Associates Corporation	Oak Ridge School of Reactor Technology 1962 B.S., Physics, 1961	45 years – nuclear reactor and nuclear facility safety analysis and risk assessment.	Lead Analyst: Accident Scenarios
Med Durel AGEISS Environmental, Inc.	M.S., Chemistry B.S., Chemistry Graduate, US Army War College	35 years – hazardous materials, environmental protection, occupational health and safety and education.	Lead Analyst: Mitigation
Mark Gonzalez Jason Associates Corporation	B.S., Forestry 2002	5 years – preparation of NEPA and CEQA documents and environmental compliance.	Lead Analyst: Waste and Hazardous Materials, Retrieval.
Ernest C. Harr, Jr. Jason Associates Corporation	B.S., Zoology/Chemistry 1977	30 years – DOE and commercial programs and projects, radiological programs, environmental monitoring, and radioactive materials and waste management.	Deputy Project Manager; Comment Response Document Lead
Dennis Heyer AGEISS Environmental, Inc.	1 ½ years of college courses	18 years – environmental investigations, regulatory compliance, and health and safety compliance.	Quality Control Team: Change Control Database check

Name	Education	Experience	Responsibility
Rich Huenefeld AGEISS Environmental, Inc.	M.S., Natural Resource Sciences, 2002 B.S., Natural Resource Sciences, 1996	11 years – wildlife and habitat research and assessment; 3 years – NEPA documentation.	Lead Analyst: Biological Resources and Soils; Integration team lead for Repository SEIS
Laurie Johnson Jason Associates Corporation	A.A., Graphic Design	25 years – graphics design.	Production Team: graphics designer
Aaron Klug AGEISS Environmental, Inc.	B.S., Reclamation, 1996	10 years – regulatory compliance, waste management projects, NEPA documentation.	Quality Control Team: Final Repository SEIS data consistency check
Dave Lechel	M.S., Fisheries Biology, 1974 B.S., Fisheries Biology, 1972	28 years – preparing and managing preparation of NEPA documents (25 years on DOE NEPA work).	DOE consultant: assisted DOE develop the construct of the Repository SEIS; performed independent review of preliminary sections of the Draft SEIS.
Scott Kinderwater Jason Associates Corporation	B.S., Soil Science, 1979	19 years – regulatory compliance, hazardous waste management and water quality enforcement.	Lead Analyst: No-Action Alternative, Statutory Requirements
Robin Klein Dade Moeller & Associates	1 year of college courses	30 years – word processing, advanced formatting, graphic design. Lead word processor on Final Yucca Mountain EIS.	Production Team: word processor

Name	Education	Experience	Responsibility
David H. Lester Jason Associates Corporation	Ph.D., Chemical Engineering, 1969 M.S., Chemical Engineering, 1966 B. Che., Chemical Engineering, 1964	32 years – hazardous and nuclear waste management; nuclear safety analysis reports, hazards analysis, risk assessment, groundwater contamination transport modeling, performance, design of treatment systems, design and analysis of high-level waste packages, and soil remediation studies.	Lead Analyst: Postclosure Consequences
Steven Maheras Battelle Memorial Institute	Ph.D., Health Physics, 1988 M.S., Health Physics, 1985 B.S., Zoology, 1982 Certified Health Physicist, 1992	19 years – transportation risk assessment and radiological assessment, environmental and occupational radiation protection.	Lead Analyst: Transportation
Sanjay Mawalkar Battelle Memorial Institute	MBA, Decision Sciences/MIS, 1993 B.E., Chemical Engineering, 1986	14 years – software design and implementation	Analyst: Transportation
Thomas I. McSweeney Battelle Memorial Institute	Ph.D., Chemical Engineering, 1967 M.A., Mathematics, 1964 M.S., Chemical Engineering, 1961 B.S., Chemical Engineering, 1960	40 years – transportation risk assessment and safety analysis	Analyst: Transportation
Julie Moniot Jason Associates Corporation	B.S., Nursing, 2000	12 years – general office, network administration	Production Team: word processor, comment distribution
Christijo Plemons Jason Associates Corporation	1 ½ years of college courses	18 years – marketing and general office.	Production Team: glossary, references, graphics production
Heidi Roberts HRA Inc., Conservation Archaeology	M.A., Anthropology, 1991	25 years – contract archaeology.	Lead Analyst: Cultural Resources

Name	Education	Experience	Responsibility
Christine Ross Battelle Memorial Institute	AD, Microcomputer Management Specialist/Multimedia Specialist, 1999	8 years – GIS and computer mapping	Analyst: Transportation
Melissa H. Russ, PG AGEISS Environmental, Inc.	M.S., Geology, 1986	25 years – environmental remedial investigations and feasibility studies; emergency response and cleanup; permitting and regulatory compliance; 10 years – NEPA documentation.	Lead Analyst: Proposed Action and Alternatives
Leroy Shaser AGEISS Environmental, Inc.	M.S., Geology 1978 B.S., Geology 1976	15 years – environmental compliance: NEPA, CERCLA, RCRA; 26 years – GIS and computer mapping.	Lead Analyst: Air Quality-nonradiological; Occupational and Public Health and Safety-nonradiological; Utilities, Energy, Materials, and Site Services; and the nonradiological air quality Appendix B; GIS graphics
Erika Shelton Battelle Memorial Institute	B.S., Engineering Physics and Astronomy, 2007	1 year – Transportation risk assessment.	Analyst: Transportation
John O. Shipman Dade Moeller & Associates	B.A., English Literature, 1966	41 years – NEPA documentation, technical writing and editing, publications management; 10 years – public participation.	Comment Response Team; Production Team: lead technical editor
Susan Sobczak-Bryan, PG AGEISS Environmental, Inc.	M.E., Geological Engineer, 1992; B.S., Geological Engineering, 1986	19 years – quality assurance and quality control management and auditing; NEPA water resource analyses; CERCLA hazardous waste site investigations and feasibility studies.	Lead Analyst: Mitigation, Best Management Practices and Unavoidable Adverse Impacts; Document Quality Assurance Manager

Name	Education	Experience	Responsibility
Alisa "Kathryn" Stapelman Jason Associates Corporation	A.A., Event Planning	10 years – office administration.	Word Team: word processor, document coding
Joanne Stover Jason Associates Corporation	B.S., Business Administration, 1996	20 years – technical editing, marketing, NEPA document development, and project management.	Production Team: document production manager, technical editor, document control, Administrative Record, references
Julianne Turko AGEISS Environmental, Inc.	M.A., Geology, 1989 B.S., Geological Sciences, 1981	16 years – environmental compliance experience, NEPA, CERCLA, RCRA, CWA, CAA.	Lead Analyst: Cumulative Impacts
Christine Van Lenten Jason Associates Corporation	B.A., English, 1965	15 years – support to OCRWM/YMP and other DOE programs including WIPP and EM, principally as writer, editor, and policy analyst, handling broad range of subjects.	Summary
Susan Walker AGEISS Environmental, Inc.	Ph.D., Pathology, 1982 B.S., Zoology, 1975	32 years – toxicology, risk assessment, environmental studies including NEPA and regulatory compliance.	Deputy Project Manager; Document Manager; Lead Analyst: Environmental Justice
YuChien Yuan Jason Associates Corporation	Ph.D., Nuclear Engineering, 1976 M.S., Chemical Engineering, 1970 B.S., Chemical Engineering, 1967	31 years – radiological and health risk assessment, radionuclide transport and pathway analysis, occupational radiation protection.	Lead Analyst: Occupational and Public Health and Safety-radiological

13.2 Reviewers

The DOE Office of Civilian Radioactive Waste Management incorporated input to the preparation of this Repository SEIS from a number of other DOE offices that reviewed the document while it was under development. These include the offices of Environmental Management, Naval Reactors, Nuclear Energy, Materials Disposition, the National Spent Nuclear Fuel Program, the National High-Level Waste Program, and General Counsel.

NEPA DISCLOSURE STATEMENT FOR PREPARATION OF THE SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT FOR A GEOLOGIC REPOSITORY FOR THE DISPOSAL OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE AT YUCCA MOUNTAIN, NYE COUNTY, NEVADA

CEQ regulations at 40 CFR 1506.5(c), which have been adopted by DOE (10 CFR 1021), require contractors who will prepare an EIS to execute a disclosure specifying that they have no financial or other interest in the outcome of the project. The term "financial interest or other interest in the outcome of the project" for purpose of this disclosure is defined in the March 23, 1981, guidance "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," (46 FR 18026-18038 at Question 17a and b).

"Financial or other interest in the outcome of the project" includes "any financial benefit such as a promise of future construction or design work in the project, as well as indirect benefits the contractor is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients)" (see 46 FR 18026-18031).

In accordance with these requirements, JASON ASSOCIATES CORPORATION hereby certifies it has no financial or other interest in the outcome of the project.

Certified By:

Signature

David Hoberg

Name (printed)

Vice-President/CFO

Title

Jason Associates Corporation

Company

September 5, 2007

Date

NEPA DISCLOSURE STATEMENT FOR PREPARATION OF THE SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT FOR A GEOLOGIC REPOSITORY FOR THE DISPOSAL OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE AT YUCCA MOUNTAIN, NYE COUNTY, NEVADA

CEQ regulations at 40 CFR 1506.5(c), which have been adopted by DOE (10 CFR 1021), require contractors who will prepare an EIS to execute a disclosure specifying that they have no financial or other interest in the outcome of the project. The term "financial interest or other interest in the outcome of the project" for purpose of this disclosure is defined in the March 23, 1981, guidance "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," (46 FR 18026-18038 at Question 17a and b).

"Financial or other interest in the outcome of the project" includes "any financial benefit such as a promise of future construction or design work in the project, as well as indirect benefits the contractor is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients)" (see 46 FR 18026-18031).

In accordance with these requirements, LECHEL, Inc. hereby certifies it has no financial or other interest in the outcome of the project.

Certified By:

David Lechel
Signature

DAVID LECHEL
Name (printed)

VICE PRESIDENT
Title

LECHEL, INC
Company

8-21-07
Date

NEPA DISCLOSURE STATEMENT FOR PREPARATION OF THE SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT FOR A GEOLOGIC REPOSITORY FOR THE DISPOSAL OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE AT YUCCA MOUNTAIN, NYE COUNTY, NEVADA

CEQ regulations at 40 CFR 1506.5(c), which have been adopted by DOE (10 CFR 1021), require contractors who will prepare an EIS to execute a disclosure specifying that they have no financial or other interest in the outcome of the project. The term "financial interest or other interest in the outcome of the project" for purpose of this disclosure is defined in the March 23, 1981, guidance "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," (46 FR 18026-18038 at Question 17a and b).

"Financial or other interest in the outcome of the project" includes "any financial benefit such as a promise of future construction or design work in the project, as well as indirect benefits the contractor is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients)" (see 46 FR 18026-18031).

In accordance with these requirements, AGEISS Environmental, Inc. hereby certifies it has no financial or other interest in the outcome of the project.

Certified By:

Donna Lawrence

Signature

Donna Lawrence

Name (printed)

President

Title

AGEISS Environmental, Inc.

Company

September 4, 2007

Date

NEPA DISCLOSURE STATEMENT FOR PREPARATION OF THE SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT FOR A GEOLOGIC REPOSITORY FOR THE DISPOSAL OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE AT YUCCA MOUNTAIN, NYE COUNTY, NEVADA

Prime Contract No. DE-AM04-02AL67953
Task Order No. DE-AT28-06RW12374
Subcontract No. 1102S-0301

CEQ regulations at 40 CFR 1506.5(c), which have been adopted by DOE (10 CFR 1021), require contractors who will prepare an EIS to execute a disclosure specifying that they have no financial or other interest in the outcome of the project. The term "financial interest or other interest in the outcome of the project" for purpose of this disclosure is defined in the March 23, 1981, guidance "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," (46 FR 18026-18038 at Question 17a and b).

"Financial or other interest in the outcome of the project" includes "any financial benefit such as a promise of future construction or design work in the project, as well as indirect benefits the contractor is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients)" (see 46 FR 18026-18031).

In accordance with these requirements, Battelle Memorial Institute hereby certifies to the best of its knowledge and belief, it has no financial or other interest in the outcome of the project.

Certified By:

Signature

Scott G. Williams
Name (printed)

Sr. Contract Administrator
Title

Battelle Memorial Institute – Columbus Operations
Company

September 6, 2007
Date

**NEPA DISCLOSURE STATEMENT FOR
PREPARATION OF THE SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT FOR A GEOLOGIC REPOSITORY FOR THE DISPOSAL OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE AT YUCCA MOUNTAIN, NYE COUNTY, NEVADA**

CEQ regulations at 40 CFR 1506.5(c), which have been adopted by DOE (10 CFR 1021), require contractors who will prepare an EIS to execute a disclosure specifying that they have no financial or other interest in the outcome of the project. The term "financial interest or other interest in the outcome of the project" for purpose of this disclosure is defined in the March 23, 1981, guidance "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," (46 FR 18026-18038 at Question 17a and b).

"Financial or other interest in the outcome of the project" includes "any financial benefit such as a promise of future construction or design work in the project, as well as indirect benefits the contractor is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients)" (see 46 FR 18026-18031).

In accordance with these requirements, Dade Moeller & Associates hereby certifies it has no financial or other interest in the outcome of the project.

Certified By:

Signature

Glenn S. Caprio

Name (printed)

Chief Operating Officer

Title

Dade Moeller & Associates

Company

9/4/07

Date

NEPA DISCLOSURE STATEMENT FOR PREPARATION OF THE SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT FOR A GEOLOGIC REPOSITORY FOR THE DISPOSAL OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE AT YUCCA MOUNTAIN, NYE COUNTY, NEVADA

CEQ regulations at 40 CFR 1506.5(c), which have been adopted by DOE (10 CFR 1021), require contractors who will prepare an EIS to execute a disclosure specifying that they have no financial or other interest in the outcome of the project. The term "financial interest or other interest in the outcome of the project" for purpose of this disclosure is defined in the March 23, 1981, guidance "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," (46 FR 18026-18038 at Question 17a and b).

"Financial or other interest in the outcome of the project" includes "any financial benefit such as a promise of future construction or design work in the project, as well as indirect benefits the contractor is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients)" (see 46 FR 18026-18031).

In accordance with these requirements, Tetra Tech NUS, Inc., hereby certifies it has no financial or other interest in the outcome of the project.

Certified By:

Signature

James L. Oliver
Name (printed)

Aiken Operations Manager
Title

Tetra Tech NUS, Inc.
Company

September 4, 2007
Date

NEPA DISCLOSURE STATEMENT FOR PREPARATION OF THE SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT FOR A GEOLOGIC REPOSITORY FOR THE DISPOSAL OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE AT YUCCA MOUNTAIN, NYE COUNTY, NEVADA

CEQ regulations at 40 CFR 1506.5(c), which have been adopted by DOE (10 CFR 1021), require contractors who will prepare an EIS to execute a disclosure specifying that they have no financial or other interest in the outcome of the project. The term "financial interest or other interest in the outcome of the project" for purpose of this disclosure is defined in the March 23, 1981, guidance "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," (46 FR 18026-18038 at Question 17a and b).

"Financial or other interest in the outcome of the project" includes "any financial benefit such as a promise of future construction or design work in the project, as well as indirect benefits the contractor is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients)" (see 46 FR 18026-18031).

In accordance with these requirements, AGEISS Environmental, Inc. hereby certifies it has no financial or other interest in the outcome of the project.

Certified By:

Heidi Robert

Signature

Heidi Roberts
Name (printed)

____
Title

HRA Archaeology
Company

9-15-2007
Date

14
Index

A

D

E

F

G

N

O

V

W

Y

CONVERSION FACTORS

Metric to English			English to Metric		
Multiply	by	To get	Multiply	by	To get
Area					
Square kilometers	247.1	Acres	Acres	0.0040469	Square kilometers
Square kilometers	0.3861	Square miles	Square miles	2.59	Square kilometers
Square meters	10.764	Square feet	Square feet	0.092903	Square meters
Concentration					
Kilograms/sq. meter	0.16667	Tons/acre	Tons/acre	0.5999	Kilograms/sq. meter
Milligrams/liter	1[a]	Parts/million	Parts/million	1[a]	Milligrams/liter
Micrograms/liter	1[a]	Parts/billion	Parts/billion	1[a]	Micrograms/liter
Micrograms/cu. meter	1[a]	Parts/trillion	Parts/trillion	1[a]	Micrograms/cu. meter
Density					
Grams/cu. centimeter	62.428	Pounds/cu. ft.	Pounds/cu. ft.	0.016018	Grams/cu. centimeter
Grams/cu. meter	0.0000624	Pounds/cu. ft.	Pounds/cu. ft.	16,025.6	Grams/cu. meter
Length					
Centimeters	0.3937	Inches	Inches	2.54	Centimeters
Meters	3.2808	Feet	Feet	0.3048	Meters
Micrometers	0.00003937	Inches	Inches	25,400	Micrometers
Millimeters	0.03937	Inches	Inches	25.40	Millimeters
Kilometers	0.62137	Miles	Miles	1.6093	Kilometers
Temperature					
Absolute					
Degrees C + 17.78	1.8	Degrees F	Degrees F – 32	0.55556	Degrees C
Relative					
Degrees C	1.8	Degrees F	Degrees F	0.55556	Degrees C
Velocity/Rate					
Cu. meters/second	2,118.9	Cu. feet/minute	Cu. feet/minute	0.00047195	Cu. meters/second
Meters/second	2.237	Miles/hours	Miles/hour	0.44704	Meters/second
Volume					
Cubic meters	264.17	Gallons	Gallons	0.0037854	Cubic meters
Cubic meters	35.314	Cubic feet	Cubic feet	0.028317	Cubic meters
Cubic meters	1.3079	Cubic yards	Cubic yards	0.76456	Cubic meters
Cubic meters	0.0008107	Acre-feet	Acre-feet	1,233.49	Cubic meters
Liters	0.26418	Gallons	Gallons	3.78533	Liters
Liters	0.035316	Cubic feet	Cubic feet	28.316	Liters
Liters	0.001308	Cubic yards	Cubic yards	764.54	Liters
Weight/Mass					
Grams	0.035274	Ounces	Ounces	28.35	Grams
Kilograms	2.2046	Pounds	Pounds	0.45359	Kilograms
Kilograms	0.0011023	Tons (short)	Tons (short)	907.18	Kilograms
Metric tons	1.1023	Tons (short)	Tons (short)	0.90718	Metric tons
English to English					
Acre-feet	325,850.7	Gallons	Gallons	0.000003046	Acre-feet
Acres	43,560	Square feet	Square feet	0.000022957	Acres
Square miles	640	Acres	Acres	0.0015625	Square miles

a. This conversion factor is only valid for concentrations of contaminants (or other materials) in water.

METRIC PREFIXES

Prefix	Symbol	Multiplication factor		
exa-	E	1,000,000,000,000,000,000	=	10^{18}
peta-	P	1,000,000,000,000,000	=	10^{15}
tera-	T	1,000,000,000,000	=	10^{12}
giga-	G	1,000,000,000	=	10^{9}
mega-	M	1,000,000	=	10^{6}
kilo-	K	1,000	=	10^{3}
deca-	D	10	=	10^{1}
deci-	D	0.1	=	10^{-1}
centi-	C	0.01	=	10^{-2}
milli-	M	0.0 001	=	10^{-3}
micro-	μ	0.000 001	=	10^{-6}
nano-	N	0.000 000 001	=	10^{-9}
pico-	P	0.000 000 000 001	=	10^{-12}