Draft

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

Summary

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

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TITLE: *Draft 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-S1D) (Repository SEIS).

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ABSTRACT: DOE's Proposed Action is to construct, operate and 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 Draft Repository SEIS evaluates (1) the potential environmental impacts from the construction, operation and 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: A 90-day comment period on this document begins with the publication of the Environmental Protection Agency Notice of Availability in the Federal Register. DOE will consider comments received after the 90-day period to the extent practicable. The Department will hold public hearings to receive comments on the document at the times and locations announced in local media and the DOE Notice of Availability. Written comments may also be submitted by U.S. mail to the U.S. Department of Energy at the above address in Las Vegas, via the Internet at http://www.ymp.gov, or by facsimile at 1-800-967-0739. This public comment period and the public hearings coincide with those of the *Draft 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-S2D; the Nevada Rail Corridor SEIS), and *Draft 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-0369D; the Rail Alignment EIS).

FOREWORD

The U.S. Department of Energy (DOE or Department) has prepared two draft National Environmental Policy Act (NEPA) documents 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:

- *Draft 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-S1D) (Repository SEIS), and

- *Draft 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* (Part 1) (DOE/EIS-0250F-S2D) (Nevada Rail Corridor SEIS), and *Draft 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* (Part 2) (DOE/EIS-0369D) (Rail Alignment EIS).

The Repository SEIS evaluates the potential environmental impacts of constructing and operating the Yucca Mountain repository under the current repository design and operational plans, the purpose of which is to assist the U.S. Nuclear Regulatory Commission (NRC) in adopting, to the extent practicable, any EIS prepared pursuant to Section 114(f)(4) of the Nuclear Waste Policy Act, as amended (NWPA; 42 United States Code 10101 *et seq.*).

The Nevada Rail Corridor SEIS and Rail Alignment EIS 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, the purpose of which is to help the Department decide whether to construct and operate a railroad, and if so, within which corridor and along which alignment.

Background and Context

The NWPA 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 *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, February 2002) (Yucca Mountain FEIS).

On February 14, 2002, the Secretary transmitted to the President his 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). The Department is now in the process of preparing an application for submittal to the NRC seeking authorization to construct the repository, as required by the NWPA (Section 114(b)).

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. 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 current repository design and operational plans, the Department announced its intent to prepare a Supplement to the Yucca Mountain FEIS (DOE/EIS-0250F-S1), consistent with NEPA and the NWPA. (*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 current 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.

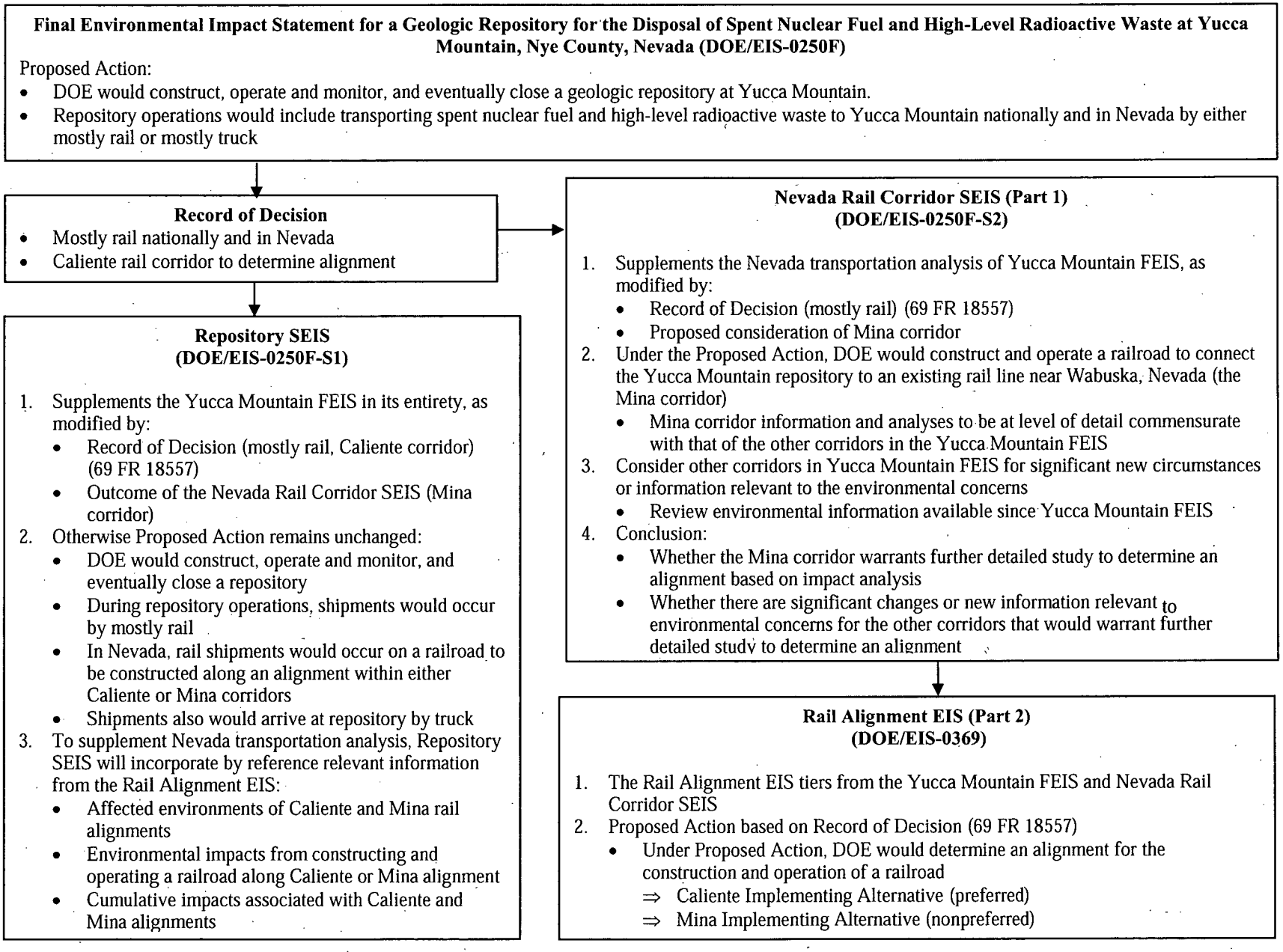
Relationships among the EISs

The Yucca Mountain FEIS, the Repository SEIS and the Nevada Rail Corridor SEIS and Rail Alignment EIS are related in several respects. The Nevada Rail Corridor SEIS, supplements the rail corridor analysis of the Yucca Mountain FEIS by analyzing 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 Code of Federal Regulations 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.

The Repository SEIS includes the potential environmental impacts of national transportation, and the potential impacts from the construction and operation of a rail line along specific alignments in either the Caliente or the Mina corridor, as described in the Rail Alignment EIS to ensure that the Repository SEIS considers the full scope of potential environmental impacts associated with the proposed construction and operation of the repository. Conversely, the Rail Alignment EIS includes the potential impacts of constructing and operating the repository as a reasonably foreseeable future action in its cumulative impacts analysis. To ensure consistency, the Repository SEIS, and the Nevada Rail Corridor SEIS and Rail Alignment EIS use the same 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 both documents. Furthermore, to promote conformity, where appropriate, consistent analytical approaches were used in both documents to evaluate the various resource areas.



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

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S.1 Purpose and Need for Agency Action

S.1.1 WHY THE YUCCA MOUNTAIN REPOSITORY IS NEEDED

For many years, civilian and defense-related activities have produced spent nuclear fuel and high-level radioactive waste. These materials have accumulated—and continue to accumulate—at 72 commercial and 4 U.S. Department of Energy (DOE or the Department) sites across the United States. Figure S-1 shows the locations of these sites. Because these materials are highly radioactive, they must be isolated from the accessible environment. More than 25 years ago, in the *Nuclear Waste Policy Act of 1982,* Congress adopted the overwhelming consensus view in the scientific community that the best option for permanently isolating these materials would be disposing of them in a deep underground repository.

The *Nuclear Waste Policy Act* established an open, science-based, and orderly process for the identification, characterization, and approval of a site for a permanent geologic repository, and for its licensing by the U.S. Nuclear Regulatory Commission (NRC). The Act assigned lead responsibility to the Secretary of Energy. After DOE considered nine sites and recommended three for detailed evaluation, Congress amended the Act in 1987 to select Yucca Mountain as the single site for further study, and it directed the Secretary to determine whether to recommend that the President approve the Yucca Mountain site for development of a repository. (The amended Act is referred to as the NWPA.)

The Secretary's February 2002 recommendation that the President approve the site followed more than two decades of scientific investigations. As required by the NWPA, the Secretary submitted 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* (Yucca Mountain FEIS) with his recommendation.

On July 23, 2002, the President signed into law a joint congressional resolution designating the Yucca Mountain site for development as a geologic repository for the disposal of spent nuclear fuel and high-level radioactive waste. This action concluded the site selection process stipulated by the NWPA. As required by the NWPA, the Department is now preparing an application seeking NRC authorization to construct a repository.

S.1.2 BACKGROUND

The Proposed Action defined in the Yucca Mountain FEIS is to construct, operate, monitor, and eventually close a geologic repository at Yucca Mountain to dispose of spent nuclear fuel and high-level radioactive waste. The Proposed Action includes transportation of these materials from commercial and DOE sites to the repository.

In the Yucca Mountain FEIS, DOE considered the potential environmental impacts of a repository design for surface and subsurface facilities, a range of canister packaging scenarios and repository thermal operating modes, and plans for the construction, operation, monitoring, and eventual closure of the repository. The FEIS also described and evaluated the transportation of spent nuclear fuel and high-level radioactive waste from commercial and DOE sites to the repository by two principal modes—mostly truck and mostly rail. Since completion of the Yucca Mountain FEIS in 2002, the repository design

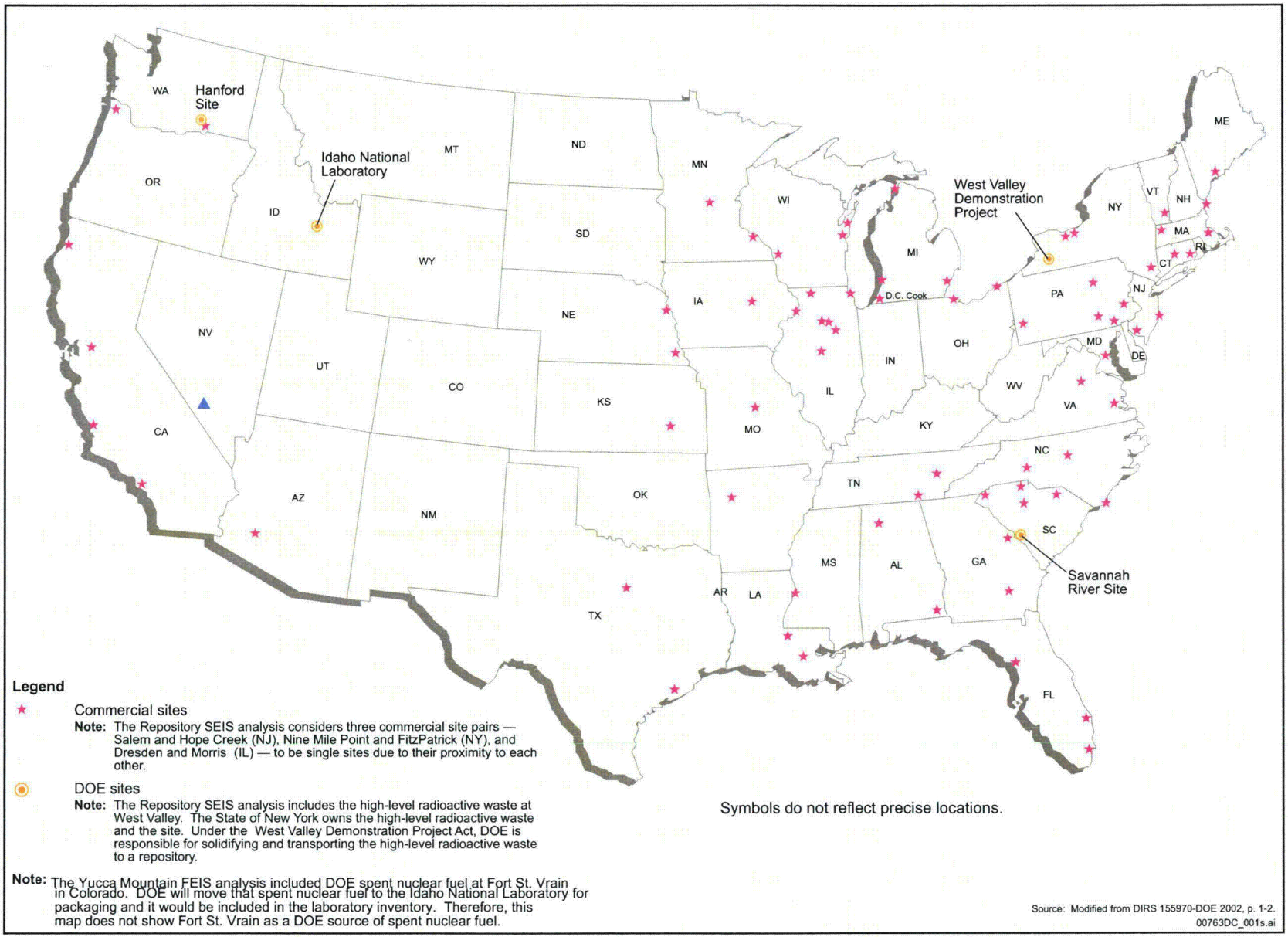


Figure S-1. Commercial and DOE sites from which DOE would ship radioactive materials to Yucca Mountain.

and associated construction and operational plans have continued to evolve, and additional information and updated analytic tools relevant to estimating potential environmental impacts have become available.

The repository design and associated plans now include the construction of up to eight waste handling facilities over a period of several years, whereas in the Yucca Mountain FEIS DOE envisioned a single waste handling building and associated facilities to be constructed at one time. The details of the infrastructure required for construction and operations (access road, power lines, and support facilities) have matured since the FEIS and are now sufficient to allow a more detailed analysis. DOE would now operate the repository following a primarily canistered approach in which most spent nuclear fuel and high-level radioactive waste would be packaged at the reactor and DOE sites in canisters suitable for transport to, and aging and disposal at, the repository. DOE also has announced its decision to ship most materials to the repository by rail, both nationally and within Nevada (more details can be found in Section S.2).

DOE used these current design and operational plans to develop information and data necessary to estimate potential environmental impacts for implementation of the Proposed Action in this *Draft 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* (Repository SEIS). New estimates of land disturbance, water demand, workforce requirements, equipment emissions, materials (concrete, steel, copper) required, and quantities of each waste type (solid waste, sanitary waste) generated have been developed and used in the analyses described herein. Potential health and safety impacts have been reanalyzed using population projections to the year 2067 (as opposed to 2035 in the Yucca Mountain FEIS).

DOE also has revised the inventory of spent nuclear fuel and high-level radioactive waste to reflect the primarily canistered approach, as well as the capabilities of the commercial sites to handle truck or rail casks. A more recent model, the Total System Model, was used to evaluate these data rather than the model used in the Yucca Mountain FEIS (CALVIN). The revised inventory is reflected in the number of shipments, by truck and train, to the repository, and in the potential radiological and nonradiological impacts to workers and the public from such shipments, and from materials handling and disposal at the repository.

As part of the reanalysis of the environmental impacts throughout this Repository SEIS, the Department updated many of the analytic tools or selected new tools to estimate potential impacts. Representative rail and truck routes and the size of the population affected by these routes were determined, in part, through use of WebTRAGIS, which has been updated since 2002 (other changes relevant to transportation are discussed in Sections S.2 and S.3.3).

Potential radiological impacts to workers and the public from atmospheric releases during normal operations are now based, in part, on CAP-88 rather than GENII. DOE now uses a computer model endorsed by the U.S. Environmental Protection Agency (EPA), AERMOD, rather than ISC-3 to estimate nonradiological air quality impacts to workers and the public.

Potential postclosure radiological impacts to the public were developed using an updated Total System Performance Assessment Model (TSPA-SEIS). TSPA-SEIS comprises a series of updated computational models that represent the inventory, and natural and engineered barriers and their interactions to produce

an estimate of a radiological dose to an individual (more details on the changes in the evaluation of postclosure performance are discussed in Section S.3.2).

This Repository SEIS also contains new analyses and updated information that result from comments received during the SEIS public scoping process. For example, DOE has included an evaluation of the potential environmental impacts that would result if (1) a higher percentage of the workforce would reside in Nye County than DOE had assumed in the Yucca Mountain FEIS, and (2) a lower percentage of commercial spent nuclear fuel were received at the repository in transportation, aging, and disposal canisters than the percentage DOE had used as a planning basis.

DOE is issuing this draft Repository SEIS now to give the public an opportunity to comment on the potential impacts associated with the repository design and operational plans that DOE intends to include in the application for construction authorization it will file with NRC. The NWPA directs that, if NRC authorizes DOE to construct a repository, it is to adopt, to the extent practicable, "[a]ny environmental impact statement prepared in connection with a repository proposed to be constructed by the Secretary ..."

S.1.3 COOPERATING AGENCY

Council on Environmental Quality regulations encourage agency cooperation early in the *National Environmental Policy Act* (NEPA) process and allow a lead agency to seek assistance from agencies that possess special expertise about issues considered in an EIS.

The Yucca Mountain site is located in Nye County, Nevada. County personnel have 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 county's current and planned infrastructure, including public services and traffic conditions.

Council on Environmental Quality regulations and guidance provide that agencies that accept the purpose of and need for agency action and the scope, definition, description, and analysis of it can participate as cooperating agencies in the development of the EIS. DOE invited Nye County to participate as a cooperating agency in the development of this Repository SEIS, and county personnel have contributed to it. This participation is consistent with the stated county policy of constructive engagement with DOE and with the objectives of the county's Community Protection Plan.

S.1.4 THE YUCCA MOUNTAIN SITE

The Yucca Mountain site is located in a remote area of the Mojave Desert in Nye County in southern Nevada, about 160 kilometers (100 miles) northwest of Las Vegas, Nevada (Figure S-2). DOE would build a repository inside Yucca Mountain that would consist primarily of an underground network of horizontal tunnels, called emplacement "drifts." The drifts would total about 66 kilometers (41 miles) in length and would be able to accommodate about 11,000 waste packages containing spent nuclear fuel and high-level radioactive waste. DOE would rely on the natural features of the site and on engineered barriers as a total system to help ensure the long-term isolation of the materials from the accessible environment (Figure S-3).

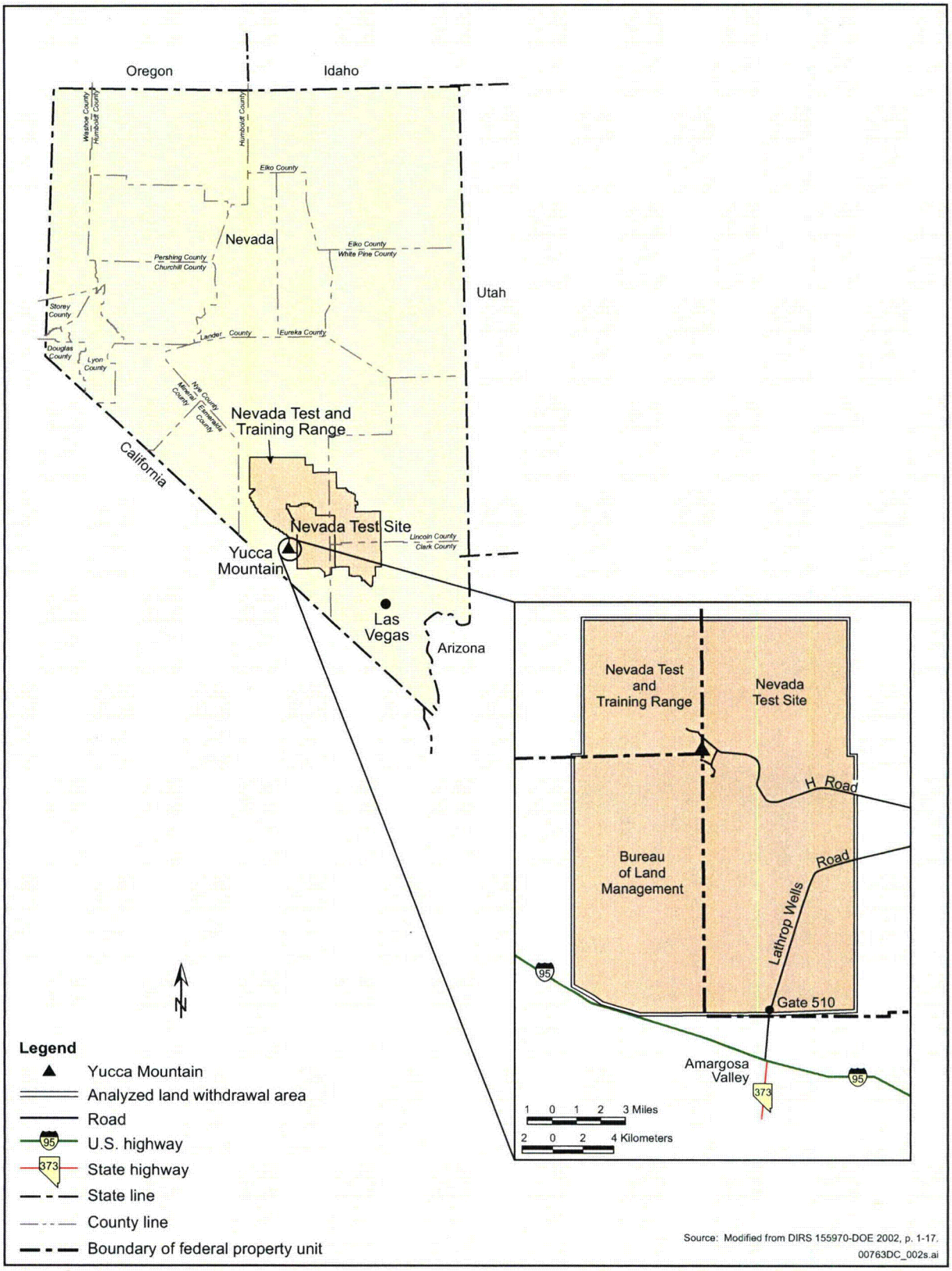


Figure S-2. Land withdrawal area used for analytical purposes.

Figure S-3. Components of the natural system.

The site has several characteristics that would limit potential long-term impacts from the disposal of spent nuclear fuel and high-level radioactive waste. It is isolated from concentrations of human population and human activity and is likely to remain so. It is on land controlled by the Federal Government. A repository at Yucca Mountain would benefit from the arid conditions at the site—an important consideration because limiting the amount of water that reached waste packages would limit their corrosion and delay mobilization and transport of radionuclides to the accessible environment. The Yucca Mountain region is one of the driest in the United States. Little water could move through the mountain, contact waste materials, and move down to the water table. Waste packages would sit about 300 meters (1,000 feet) below the surface of the mountain and about 300 meters (1,000 feet) above the water table, a location that would further isolate them from water. Groundwater beneath Yucca Mountain flows into a "closed" hydrogeologic basin from which it cannot flow to any river or ocean. This would prevent radionuclides from spreading to other areas.

To develop a repository at Yucca Mountain, DOE would have to obtain permanent control of about 600 square kilometers (230 square miles or 150,000 acres) currently under the control of DOE, the Department of Defense (U.S. Air Force), and the Department of the Interior (Bureau of Land Management). This would require congressional action. The repository would occupy a small portion of this area, most of which would serve as a buffer zone. Because Congress has not withdrawn this land, this Repository SEIS refers to it as the analyzed land withdrawal area.

S.2 Proposed Action

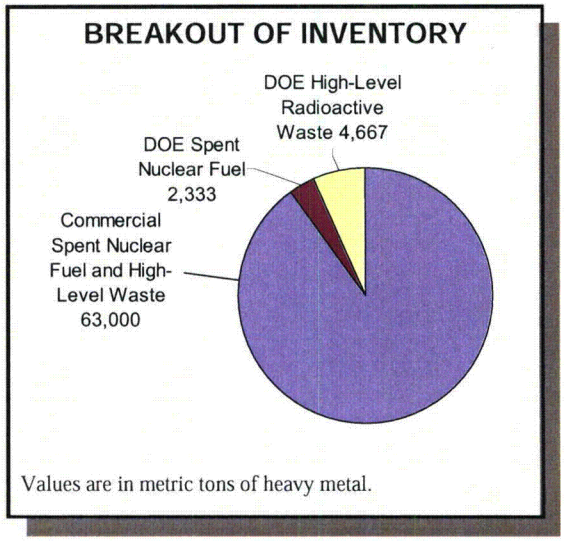
The Proposed Action analyzed in this Repository SEIS is for DOE to construct, operate, monitor, and eventually close a geologic repository at Yucca Mountain for the disposal of 70,000 metric tons of heavy metal (MTHM) of spent nuclear fuel and high-level radioactive waste. Under the Proposed Action, most spent nuclear fuel and high-level radioactive waste would be shipped from 72 commercial and 4 DOE sites to the repository on trains dedicated to these shipments. Naval spent nuclear fuel would be shipped on railcars in general freight service or on dedicated trains. The balance of the shipments would be made by truck. All materials would be shipped in NRC-certified transportation casks.

At the repository, spent nuclear fuel and high-level radioactive waste, sealed in waste packages, would be emplaced underground about 300 meters (1,000 feet) below the surface and about 300 meters (1,000 feet) above the water table. The natural features of the site and the engineered barriers would work together as a total system to help ensure the long-term isolation of the materials from the accessible environment. To prevent inadvertent intrusion by and exposures to members of the public, DOE would use active institutional controls such as controlled access, inspection, and maintenance through the end of the repository closure period, after which it would use monitoring and passive institutional controls such as markers.

NRC, through its licensing process, would regulate repository construction, operation, monitoring, and closure.

S.2.1 MATERIALS CONSIDERED FOR DISPOSAL

The NWPA limits how much spent nuclear fuel and high-level radioactive waste DOE could emplace in the first geologic repository to 70,000 MTHM until a second repository is in operation. The materials proposed to be disposed of under the Proposed Action would include about 63,000 MTHM of commercial spent nuclear fuel and high-level radioactive waste. The remaining 7,000 MTHM would consist of about 2,333 MTHM of DOE spent nuclear fuel (including naval spent nuclear fuel) and the equivalent of 4,667 MTHM of DOE high-level radioactive waste.



This inventory could include surplus weapons-usable plutonium, which DOE could immobilize and dispose of as part of the high-level radioactive waste inventory, or use to produce mixed uranium and plutonium oxide fuel (called "mixed-oxide fuel"). Utilities would use the fuel to generate electricity in commercial nuclear reactors, and DOE would later dispose of that fuel as commercial spent nuclear fuel.

S.2.2 DOE'S CURRENT APPROACH TO DISPOSAL

In the Yucca Mountain FEIS, DOE evaluated the receipt of commercial spent nuclear fuel under two packaging scenarios. These include the mostly canistered scenario, in which most commercial spent nuclear fuel would be received in dual-purpose (storage and transportation) 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 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 prior to loading it into waste packages for emplacement. In the 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.

Among recent developments in repository design and operational plans is DOE's adoption of an approach to managing commercial spent nuclear fuel that would rely on a single canister design for three functions: transportation, aging, and disposal (referred to as a TAD canister). Figure S-4 shows a schematic of a TAD canister. DOE would seek NRC certification of the TAD canister design for surface storage at commercial sites and for transportation. In its application for a construction authorization, DOE would seek NRC approval to use TAD canisters for spent nuclear fuel transfer, aging, and geologic disposal at the repository. TAD canisters would not substitute for waste packages. They would be placed in waste packages for disposal, as explained below, as would all other forms of waste.

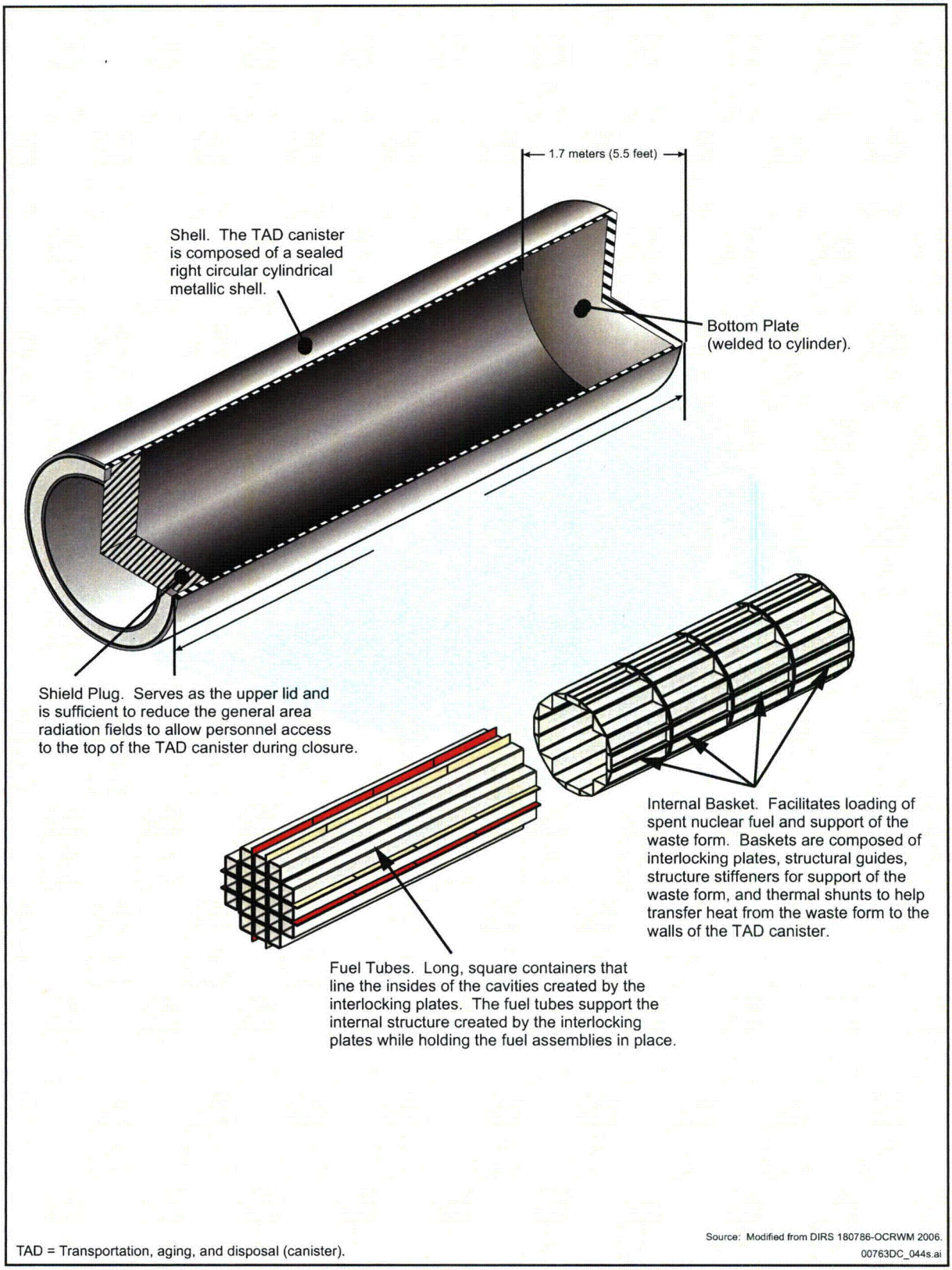


Figure S-4. TAD canister schematic (artist's concept).

At commercial reactor sites, most spent nuclear fuel (a goal of 90 percent) would be packaged in TAD canisters. Once sealed, the canisters would not have to be reopened. This would minimize the handling of individual spent fuel assemblies and limit the need for more complex repository surface facilities. Because the approach relies on practices familiar to the nuclear industry and NRC, it would simplify repository design, construction, and operation. At DOE sites, most materials destined for the repository would continue to be packaged in disposable canisters, as was the plan in the Yucca Mountain FEIS.

At the repository, some commercial spent nuclear fuel would be aged to reduce its thermal output, as part of a strategy to manage temperatures within and between emplacement drifts in order to divert water from them. Managing temperatures is important to DOE's strategy to always allow water to drain freely in the rock between the emplacement drifts. As part of this strategy, which would employ a "thermal energy density concept," DOE would place some TAD canisters into aging overpacks and place the overpacks on aging pads near the surface facilities. When heat output had declined to an appropriate level, the canisters would be placed directly into waste packages for disposal. Those TAD canisters not placed on aging pads would be placed into waste packages for disposal, as would all disposable canisters containing DOE spent nuclear fuel and high-level radioactive waste.

DEFINITIONS OF PRECLOSURE ANALYTICAL PERIODS

To evaluate the repository's potential environmental impacts through its final closure, this Repository SEIS analyzes the Proposed Action around four preclosure time periods—construction, operations, monitoring, and closure. Some activities would span more than one time period.

- **Construction: 5 years –** Begins upon DOE's receipt of construction authorization from NRC and ends with receipt of a license to receive and possess radiological materials. Activities include site preparation, surface construction, and subsurface development.
- **Operations: 50 years –** Begins upon receipt of a license to receive and possess radiological materials. Activities include receipt, handling, aging, emplacement, and monitoring of waste, as well as continued construction of surface and subsurface facilities.
- **Monitoring: 50 years** – Begins upon emplacement of the final waste package. Activities 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: 10 years –** Overlaps the last 10 years of the monitoring period and includes activities that begin upon receipt of a license amendment to close the repository. Activities 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.

S.2.3 REPOSITORY FACILITIES AND OPERATIONS

The handling and disposal of spent nuclear fuel and high-level radioactive waste at the repository would take place in the geologic repository operations area (Figure S-5). The surface portion of the 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 would include the facilities necessary for emplacement and disposal.

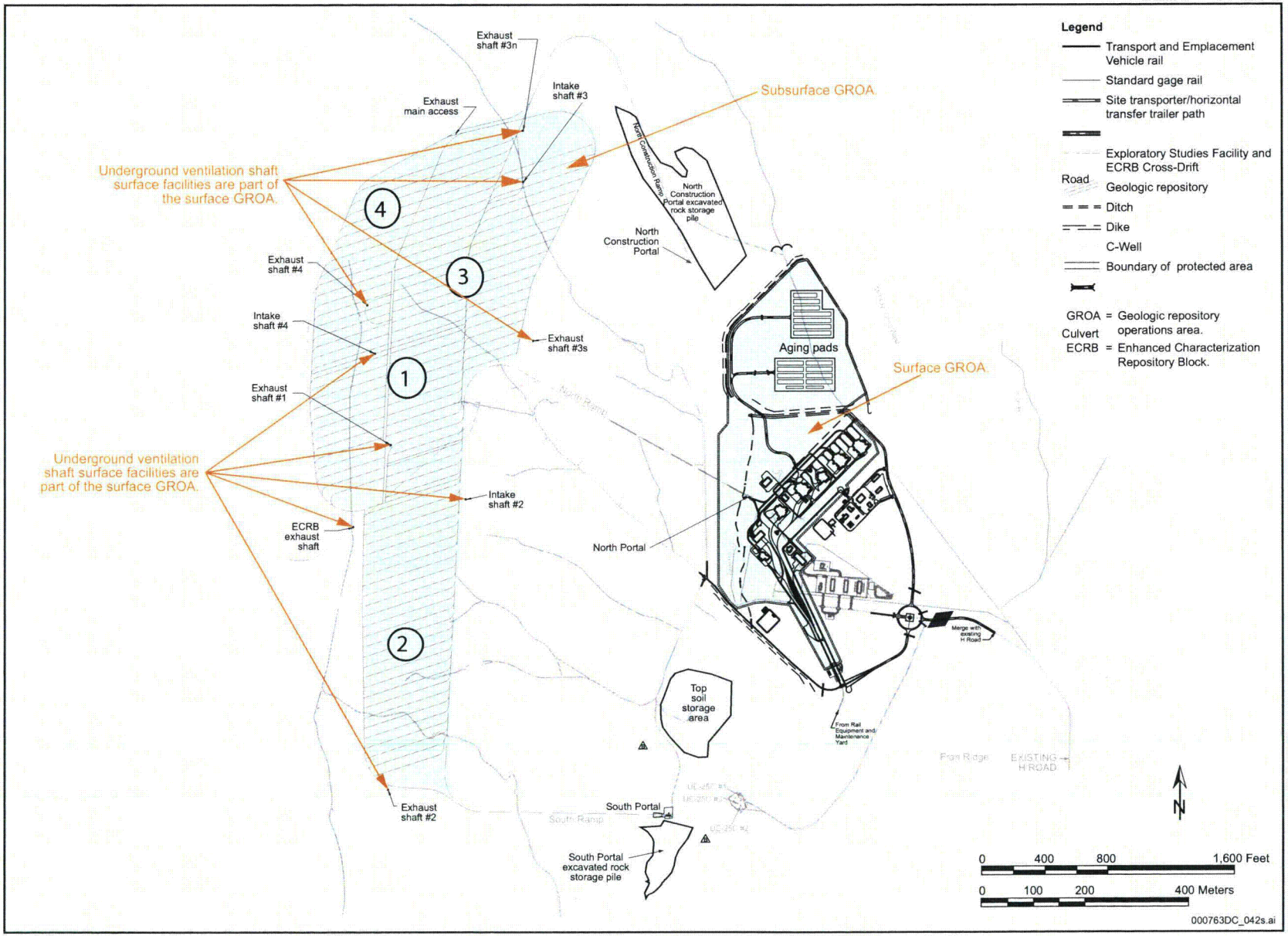


Figure S-5. Geologic repository operations area.

Figure S-6 shows how DOE would handle waste under current design and operational plans.

DOE organized its analyses of the potential impacts of the Proposed Action around preclosure (short-term) and postclosure (long-term) impacts, and it analyzed potential preclosure impacts for four time periods: repository construction, operations, monitoring, and closure.

S.2.3.1 Waste Handling Surface Facilities and Operations

The following types of surface facilities or areas would be used for waste handling: a Cask Receipt Security Station, an Initial Handling Facility, three Canister Receipt and Closure Facilities, a Wet Handling Facility, two aging pads, and a Receipt Facility.

PRIMARY FUNCTIONS OF WASTE PREPARATION AND HANDLING FACILITIES

Aging Pads: Provide the capability 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: Conduct 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 Pads.

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

Surface facilities would be constructed in phases. This would mean that, for several years, radiological operations would be occurring while construction of surface facilities continued. When surface construction was complete, full operational capability would be achieved. The site layout facilitates concurrent construction and operations in the geologic repository operations area.

The purpose of the waste preparation and handling facilities would be to ensure that commercial spent nuclear fuel received at the repository met waste package thermal limits, as explained below, and that all waste forms are packaged in sealed waste packages for emplacement. This would be accomplished as follows:

- Most commercial spent nuclear fuel would arrive in TAD canisters that had been loaded and sealed by the commercial nuclear utilities. Transportation casks that contained commercial spent nuclear fuel in TAD canisters that required aging, to reduce the fuel's heat output, would be unloaded in the Receipt Facility, or a Canister Receipt and Closure Facility. The TAD canisters would be transferred to aging overpacks and moved to the aging pads 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, where TAD canisters would be placed in waste packages for subsurface emplacement. TAD canisters that did not require aging would be sent directly to a Canister Receipt and Closure Facility for packaging in a waste package.

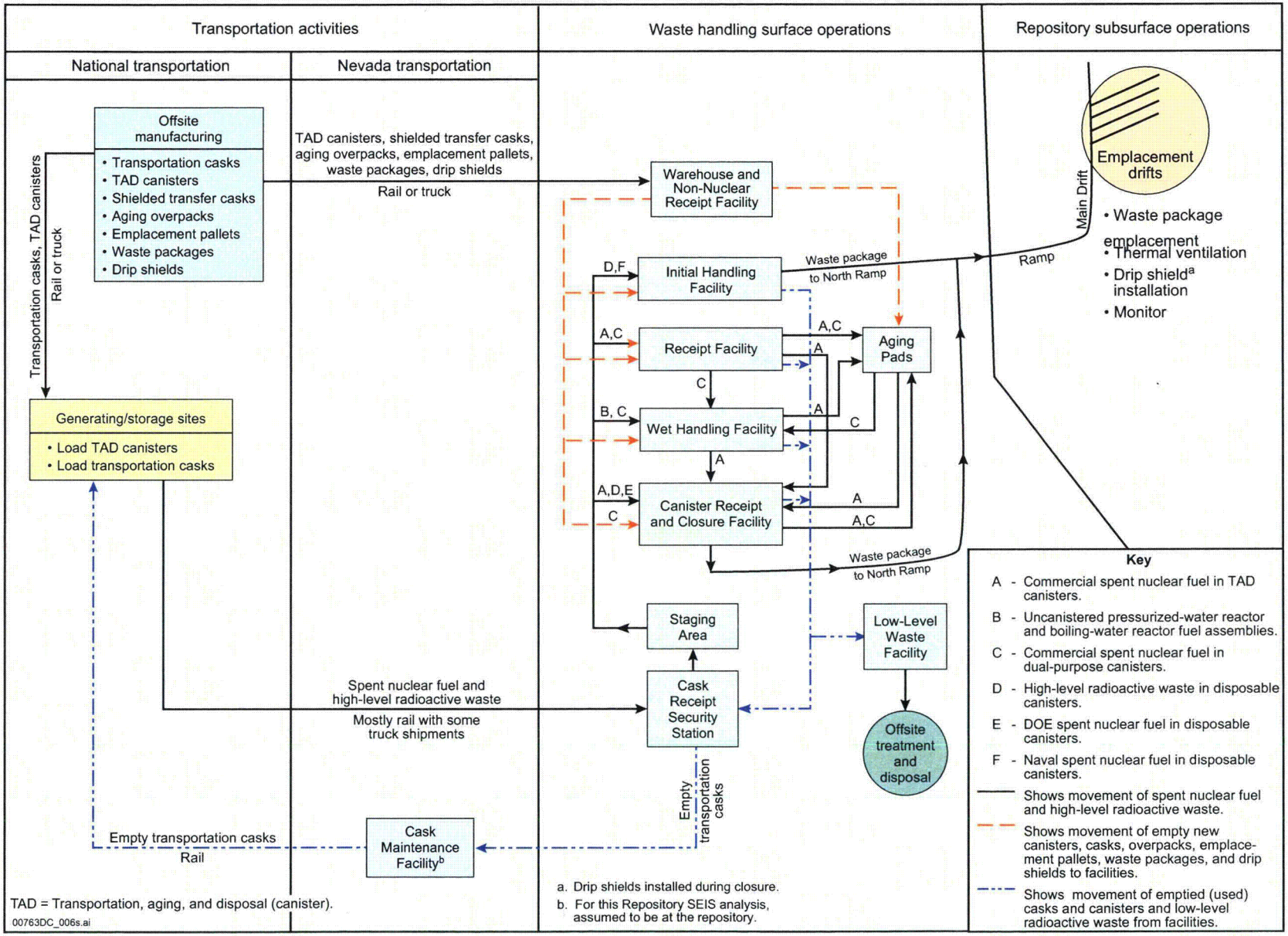


Figure S-6. Overview flowchart for typical operations of the Proposed Action.

- A small fraction of commercial spent nuclear fuel could arrive in transportation casks as uncanistered spent nuclear fuel assemblies. DOE would move these transportation casks to the Wet Handling Facility, where the fuel would be transferred to TAD canisters and subsequently managed as described above.

- Some commercial spent nuclear fuel could arrive in sealed dual-purpose canisters inside transportation casks. These canisters would be unloaded at the Receipt Facility and either be transferred to the aging pads in overpacks or transferred to the Wet Handling Facility, where they would be opened and the fuel would be transferred to TAD canisters.

- High-level radioactive waste, naval spent nuclear fuel, and DOE spent nuclear fuel would arrive at the repository in disposable canisters, inside transportation casks. Different waste types would be segregated and placed in appropriate waste packages. Casks containing naval spent nuclear fuel canisters would be unloaded in the Initial Handling Facility, where the canisters would be placed in waste packages. Casks containing DOE spent nuclear fuel would be sent directly to a Canister Receipt and Closure Facility, where the contents would be unloaded and transferred to waste packages. Casks containing high-level radioactive waste would be unloaded at either the Initial Handling Facility or a Canister Receipt and Closure Facility. High-level radioactive waste would be co-disposed with DOE spent nuclear fuel canisters. However, a naval spent nuclear fuel canister would be placed in a waste package by itself.

DOE would conduct waste transfer operations in these facilities using mostly remotely operated equipment. Thick, reinforced concrete shield walls, shielded canister transfer, and controlled access techniques would protect workers from radiation exposure. DOE would use a site transportation network to move transportation casks and waste packages between the waste handling facilities and eventually to the subsurface facility.

S.2.3.2 Subsurface Facilities and Operations

Once the various types of wastes received at the repository were sealed in waste packages, the waste packages would be transferred to the subsurface portion of the geologic repository operations area.

The subsurface facilities would consist of a main drift that would provide access to smaller, dedicated drifts into which the waste would be placed. Emplacement drifts would be excavated horizontally in a series of four emplacement panels that would be developed and made operational over a period of years coinciding with the schedule for receipt of waste (Figure S-5).

Under the current repository design, the area required to accommodate 70,000 MTHM totals about 6 square kilometers (1,500 acres), with approximately 66 kilometers (41 miles) of emplacement drifts. About 11,000 waste packages and their emplacement pallets would be placed in these drifts. DOE would use tunnel boring machines to excavate the drifts.

The waste package and emplacement pallet are two of the engineered barriers that would contribute to waste containment and isolation. Waste packages would be supported on emplacement pallets and aligned end-to-end on the drift floor. Figure S-7 shows emplacement pallets loaded with waste packages in an emplacement drift. The waste packages would consist of two concentric cylinders. The inner cylinder would be made of Stainless Steel Type 316, and the outer cylinder would be made of

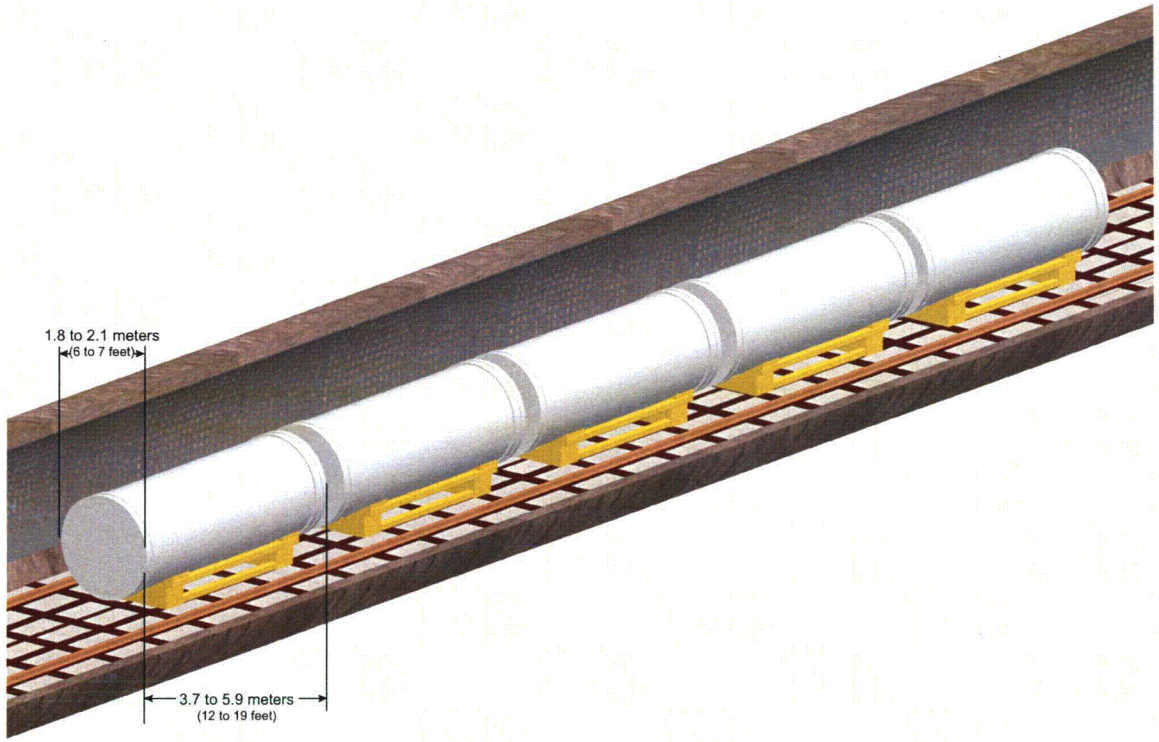


Figure S-7. Emplacement pallets loaded with waste packages in an emplacement drift (artist's concept).

corrosion-resistant, nickel-based Alloy 22. Emplacement pallets would be fabricated from Alloy 22 plates and stainless steel. The current waste package design differs only in minor ways from that in the Yucca Mountain FEIS.

DEFINITIONS OF PACKAGING TERMS

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

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 in a waste package. There are a number of types of disposable canisters, including standard canisters, multicanister overpacks, 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, open them, remove the spent nuclear fuel assemblies, and place them in a TAD canister, which would be placed 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 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, which would be placed in a waste package or site aging overpack.

Shielded transfer cask: A metal vessel used to transfer canisters between waste handling facilities.

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 in a TAD canister at the commercial reactor. At the repository, DOE would remove the TAD canister from the transportation cask and place it in 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 regulatory requirements for transport of spent nuclear fuel or high-level radioactive waste via public transportation routes.

Waste package: A container that would consist of a corrosion-resistant outer container (an Alloy 22 outer cylinder and a stainless-steel inner cylinder), the waste form, and any internal containers (such as TAD canisters), spacing structure or baskets, and shielding integral to the container. Waste packages would be ready for emplacement in the repository when the outer lids were welded shut and the welds were verified to be complete.

In addition to being radioactive, spent nuclear fuel and high-level radioactive waste give off heat from radioactive decay. This is referred to as thermal energy or thermal output. When placed in a confined space, such as an emplacement drift, where heat cannot readily dissipate, these materials would heat the surrounding area. In a repository, 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° Celsius (205° Fahrenheit). 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 are below boiling. There, steam would condense back to water.

To provide a path that diverts the mobilized liquid water downward past the emplacement drifts, away from the waste packages, DOE has designed the repository to include regions between the drifts (the midpillar region) that would remain 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 that would keep the temperature in the midpillar region below the boiling point of water, as shown in Figure S-8.

The evaluation of whether a waste package is too thermally hot for emplacement would employ 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 already emplaced in specific drifts in the repository and the thermal characteristics of waste packages available for emplacement, DOE can select those appropriate for emplacement. DOE would make the selections based on calculations of how the added thermal energy of the additional waste packages would affect the goal of maintaining the temperature of the midpillar region below the boiling point of water.

Managing an upper limit to the thermal energy density for emplacement thus would rely on selecting or blending waste packages with specific thermal characteristics. DOE would have flexibility in selecting specific waste packages for emplacement. If a waste package were too thermally hot for emplacement at the time it was received, DOE would use the aging pads to allow the thermal heat to reduce naturally through radioactive decay.

After emplacement was complete, the drifts would remain open and ventilated for a nominal period of 50 years, so ventilation would remove much of the heat and humidity from the drifts. After DOE closed and sealed the subsurface facility, the rock around the emplacement drifts would dry, further minimizing, for hundreds of years, the amount of water that could come into contact with the waste packages. A portion of the rock between the drifts would remain at temperatures below boiling, which would continue to promote drainage of water through the portions of the rock between the drifts rather than into the drifts themselves.

S.2.4 TRANSPORTATION

The Yucca Mountain FEIS considered the potential environmental impacts of transporting spent nuclear fuel and high-level radioactive waste from commercial and DOE sites by two principal modes—mostly truck and mostly rail. Since the FEIS was completed, the Department has decided to transport most spent nuclear fuel and high-level radioactive waste by rail both nationally and in Nevada. This Repository SEIS updates transportation analyses to reflect the mostly rail scenario.

DOE cannot use rail transport exclusively because some commercial nuclear generating sites do not have the ability to load large-capacity rail shipping casks. Those sites would use overweight trucks to ship material to the repository. Commercial sites that could load the rail shipping casks but lacked rail access could use heavy-haul trucks or barges to ship spent nuclear fuel to the nearest rail line. Figure S-9 shows the commercial and DOE sites and Yucca Mountain in relation to the railroad system over which the railcars could travel.

Because no rail service currently extends to the Yucca Mountain site, DOE would have to build a railroad linking the site to the terminus of an existing rail line in Nevada. As explained in the Foreword, to evaluate the potential impacts of constructing and operating a railroad in Nevada, DOE has prepared a Rail Alignment EIS that has been published coincident with this Repository SEIS. The Rail Alignment

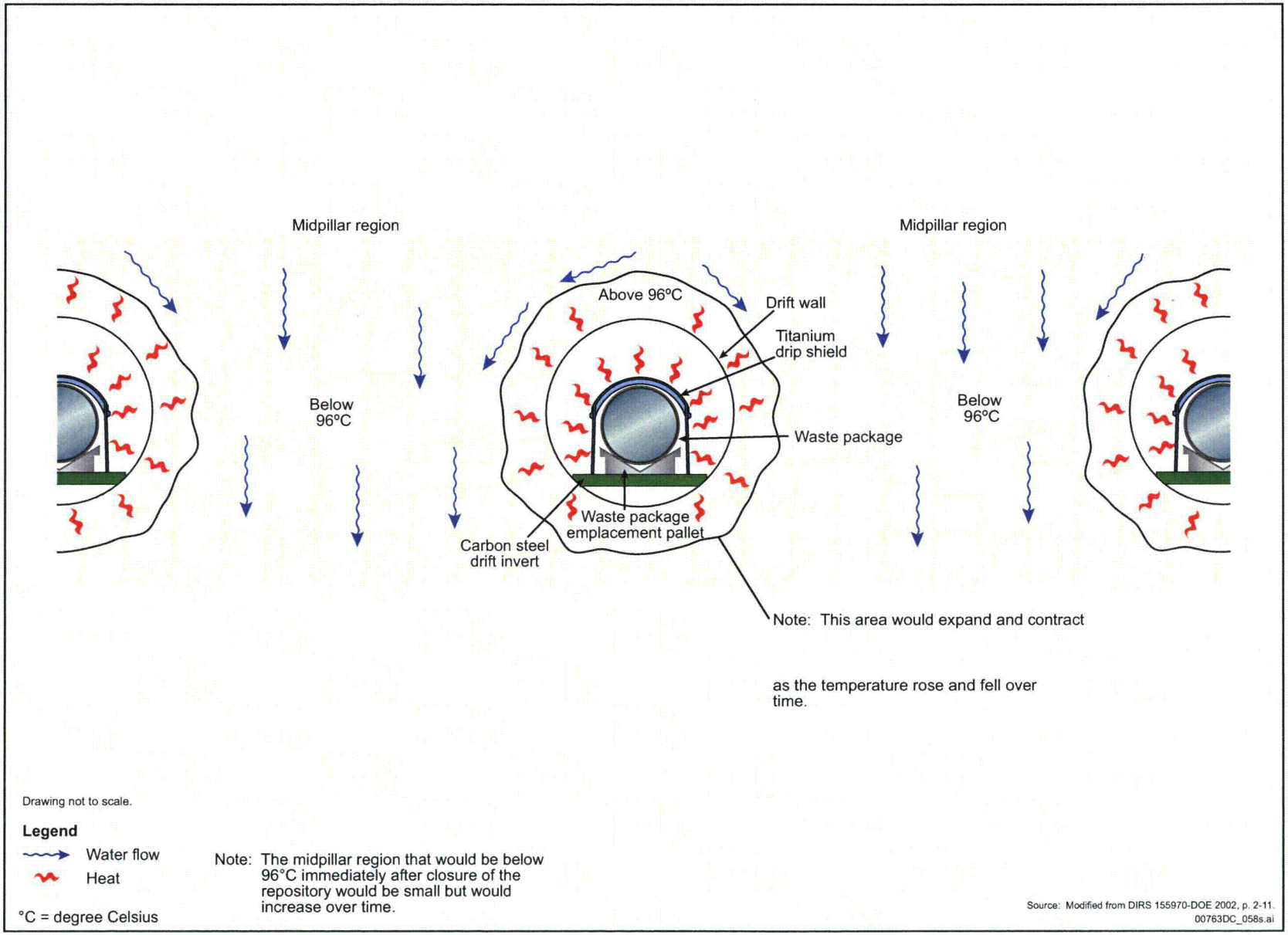


Figure S-8. Management of waste package emplacement using thermal energy density (artist's concept).

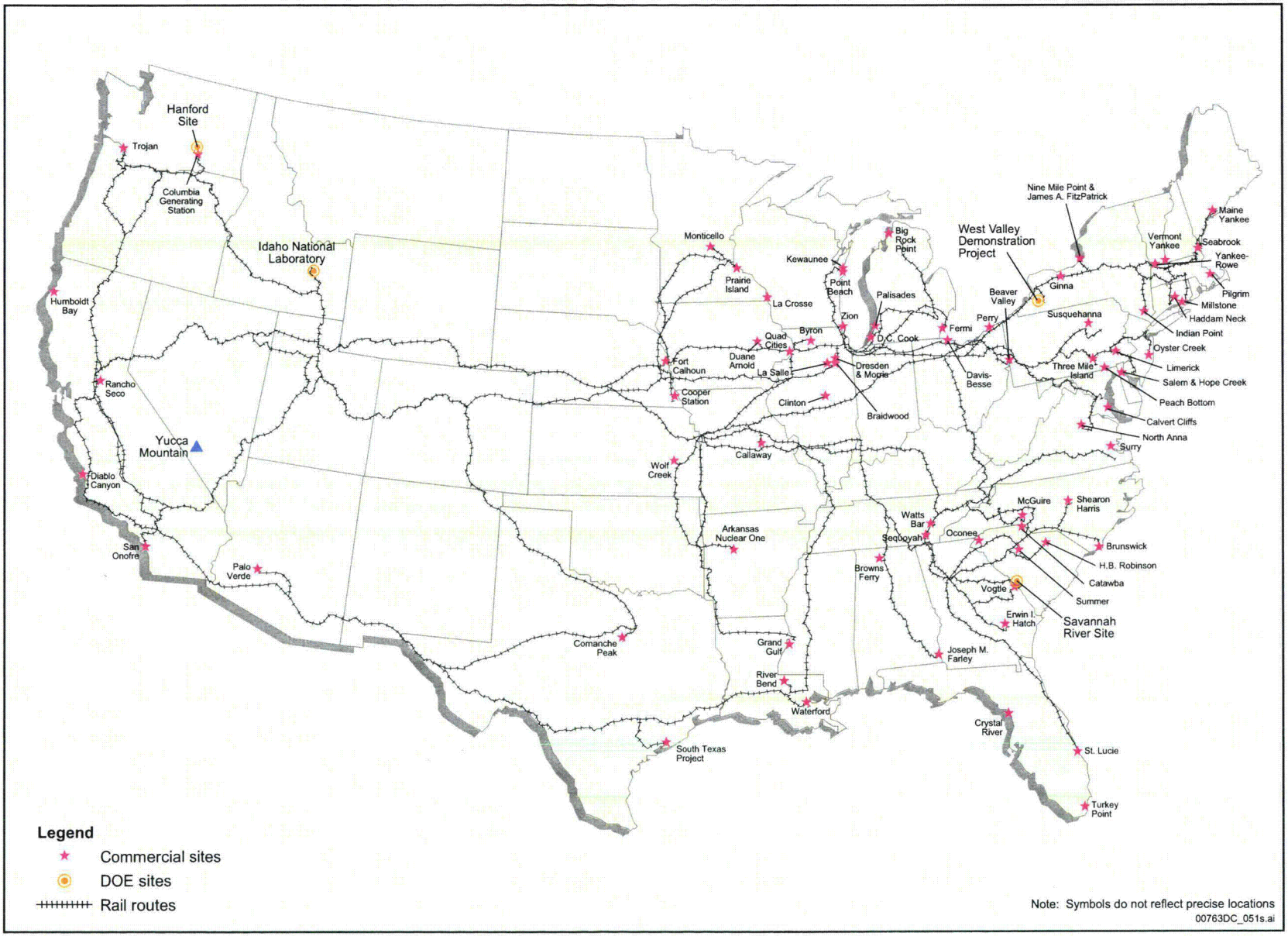


Figure S-9. Representative national rail routes considered in the analysis for this Repository SEIS.

EIS analyzes the potential impacts of constructing and operating a railroad along specific alignments in the Caliente and Mina corridors. Under the Proposed Action, DOE would determine a rail alignment in which to construct and operate a railroad for shipments of spent nuclear fuel, high-level radioactive waste, and other materials from an existing rail line in Nevada to a geologic repository at Yucca Mountain. The railroad would approach Yucca Mountain from east of U.S. Highway 95, trending generally southeast for 40 kilometers (25 miles) from Oasis Valley to Beatty Wash. It would then turn north at the southern end of Busted Butte, running west of Fran Ridge and then trending generally north for an additional 11 kilometers (7 miles) until terminating at the Rail Equipment Maintenance Yard inside the Yucca Mountain Site boundary and about 1.6 kilometers (1 mile) south of the southern boundary of the geologic repository operations area (Figure S-10). The geologic repository operations area interface would consist of a double-track spur for delivery of casks and supplies to the surface geologic repository operations area.

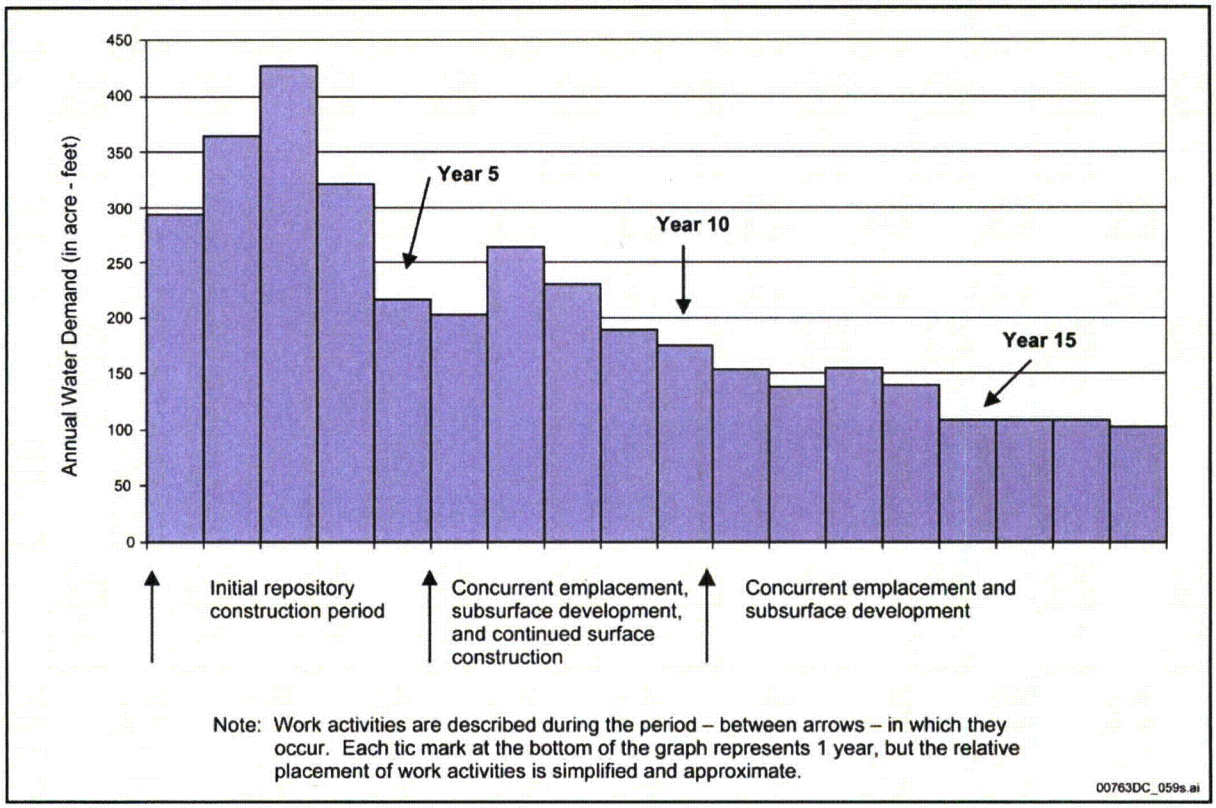


Figure S-10. Annual water demand during the repository construction period and the initial phases of operations.

The Department identifies the Caliente Implementing Alternative as its preferred alternative, and identifies its preferred rail alignment segments starting in Caliente and ending at Yucca Mountain. The Department also indicates that it prefers the Shared Use option, that is, DOE would make its rail line available to commercial shippers for shipments of general freight.

The Rail Alignment EIS also includes a No Action Alternative under which DOE would not determine an alignment or construct and operate a railroad within the Caliente or Mina rail corridors. As a general

matter, the Repository SEIS summarizes and incorporates by reference information in the Rail Alignment EIS, as appropriate.

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

- Rail shipments would be made on dedicated trains. (This policy would not apply to shipments of naval spent nuclear fuel.)
- Armed security escorts would accompany all shipments.
- Trucks carrying transportation casks could be overweight rather than legal weight. Overweight trucks would be subject to permitting requirements in each state through which they traveled.

The Yucca Mountain FEIS analyzed the shipment of about 9,600 rail casks and 1,100 truck casks under the mostly rail shipping scenario. This Repository SEIS analyzes the shipment of about 9,500 rail casks and 2,700 truck casks of spent nuclear fuel and high-level radioactive waste. The increased number of truck shipments in the Repository SEIS is primarily due to the revised information on the cask handling capabilities at commercial reactor sites. The FEIS assumed that the reactor sites that did not currently have the ability to load large rail casks would modify their facilities to obtain that ability. This SEIS does not make that assumption.

S.3 Potential Environmental Impacts of the Proposed Action

The Repository SEIS analysis of potential impacts of the Proposed Action summarizes, incorporates by reference, and updates corresponding sections of the Yucca Mountain FEIS, as appropriate. The SEIS explains where and why DOE has modified its analytic approach or assumptions and where it has updated information.

To assess potential impacts, DOE assessed baseline conditions that the current repository design and operational plans for a repository could affect. DOE organized its assessment around 12 resource areas that include features of the natural environment and matters of social, cultural, and economic concern. For each resource area, DOE defines a region of influence in which impacts could occur as a geographic area that bounds the environmental, social, cultural, and economic features of interest. Regions vary considerably because the natures of the resources vary.

DOE uses these time frames to assess impacts:

- *Preclosure* or *short-term impacts* would encompass construction, operation, monitoring, and closure.
- *Postclosure* or *long-term impacts* would occur after closure was complete. This Repository SEIS analyzes health effects for two periods: the period during the first 10,000 years after closure and the period from 10,000 years after closure to one million years after closure (the post-10,000-year period).

DOE has characterized potential impacts as *direct* or *indirect*, and has quantified them where possible. Otherwise, it 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.

The potential impacts reported in this Repository SEIS are likely to be higher than the actual impacts for several reasons. For example, DOE did not take into consideration best management practices for dust suppression in the analyses for air quality, and did not take credit for proven remediation and reclamation techniques in the disturbed land analysis. Likewise, in the estimation of potential health effects in the preclosure period, DOE did not apply administrative restrictions for limiting radiological exposure in calculating potential doses to the hypothetical maximally exposed worker, who would handle spent nuclear fuel at the repository surface for an entire working lifetime of up to 50 years. Further, DOE assumed that the hypothetical maximally exposed member of the public would reside continuously for 70 years at the site boundary in the prevailing downwind direction. In the postclosure period, DOE assumed that the reasonably maximally exposed individual (who is a hypothetical individual with characteristics defined by 40 CFR Part 197) lives above the highest concentration of radionuclides in the plume of contamination and drinks 2 liters (0.5 gallon) of water per day drawn from contaminated groundwater.

S.3.1 POTENTIAL PRECLOSURE IMPACTS OF THE REPOSITORY

S.3.1.1 Land Use and Ownership

To develop a repository at Yucca Mountain, DOE would have to obtain permanent control of approximately 600 square kilometers (150,000 acres) of land now managed by the Bureau of Land Management, U.S. Air Force (Nevada Test and Training Range), and DOE (Nevada Test Site). This would require congressional action. If Congress authorized and directed the withdrawal of lands for the proposed repository, any other use of the land would be subject to conditions of the withdrawal. Because the land has not yet been withdrawn, in this Repository SEIS it is referred to as the analyzed land withdrawal area.

To analyze impacts on land use and ownership, DOE defined the region of influence as the analyzed land withdrawal area (Figure S-2) and an area to the south that DOE proposes to use for offsite facilities and a new access road from U.S. Highway 95 to the Yucca Mountain site.

The Bureau of Land Management now administers approximately 180 square kilometers (44,000 acres) of the analyzed land withdrawal area. With the exception of about 17.4 square kilometers (4,300 acres) near the site of the proposed repository and an existing patented mining claim on private land, these lands are available for public uses such as mineral exploration and recreation. Congress granted these rights under various federal laws, such as the *Federal Land Policy and Management Act of 1976.* The Bureau would evaluate and adjudicate the validity of all mining claims on the portion of the land withdrawal area that was under its control before the permanent legislative withdrawal.

To construct, operate, and monitor a repository, DOE would disturb or clear a total of approximately 9 square kilometers (2,200 acres) of land, inside and outside the analyzed land withdrawal area. Overall,

impacts on land use would be small. During repository closure, DOE would restore disturbed areas that were no longer needed to their approximate condition before construction.

S.3.1.2 Air Quality

DOE analyzed potential impacts to the public from releases of nonradiological air pollutants. Air pollutants were assessed against the EPA National Ambient Air Quality Standards, which define permissible average and maximum concentration levels of pollutants for periods ranging from 1 hour to a year. DOE evaluated impacts for maximally exposed individuals at the nearest points of unrestricted public access outside the analyzed land withdrawal area. Its analysis examined five criteria pollutants—carbon monoxide, nitrogen dioxide, sulfur dioxide, ozone, and particulate matter (PM), for which EPA defines two particle sizes: $PM_{2.5}$, which has an aerodynamic diameter of 2.5 micrometers (about 0.0001 inch) or less in diameter, and PM_{10}, which has an aerodynamic diameter of 10 micrometers (about 0.0004 inch) or less in diameter. (DOE did not analyze the sixth criteria pollutant, lead, because repository-related activities would not emit airborne lead.) Fugitive dust from land disturbances contains PM_{10}. DOE would use common dust suppression measures to reduce releases, but did not take credit for these actions in the analyses.

DOE also analyzed potential impacts of cristobalite, a form of silica dust that causes silicosis and might be carcinogenic. Cristobalite would be emitted during subsurface excavation in fugitive dust. The highest level that would reach a member of the public would be only 0.5 percent of the benchmark DOE used in its analysis.

In all cases, the highest concentrations of criteria pollutants except PM_{10} would be less than 3 percent of applicable standards. The highest concentrations of PM_{10} from activities in the analyzed land withdrawal area would be 40 percent of the 24-hour regulatory limit during construction. Most air quality impacts would result from construction.

S.3.1.3 Hydrology

This Repository SEIS identifies and evaluates potential surface- and groundwater impacts separately, as the Yucca Mountain FEIS did. The regions of influence and criteria for evaluating impacts are the same as those in the FEIS.

S.3.1.3.1 *Surface Water*

The region of influence includes construction and operations sites susceptible to erosion, areas that could be affected by permanent changes in water flow near these sites, and downstream areas that could be affected by eroded soil or spills of contaminants. There are no perennial streams or other permanent surface-water bodies in the region of influence, and precipitation and runoff are seldom sufficient to generate flowing water in drainage channels.

During all project phases, the potential for uncontrolled or contaminated discharges to the surface would be small. DOE would store water in tanks and would pipe sanitary sewage to septic tanks and leach fields. Water used for other purposes would be collected after use and pumped to lined evaporation ponds. Water used for dust suppression would not produce runoff or infiltration. DOE would manage water contaminated with radionuclides as low-level radioactive waste. Throughout the project, DOE would manage potential contaminants in compliance with regulatory requirements and its *Spill*

Prevention, Control, and Countermeasures Plan for Site Activities, and would monitor to detect contaminants.

Repository-related activities would disturb as much as 9 square kilometers (2,300 acres) of land. Because DOE would compact many surface areas or cover them with impermeable materials, infiltration rates would generally decline and surface-water runoff would increase. The increased runoff that reached drainage channels would be small and have negligible impacts, primarily because storm water detention ponds would be integral to repository design. Moreover, the total land disturbed would constitute only around 1 percent of the natural drainage area in which it would lie, and the drainage channels are so remote that minor changes in runoff could not affect downstream facilities.

S.3.1.3.2 *Groundwater*

A supply of groundwater would be essential to repository construction and operation. DOE would use most of the water to compact surface soil and suppress dust and for subsurface development. The region of influence for groundwater includes aquifers from which DOE could obtain water and the downstream aquifers that DOE's use of water could affect. The Yucca Mountain FEIS summarized DOE's efforts to obtain water rights from the State of Nevada to meet projected water needs. DOE is currently engaged in litigation with the State of Nevada with regard to these water rights.

DOE would track the volume of water it pumped to the subsurface for dust suppression and tunnel boring, and would collect the excess water and remove it. Water pumped to the subsurface probably would have little effect on aquifer recharge. No additional land disturbance would occur during monitoring and maintenance or closure, so further effects on infiltration rates would be unlikely. Soil reclamation and revegetation would accelerate a return to more natural infiltration conditions. Overall, repository construction and operations would result in minor changes to runoff and infiltration rates.

DOE would pump groundwater from wells in the Jackass Flats hydrographic area. Groundwater from that area flows into Amargosa Desert aquifers. Because those aquifers meet most of the regional water demand, the potential effects of DOE groundwater use on this downgradient use is of particular concern.

Figure S-10 shows that water demand for the Proposed Action would peak during initial construction. The Nevada Test Site would require groundwater from Jackass Flats wells during the same period; for the peak demand years, the estimated additional demand from the Test Site would be 83,000 cubic meters (67 acre-feet). Figure S-11 does not show the Test Site use, but DOE analyzed the combined impacts and concluded in this Repository SEIS that they would not noticeably affect nearby groundwater users.

Perennial yield is the estimated quantity of groundwater that can be withdrawn annually from a basin without depleting its aquifers. The State of Nevada uses estimates of perennial yield as one of several tools in evaluating requests for groundwater appropriations. DOE's analysis focused on the following hydrographic areas:

- Jackass Flats. Estimates of perennial yield in groundwater studies and the Nevada State Engineer's rulings range from 1.1 million to 4.9 million cubic meters (880 to 4,000 acre-feet), depending on assumptions about aquifer flow characteristics. In a conservative scenario, DOE's water demand is compared to the lowest estimate of perennial yield. This low estimate can be further reduced by attributing 720,000 cubic meters (580 acre-feet) to the western two-thirds of this hydrographic area

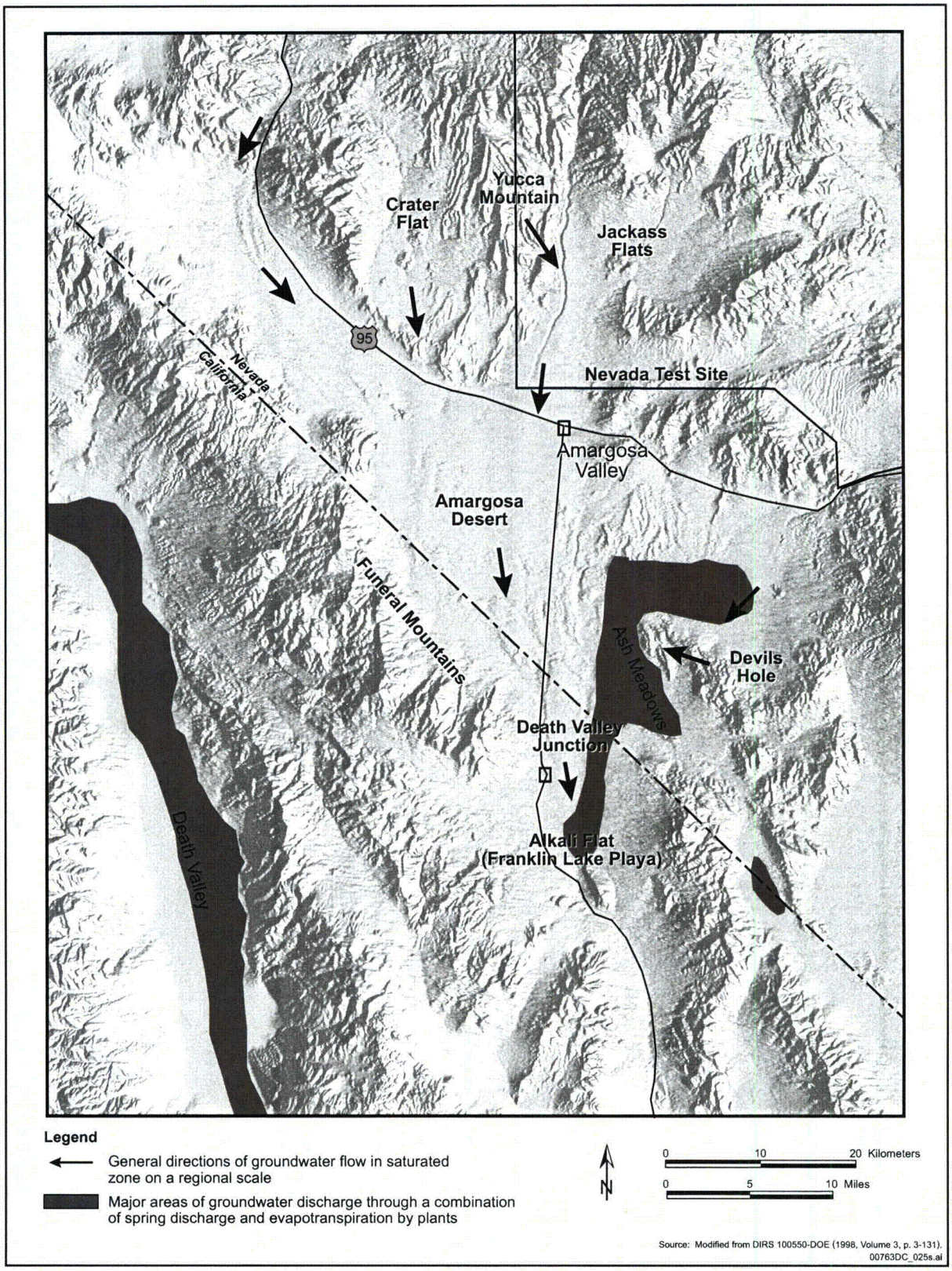


Figure S-11. Map of the saturated groundwater flow system.

where DOE's wells are located. Peak annual demand would be below the lowest estimates of perennial yield. Adding annual demand for the Nevada Test Site activities in the same hydrographic area would still result in groundwater withdrawals below the lowest estimate, and it represents only 13 percent of the highest estimate. If demand exceeded local recharge for a few years (longer durations would be unlikely), general flow patterns in the area could shift, but only slightly.

- Amargosa Desert. While water demand would decrease the availability of water in this downgradient area, the combined peak annual demand for the Proposed Action and the Nevada Test Site would be only about 4 percent of the average annual water pumped in the Amargosa Desert from 2000 to 2004, and an even smaller fraction of the estimated perennial yield for the Amargosa Desert. In recent years, groundwater in the Amargosa Desert has been over-appropriated compared to many estimates of perennial yield, but the amount actually withdrawn each year has averaged only about half of the total appropriations.

The Yucca Mountain FEIS described modeling that estimated how DOE's water demand would affect groundwater elevations and flow patterns. DOE's current projections of annual demand peaks for only 1 year at the long-term withdrawal rate assumed by those models, so their predicted results remain very conservative. Water demand for the Proposed Action and Nevada Test Site activities in Jackass Flats together would have, at most, small impacts on the availability of groundwater in the Amargosa Desert area compared with the quantities already being withdrawn there.

S.3.1.4 Biological Resources and Soils

S.3.1.4.1 *Biological Resources*

Biological resources include species that are typical of the Mojave and Great Basin deserts and generally common throughout those areas. DOE evaluated the potential for impacts to sensitive, threatened, or endangered species and their habitats. DOE also considered potential impacts to the migratory patterns and populations of game animals. Overall impacts would be small. The removal of vegetation from the area required for the repository and the small impacts to some wildlife species from disturbance or loss of individuals would not affect regional biodiversity and ecosystem function.

Impacts to vegetation from repository construction would occur as a result of direct disturbance. Repository-related activities have disturbed approximately 2.5 square kilometers (620 acres) and would disturb as much as 6.5 more square kilometers (1,600 acres). Construction could induce further colonization by invasive plant species already present, which could suppress native species and increase the fire-fuel load. However, because the vegetated area that would be disturbed is relatively small, and because DOE would reclaim areas no longer in use, impacts would be small.

Direct impacts to wildlife would occur through loss of habitat from construction; deaths of individuals of some species, particularly burrowing species of small mammals and reptiles, and deaths of individuals hit by vehicles; fragmentation of undisturbed habitat that created a barrier to wildlife movement; and displacement of wildlife because of noise and activity. Impacts would be small for many reasons. Habitats similar to those at Yucca Mountain are widespread locally and regionally. The animal species of concern are generally widespread in the region, and the impact of individual deaths on regional populations or biodiversity would be small. Large areas of undisturbed and unfragmented habitat would

remain available. Impacts from noise and vibration would decline with distance, and some species would acclimate to the noise. No species would be threatened with extinction locally or regionally.

The Mojave population of the desert tortoise is listed as threatened under the *Endangered Species Act*. Construction would result in the loss of a small portion of tortoise habitat in an area where tortoise density is already low. DOE has had success relocating tortoises and their nests to safer terrain. Based on past experience, DOE estimates that the number of tortoises killed by vehicles and construction would be small and would not affect the species' long-term survival locally or regionally. As required by the *Endangered Species Act*, DOE has consulted with the U.S. Fish and Wildlife Service to ensure that the project's effects on the desert tortoise are minimized. This consultation would continue.

S.3.1.4.2 *Soils*

During construction, disturbing the land would make soil more susceptible to wind and water erosion. Because natural succession is slow on disturbed dry, semiarid lands, recovery would require reclamation. Continuing its current reclamation program, DOE would stockpile for use in reclamation the topsoil it removed during excavation. It would use fugitive dust control measures to protect the stockpile from wind erosion. Minimizing the extent of areas disturbed and using engineering practices to stabilize them would minimize erosion. During closure, DOE would revegetate as practicable areas it had not already reclaimed to reduce the loss of the most critical types of topsoil. Based on past experience DOE expects little erosion during any project phase.

Spills or releases of contaminants could occur, but DOE's continued implementation of its *Spill Prevention, Control, and Countermeasures Plan for Site Activities* would prevent, control, and remediate soil contamination. DOE would train workers to manage hazardous materials. Fueling operations and storage of hazardous materials and other chemicals would take place in bermed areas away from floodplains.

S.3.1.5 Cultural Resources

Cultural resources are nonrenewable, and the values they represent could be diminished by physical disturbance. This Repository SEIS evaluates the potential for damage or modification to the character of archaeological and historic sites and other cultural resources, with particular emphasis on those important to sustaining and preserving American Indian cultures. Overall, impacts to cultural resources would be small.

Direct impacts could result from ground disturbances and activities that would destroy or modify the integrity of archaeological or cultural resource sites. Indirect impacts could result from activities that increased the potential for intentional or unintentional adverse impacts, for example, illicit collection or inadvertent destruction. Although some indirect impacts could occur, the repository project's overall long-term effect would be beneficial because limits on access to and uses of the analyzed land withdrawal area would protect cultural resources from most human intrusion.

Because DOE would strive to avoid archaeological resources and would mitigate impacts to them, direct adverse impacts would be small. While easier physical access to the land withdrawal area could result in unauthorized excavation and collection of artifacts, DOE would mitigate such indirect impacts by training workers, monitoring archaeological sites, and establishing long-term management of the sites.

DOE, the Advisory Council on Historic Preservation, and the Nevada State Historic Preservation Officer have prepared a programmatic agreement to manage cultural resources during characterization of the Yucca Mountain site. The agreement is undergoing revision as part of negotiations with the State Historic Preservation Office. DOE will continue to work under the current agreement until a new one is in place.

S.3.1.5.1 *American Indian Viewpoint*

The Yucca Mountain FEIS summarized the American Indian view of resource management and preservation. Holistic in its concept of cultural resources, that view integrates elements of the natural and physical environment into a unified value system. To enhance the protection of archaeological sites and cultural items important to American Indians, DOE would maintain its commitment to its Native American Interaction Program throughout the implementation of the Proposed Action.

Because American Indians regard Yucca Mountain as integral to a valued cultural landscape, they consider the repository program to be intrusive and to constitute an adverse impact. Meetings with the Consolidated Group of Tribes and Organizations held since the completion of the Yucca Mountain FEIS indicate that this viewpoint has not changed.

S.3.1.6 Socioeconomics

DOE evaluated how the Proposed Action could affect employment, population, economic measures (real personal disposable income, spending by state and local governments, and Gross Regional Product), housing, and some public services. The operations period would result in the highest impacts to employment, population, Gross Regional Product, real disposable income, and government spending.

DOE's analysis of impacts on employment is inherently complex. For example, it must discriminate between new workers and those who are already part of the employment baseline, and between total employment and incremental additions, and it must make assumptions about how many workers will in-migrate to work at the repository and how many already reside locally. However, by any measure, impacts to employment in Clark and Nye counties from repository-related construction and operations would be small. The number of jobs created directly and indirectly would peak in 2021 in both counties at around 1,300, a 0.09-percent increase above the projected employment baseline for that year. Indirect jobs would result from project expenditures, such as procurement of goods and services, and personal expenditures by directly employed workers.

DOE used the Regional Economic Models, Inc. (REMI) model, *Policy Insight* and State of Nevada demographer data to project that regional population would grow steadily from about 2.48 million residents in 2012 to about 5.13 million in 2067. The peak year contribution due to project workers and their households, in 2035, would be about 2,280 people, or about 0.06 percent of the 3.63-million-person baseline. Based on historical data, DOE assumes that 80 percent of the construction and operations workforce would live in Clark County and 20 percent would live in Nye County.

The proposed repository would increase real personal disposable income, spending by state and local government, and Gross Regional Product by less than one-third of 1 percent over projected baselines, in 2006 dollars. Gross Regional Product would peak in 2034 because of consumption of goods and services

due to construction. The estimated increase would be about $168 million or 0.08 percent of the baseline, with about $98.7 million spent in Clark County and $68.9 million in Nye County.

DOE analyzed potential impacts to housing only at the county level because demand at the community level is inherently hard to predict. The increase in population due to the repository would occur over a long period and the housing market could readily respond. Given the region's large housing inventory, baseline population growth would mask changes due to the repository. Impacts would be more pronounced in Nye County, particularly in Pahrump, where recent growth has been rapid and largely unanticipated and unmanaged, the housing stock is limited, and much of the infrastructure to support housing development is at capacity.

Impacts to services such as schools, police and fire protection, and medical services would be small because repository-related population changes would be a small fraction of population growth in the region. Because most in-migrating workers would probably live in the many communities of metropolitan Clark County, their demand for public services would be dispersed.

In southern Nye County, particularly Pahrump, public services are currently at capacity, and the county is medically underserved. Because population changes would occur steadily over a long period, the county would be able to meet increased demands on services as its revenue base grew. Pahrump's new hospital and the ample medical services in the metropolitan Las Vegas area would help meet the need for medical services.

S.3.1.7 Health and Safety of Workers and the Public

The design of the repository is based on multiple safety principles and on proven nuclear industry precedent. Facility components are designed with robust margins, and they employ diverse and redundant systems. Mechanical handling, shielding, and related safety equipment are based on proven technology. The safety philosophy is based on design approaches and features for the prevention of events rather than consequence mitigation or administrative controls, on passive features rather than active features, and on automatic initiation rather than manual initiation of control.

The results of the preclosure safety analyses confirm that the Yucca Mountain site characteristics combined with the repository design provide an inherently safe facility that meets the preclosure performance objectives with substantial margin.

DOE estimated health and safety impacts to workers and to members of the public for each repository analytical period.

S.3.1.7.1 *Nonradiological Impacts*

Impacts to workers could include those from common industrial hazards, naturally occurring nonradioactive airborne hazardous materials, and unexploded ordnance. To estimate the impacts of industrial hazards for this Repository SEIS, DOE used the methods and data source it had used in the Yucca Mountain FEIS. The data source is the DOE Computerized Accident/Incident Reporting System (CAIRS). A compilation of data from DOE and DOE contractor operations, CAIRS contains annual numbers of total recordable cases and lost workday cases and the incidence rates per 100 full-time equivalent worker years. It also contains the annual number of total fatalities, which is used to calculate

the fatality incident rate per 100,000 worker years. DOE applied these incident rates to estimate impacts to repository workers from industrial hazards.

Throughout the project, workers and the public could be exposed to naturally occurring cristobalite, a form of silica in rock that as dust causes silicosis and might be carcinogenic, and erionite, an uncommon zeolite mineral that forms wool-like fibrous masses and can be inhaled as dust. This Repository SEIS estimated that public exposures to cristobalite and public and worker exposures to erionite would be very small.

The project would last 105 years. DOE calculated total impacts to workers from industrial hazards for the entire project. For all workers, this SEIS estimated 1,800 total recordable cases, 800 lost workday cases, and less than 1 fatality.

S.3.1.7.2 *Radiological Impacts*

Since it completed the Yucca Mountain FEIS, DOE has modified its analysis of radiological impacts. The primary modifications include:

- Population distribution data. DOE now assumes operations would start in 2017 and last for as many as 50 years, so its analysis uses population projections updated to 2067. This is in contrast to the FEIS projection of population to the year 2035.

- Updated latent cancer fatality conversion factors. Measures of latent cancer fatality express the risk that a given dose of radiation would produce an additional cancer in an exposed population. To reflect current DOE guidance for converting worker and public doses to health effects, DOE used a conversion factor of 0.0006 latent cancer fatality per person-rem. The Yucca Mountain FEIS used two different LCF conversion factors: for workers, 0.0004 per person-rem, and for the public, 0.0005 per person-rem. This would result in a 50-percent and 20-percent impact increase from the FEIS for workers and the public, respectively, for the same radiation dose.

Construction of subsurface facilities would begin at the same time as construction of surface facilities. Disturbance of rock would result in releases of naturally occurring radon-222 and its decay products, which subsurface exhaust ventilation would pump to the surface. Throughout the project, workers and members of the public would be exposed to these releases. They could also be exposed to releases from radioactive materials at the site.

In the analysis of radiological impacts, this Repository SEIS calculates an annual dose to an individual or to a population and converts these doses to probabilities of latent cancer fatalities to express potential health effects. The impact for maximally exposed individuals is measured by the increase in the probability of a latent cancer fatality. For exposed populations, it is the estimated number of latent cancer fatalities that would result from the collective doses.

POPULATION DOSE AND FUTURE POPULATION SIZE

Population dose is a summation of the doses received by individuals in an exposed population (the unit of measure is *person-rem*). The population dose depends on the number of people at a given location. If the number increases, the population dose estimate does, too. The individual dose remains the same.

For workers, DOE estimated doses for maximally exposed involved workers and worker populations. About 80 percent of the doses to workers would occur during operations, principally from surface handling of spent nuclear fuel and subsurface monitoring and maintenance activities. The maximally exposed worker would be a cask operator who handled spent nuclear fuel at the surface and whose entire working lifetime spanned up to the 50-year operations period (an unlikely, and therefore conservative, assumption). The dose to that worker over a 50-year period would be about 30 rem, with an increase in latent cancer fatality risk of about 0.02. The total number of latent cancer fatalities for workers over the course of 105 years (project lifetime) would be about 4. DOE expects that workers would receive a dose much below that estimated in this repository SEIS, in keeping with DOE's safety goals and practices and experience with similar activities at existing DOE facilities.

For the public, DOE estimated impacts to the maximally exposed individual who would reside continuously for 70 years at the site boundary in the prevailing downwind direction. About 99.9 percent of the impact would be from exposure to airborne radon-222 and its decay products. The increase in probability of a latent cancer fatality during the preclosure period would be about 3 in 10,000. The highest annual dose would be 6.8 millirem, less than 4 percent of the annual average 200-millirem dose to members of the public from ambient levels of radon-222 and its decay products.

Over 105 years, the collective dose for the population within 80 kilometers (50 miles) would be 13,000 person-rem. This dose can be compared to 2.5 million person-rem the same population would receive from ambient levels of naturally occurring radon-222 and its decay products. The estimated health effects from this additional exposure to radioactivity would be 8 latent cancer fatalities.

S.3.1.8 Accidents and Sabotage Events

S.3.1.8.1 *Accidents*

DOE estimated impacts from reasonably foreseeable accidents for (1) the maximally exposed individual (an individual at the analyzed land withdrawal boundary who would receive the largest radiation dose from the accident), (2) the noninvolved worker (a worker 60 meters [200 ft] from the point of release from the accident), and (3) members of the public residing within 80 kilometers (50 miles) of the repository. Because waste handling operations would be performed remotely, involved workers would be in enclosed facility operating rooms isolated from the waste. Doses to the noninvolved worker could be as high as 2.3 rem. Impacts to offsite individuals from repository accidents would be small, with calculated doses of 23 millirem or less to the maximally exposed individual.

Since DOE completed the Yucca Mountain FEIS, it has acquired new information and analytical tools that contribute to the understanding of potential impacts of accidents. For this Repository SEIS, DOE has applied them to the evaluation of the accident scenarios.

With the current repository design and operational plans as its starting points, DOE considered external and internal events that could initiate accidents. External events would originate outside the repository and affect its ability to confine radioactive material; they include human-caused events such as aircraft crashes, external fires, and explosions, and natural phenomena such as seismic disturbances and extreme weather conditions. Internal events would originate in the repository and would include human errors, equipment failures, or combinations of these.

DOE defined various accident scenarios that entail drops and collisions involving shipping casks, TAD canisters, dual-purpose canisters, uncanistered fuel assemblies, and a fire involving low-level waste drums. The analysis presents consequences for average and unfavorable meteorological conditions (which would be exceeded less than 5 percent of the time).

The maximum reasonably foreseeable accident scenario that would result in the highest offsite population impact involves the drop and breach of a dual-purpose canister containing 36 pressurized water reactor spent nuclear fuel assemblies. The maximum reasonably foreseeable accident scenario that results in the highest worker impact involves a seismic event that releases radioactive material from the high-efficiency-particulate-air filtration system and the Low Level Radioactive Waste Facility. Potential impacts under these accident scenarios to the offsite exposed population would be less than 1 additional latent cancer fatality (0.16) in a population of approximately 104,000 in the south-southeast direction within an 80-kilometer (50 mile) radius of the site. The seismic event could result in the highest dose and health impacts to workers, 2.3 rem, which could result in an increased latent cancer risk of 0.0014.

S.3.1.8.2 *Sabotage Events*

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.

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 inadvertent and intentional human intrusion, including potential terrorist activities. The use of robust metal waste packages to contain the spent nuclear fuel and high-level 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.

Although it is difficult to predict if sabotage events would occur, and the nature of such events if they were to occur, 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 would crash into and penetrate 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 4.0 rem resulting in an estimated likelihood of a latent cancer fatality of 0.0024, 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 13,000 person-rem for average weather conditions resulting in an estimated 7.8 latent cancer fatalities.

S.3.1.9 Noise

The region of influence for noise includes the Yucca Mountain site and existing and future residences south of the analyzed land withdrawal area. Sources of noise during construction would be heavy equipment, ventilation fans, and diesel generators. Sources during operations and monitoring would include diesel generators, cooling towers, ventilation fans, air conditioners, and concrete batch plant activities. Ventilation fans would have suppressors to maintain noise levels below 85 dBA. 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. Because the distance between repository noise sources and an individual at the boundary of the analyzed land withdrawal area would be great enough to reduce noise to background levels or below, and because there would be no residential or community receptors at the boundary, DOE expects no noise impacts to the public.

At times, workers at the repository site would be exposed to elevated levels of noise. DOE would use engineering controls to control noise levels and worker exposures, so impacts such as hearing loss would be unlikely. Workers would use personal hearing protection as necessary.

Sources of offsite noise would include construction of the access road from U.S. Highway 95 and facilities south of the Yucca Mountain site near Gate 510. Typical construction equipment would intermittently generate noise levels of about 85 dBA at 15 meters (50 feet). Because of the distance between construction activities and potential receptors and the temporary and intermittent nature of construction noise, DOE would not expect noise impacts to the public. Traffic on the access road would not significantly add to existing noise on U.S. Highway 95. Noise from offsite facilities would be typical of commercial environments and would not cause impacts.

S.3.1.10 Aesthetics

DOE's analysis of aesthetic impacts considered the natural and manmade physical features that give a particular landscape its character and value, specifically scenic quality, visual sensitivity, and distance from observation points.

From publicly accessible locations, Yucca Mountain's visibility is limited. DOE identified two general locations from which the public could see repository facilities. One is approximately 22 kilometers (14 miles) to the south of the repository, near the intersection of Nevada State Route 373 and U.S. Highway 95. The other is west of the repository. From the latter location, repository ventilation exhaust stacks could be visible.

The low elevation of the southern end of Yucca Mountain and Busted Butte would obscure the view of repository facilities from the south, and therefore the repository would cause a weak degree of contrast with the landscape. Exhaust ventilation stacks on the crest of Yucca Mountain would cause a moderate degree of contrast, and American Indians would consider the presence of the stacks an adverse aesthetic impact. Because of the height of the stacks, the U.S. Air Force might require DOE to install flashing beacon lights on top of them. Such beacons could be visible for several miles, especially to the west of Yucca Mountain, but would not be visible from Death Valley National Park.

Construction of the access road from U.S. Highway 95 and of offsite facilities near Gate 510 would be sources of short-term visual impacts. DOE would reclaim disturbed areas when they were no longer needed. Best management practices would ensure that construction created only a weak degree of contrast. When construction was complete, the access road and offsite facilities would cause a weak degree of contrast.

Closure activities, such as dismantling of facilities and site reclamation, would reduce the repository's visual contrast with the landscape.

S.3.1.11 Utilities, Energy, Materials, and Site Services

DOE calculated its needs for electricity, fossil fuel, oil, lubricants, construction materials, and services such as emergency medical support, fire protection, and security and law enforcement, and compared them with available supplies and capacity.

In general, quantities of utilities, energy, and materials the project used would be small in comparison to the regional supply capacity and would be unlikely to affect regional supplies or prices. A major reason is that the repository schedule would extend over decades.

As its repository program proceeds, DOE would examine how it could modify its engineering, construction, and operational plans to take advantage of emerging green technologies, in order to reduce its consumption of nonrenewable resources, including fossil fuels.

S.3.1.12 Repository-Generated Waste and Hazardous Materials

Repository construction, operations, monitoring, and closure would generate waste and entail the use of hazardous materials. DOE identified types of waste and hazardous materials and estimated the maximum quantities it would generate for each project period. The types include construction and demolition debris, industrial wastewater, low-level radioactive waste, sanitary sewage, sanitary and industrial waste, hazardous waste, mixed waste, and transuranic waste. DOE could build onsite solid waste facilities to accommodate nonhazardous waste or dispose of such waste at offsite facilities. DOE would manage industrial wastewater with onsite evaporation ponds.

DOE would dispose of construction and demolition debris and sanitary and industrial waste either at an onsite landfill or at offsite facilities. Hazardous waste and low-level radioactive waste would be disposed of in offsite facilities. The impact on offsite disposal facilities of the amounts of waste generated during all project periods would be small because current capacities could readily accommodate estimated quantities. Best management practices would reduce the amount of waste generated.

S.3.1.13 Environmental Justice

As in the Yucca Mountain FEIS, in this Repository SEIS DOE does not identify any high and adverse potential impacts to populations. 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, DOE has concluded that no disproportionately high and adverse impacts would result from the Proposed Action.

In the Yucca Mountain FEIS, DOE acknowledged that members of American Indian tribes have used lands around the Yucca Mountain site that contain cultural, animal, and plant resources important to them. The FEIS presented views and beliefs about those lands that tribal members had expressed. DOE continues to recognize that the Proposed Action would conflict with the viewpoint expressed by the American Indian Writers Subgroup in *American Indian Perspectives on the Yucca Mountain Site Characterization Project and the Repository Environmental Impact Statement.*

S.3.2 POTENTIAL POSTCLOSURE IMPACTS OF THE REPOSITORY

S.3.2.1 Analytical Framework and Tools for Assessment

S.3.2.1.1 *The Regulatory Framework*

In 2001, both EPA and NRC adopted public health and safety standards for radioactive materials disposed of in the Yucca Mountain repository based on a dose not to be exceeded for the "reasonably maximally exposed individual" (RMEI) during the first 10,000 years. 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 of time for which compliance must be demonstrated, and it remanded the provisions to the federal agencies for revision.

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.

In 2005, EPA proposed new standards to address the court's decision. The proposed EPA 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. Because the *Energy Policy Act of 1992* requires NRC to modify its technical requirements for licensing of the 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.

To obtain NRC authorization to construct the Yucca Mountain repository, DOE must demonstrate that the proposed repository meets the regulatory individual radiation protection standards set by EPA and NRC. Under the existing standards, estimated repository performance will be compared to a mean annual dose of 15 millirem for the first 10,000 years after closure. Under the proposed standards, estimated repository performance will be compared to a median annual dose of 350 millirem for the post-10,000-year period. In this Repository SEIS, comparison to the existing and proposed standards is intended only to provide a perspective on potential health impacts.

WHY 10,000 YEARS AND 1 MILLION YEARS?

The TSPA-SEIS model provides estimates of potential radiological impacts (doses) for two periods: the estimated dose at times up to 10,000 years after closure and a dose at times after 10,000 years and up to 1 million years after closure. The TSPA-SEIS 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 EPA and NRC have existing and proposed dose limits for the annual individual dose in each period. While these dose limits will provide a regulatory limit against which NRC could evaluate DOE's application for construction authorization, they also provide a context in which to consider the potential environmental impacts of the Proposed Action.

S.3.2.1.2 *Estimating Repository Performance in the Postclosure Period*

DOE estimates postclosure repository performance by means of probabilistic modeling in computer simulations using numerical data. The model that DOE has developed to estimate repository performance after closure is called the Total System Performance Assessment (TSPA). The version of the model used to represent the results in this Repository SEIS is called the TSPA-SEIS. The TSPA-SEIS reflects modifications made to repository design since the Yucca Mountain FEIS was completed. It also reflects the acquisition of more scientific data and the refinement of models, which serve to further reduce levels of uncertainty associated with assessments of repository performance.

The results of assessments of postclosure repository performance for this Repository SEIS and those of the Yucca Mountain FEIS are different. The differences are due to the use in this Repository SEIS of a TSPA model that is consistent with newly proposed EPA standards, as well as to the incorporation of additional data and enhancements in the description of engineered and natural components. In addition, the TSPAs for the Yucca Mountain FEIS and the Repository SEIS use different representations for earthquakes, climate change, and volcanism. As a result of these differences, 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 shown in the FEIS (for example, FEIS, page 5-26, Figure 5.4) 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 proposed EPA standards require DOE to represent long-term climate using a probabilistic distribution for a constant-in-time but uncertain long-term average climate for Yucca Mountain specified by NRC. Inclusion of these changes in the FEIS would have resulted in a significant lowering of the projected dose values.

COMPARISON OF DOSES IN THE YUCCA MOUNTAIN FEIS AND IN THE REPOSITORY SEIS

For the post-10,000-year period, the maximum mean annual individual dose reported in the Yucca Mountain FEIS is 154 millirem per year, while the maximum mean annual individual dose reported in the Repository SEIS is 2.3 millirem per year. Any comparison of these two numbers must take into account the differences in the modeling that resulted in the two results. Specifically, the modeling for the Repository SEIS reflects regulatory direction in the EPA proposed standards on how to treat certain features (e.g., climate) and also reflects DOE's current assessment as to what are the appropriate assumptions to use in demonstrating compliance under a reasonable expectation standard. DOE expects that the maximum annual individual dose in the final Repository SEIS to be submitted to NRC in connection with DOE's submission of the application for construction authorization will not be substantially different from the maximum annual individual dose reported in this draft Repository SEIS. It should be noted, however, that various elements of our modeling approach may be challenged as part of the NRC licensing process. Depending on the outcome of any such challenges, the maximum annual individual dose ultimately considered by NRC in making its decision whether to authorize construction may be higher or lower than the maximum annual individual doses reported in the Yucca Mountain FEIS or the Repository SEIS.

- The proposed EPA standards require DOE to use revised International Commission on Radiation Protection weighting factors for calculation of individual doses. In general, biosphere dose conversion factors for actinides 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 referenced in the FEIS (FEIS page 5-31) indicate that dose estimates would be significantly lower if the revised Commission 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 TAD canister. Inclusion of temperature dependence of Alloy 22 corrosion rates in the SEIS results 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.

DOE has made other refinements to the TSPA model for the SEIS to improve the treatment of uncertainties, incorporate new data and understanding of processes, and reduce conservatism in the projection of repository performance.

S.3.2.1.3 *The Focus of Analyses*

In this Repository SEIS, DOE's analysis examines impacts on human health from radioactive and nonradioactive materials (hazardous and carcinogenic chemicals in the engineered barriers) released to the environment, biological and environmental impacts from radiological and chemical groundwater contamination, and biological impacts from heat due to decay of radioactive materials. It examines three transport pathways through which releases could reach human populations: groundwater, surface water, and the atmosphere.

Radioactive releases and groundwater are of primary concern. Groundwater is of concern because rainwater could migrate into the repository, dissolving or mobilizing material in it and carrying contaminants down through the groundwater system into an aquifer (Figures S-3 and S-11). Through a well or at a surface-water discharge point, humans would draw that water for use as drinking water or for irrigation and watering livestock, through which it could enter the human food chain.

The TSPA-SEIS evaluates radiological impacts over two time frames: the first 10,000 years and up to one million years after repository closure. The end point is an estimate of an annual dose to an individual, expressed in millirem. Converting doses to the probability of latent cancer fatalities provides an estimate of health effects.

The Repository SEIS examines the annual dose to the RMEI at a location 18 kilometers (11 miles) south of Yucca Mountain in the direction of groundwater flow. The RMEI is a hypothetical individual who lives above the highest concentration of radionuclides in the plume of radioactive contamination, and drinks 2 liters of water per day from wells drilled into the groundwater at that location. DOE estimated the annual RMEI dose and groundwater impacts using a representative volume of 3000 acre-feet of groundwater, consistent with the regulatory requirements applicable to projections of repository performance for Yucca Mountain to calculate the concentration of radionuclides. The TSPA-SEIS model collected the radionuclides released at a given time and used that number to project the concentration of radionuclides released from the Yucca Mountain disposal system into the representative volume. That concentration of radionuclides is used to determine the annual dose to the RMEI, which is expressed in millirem.

S.3.2.1.4 *The Nature of Analyses*

For the Repository SEIS, DOE performed 300 model simulations using TSPA for the RMEI location. Analyses examine the possible effects of "scenario classes" that include such expected processes as corrosion and degradation of waste packages and drip shields, degradation and dissolution of waste forms, flow through the saturated and unsaturated zones, and changing climate. They also consider early waste package and drip shield failure mechanisms, igneous and seismic events, and such disturbances as exploratory drilling and criticality.

The analysis draws from comprehensive data on engineered barriers and studies of the natural features of the site. But many parameters about the latter cannot be exactly quantified or known, and of course the more complex and variable a system is and the further into the future a forecast extends, the greater the level of uncertainty. DOE uses a variety of analytic techniques to gauge how sensitive end results are to uncertainties and data limitations, and thus how much they matter. Where assumptions must be made, they are generally conservative. DOE also draws upon expert opinion. Its analysis explicitly accounts for uncertainty and expresses results as ranges of potential consequences.

The goal is a cautious but reasonable projection of what might occur. The Repository SEIS explains sources of uncertainty and how DOE handles it in modeling. Continued testing and monitoring at the Yucca Mountain site and analysis of findings in the future will further reduce uncertainty.

S.3.2.2 Postclosure Radiological Impacts

The safe long-term isolation of nuclear waste in the Yucca Mountain repository would result from the performance of multiple natural and engineered features of the site and the system, acting in concert, to prevent or delay the transport of radioactive materials to points at which the public could eventually be exposed to them. Each of the barriers in the system would work individually and together to limit the movement of water and the release and movement of radionuclides. Yucca Mountain's geologic and hydrologic characteristics form effective natural barriers to the flow of water and to the potential movement of radionuclides. The underground environment within the natural setting is conducive to the design and construction of components that would prevent or reduce the movement of water or the potential release and transport of radionuclides. The Engineered Barrier System consists of components designed to function in the natural environment of the unsaturated rock units, and it uses materials chosen to perform their intended functions for many thousands of years. Analyses indicate that a Yucca Mountain repository could be expected to effectively isolate waste for tens of thousands to hundreds of thousands of years.

The Yucca Mountain site was selected, and the repository designed, to take advantage of the attributes of the natural setting at Yucca Mountain. Because water is the primary medium by which radionuclides could be released from the repository, the beneficial characteristics of the repository primarily relate to the ability of the site and the design to limit the movement of water into and out of repository emplacement drifts. The attributes of the disposal system that are particularly important to post-closure performance include an unsaturated zone and facility design that will limit water entering emplacement drifts, long-lived drip shields and waste packages that will prevent or limit the contact of water and waste, other engineered features that will contribute to limiting radionuclide release, natural features that will delay and reduce the concentration of radionuclides, and a disposal system concept that results in low mean annual radiological doses even when potentially disruptive events are considered.

The performance analysis for the first 10,000 years after closure indicates that there would be very limited combined releases with small radiological impacts for the total of all scenario classes. For the first 10,000 years after repository closure, the mean annual individual dose would be approximately 0.24 *millirem*. This is about 1 percent of the existing EPA standard, which allows up to a 15-millirem annual committed effective dose equivalent during the first 10,000 years.

CALCULATION OF MEAN, MEDIAN, AND 95TH-PERCENTILE RESULTS

Because of the probabilistic nature of the TSPA 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.

Analyses indicate that for the post-10,000-year period, the median annual individual doses would be approximately 0.98, respectively. The median value is about 0.2 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 proposed EPA standard (Figures S-12 and S-13).

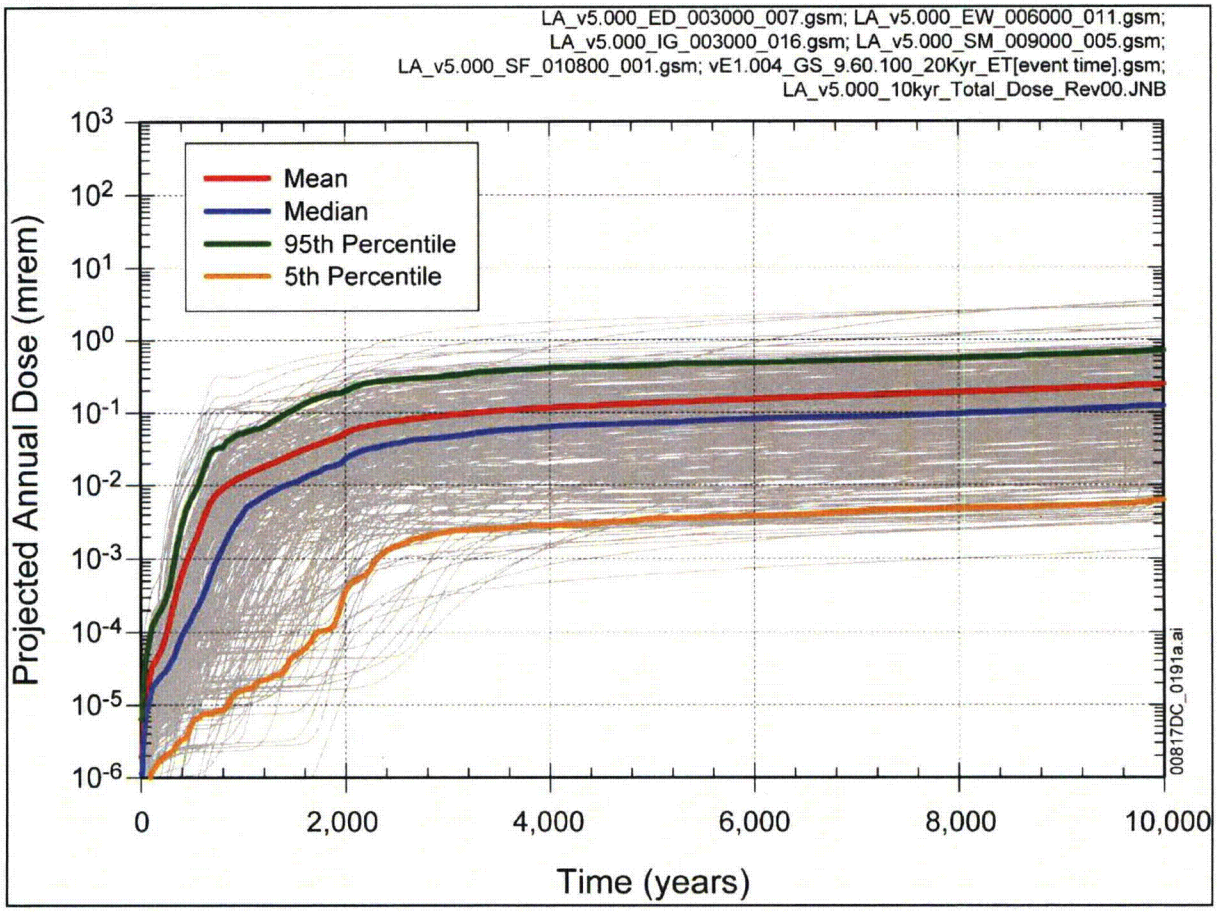


Figure S-12. Projected total annual dose for the first 10,000 years after repository closure–combined drip shield early failure, waste package early failure, igneous intrusion, volcanic eruption, seismic ground motion, and seismic fault displacement modeling cases.

S.3.2.2.1 *Human Intrusion*

A human intrusion scenario, in which a driller would penetrate a waste package without realizing it, is difficult to envision because of the design of the drip shields and waste packages. It is more plausible that the engineered barriers would deflect or divert a borehole that penetrated the repository. It is also more plausible that the drillers would recognize the intrusion. Nonetheless, DOE adopted a simple conservative calculation method to estimate the earliest time at which a drilling intrusion could occur, based on the fact that the waste package would be susceptible to drilling once the drip shield failed. DOE conservatively assumed that waste package failure and inadvertent drilling would occur at the same time. Based on this analysis, the earliest time that this could happen is estimated to be 200,000 years after closure.

DOE conducted a TSPA calculation for the drilling intrusion scenario for all environmental pathways to represent the dose from a single waste package. The mean and median annual individual doses from human intrusion would both be less than 0.01 millirem and would occur approximately 4,000 years after intrusion. These results indicate that the repository would be sufficiently robust to limit releases from

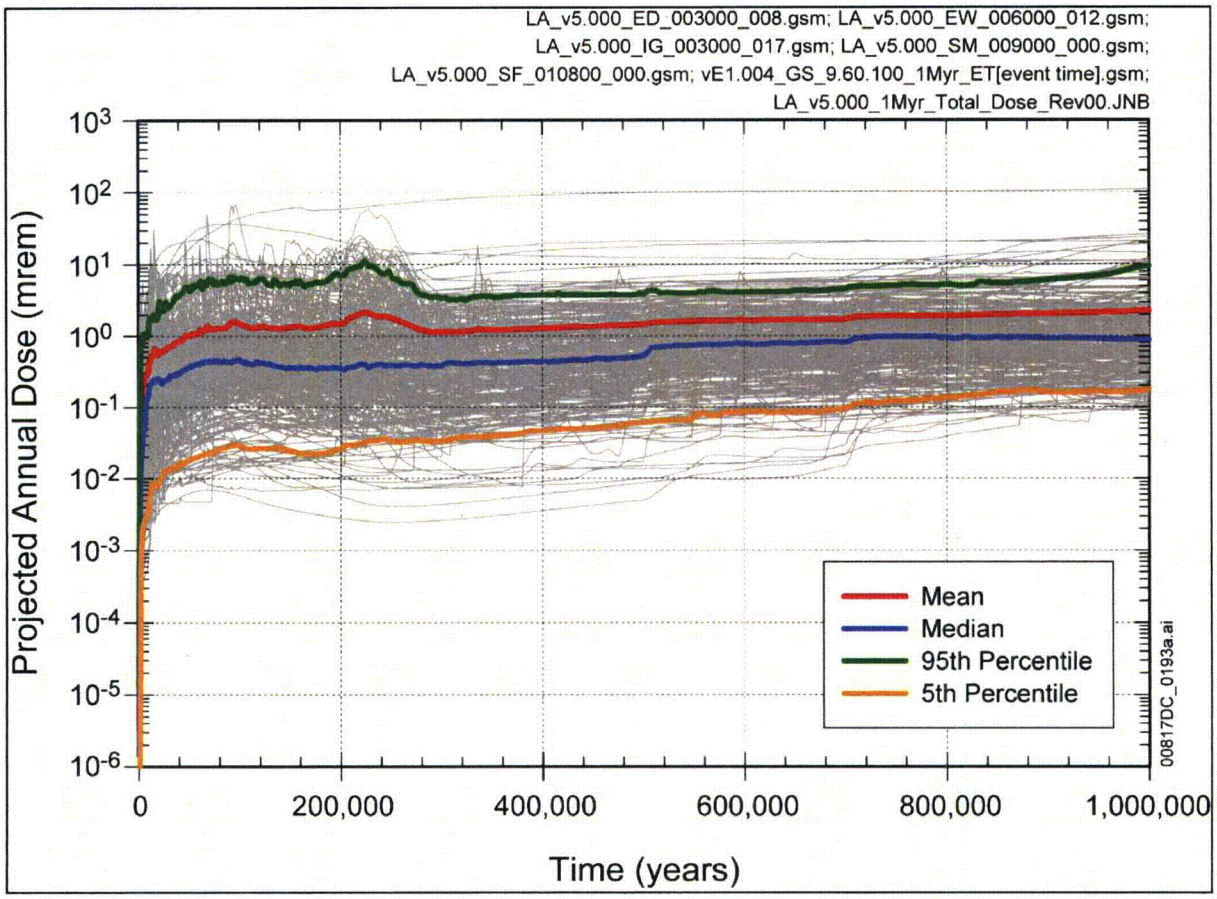


Figure S-13. Projected total annual dose for the post-10,000-year period–combined drip shield early failure, waste package early failure, igneous intrusion, volcanic eruption, seismic ground motion, and seismic fault displacement modeling cases.

human intrusion to values well below the proposed individual protection standard of 350-millirem annual individual dose for human intrusion for intrusions in the post-10,000-year period.

S.3.3 TRANSPORTATION IMPACTS

After DOE completed the Yucca Mountain 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. Since completing the Yucca Mountain 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 TAD canisters and most DOE materials in disposable canisters at the DOE sites. There have also been changes to some of the data DOE used to estimate radiation doses and radiological impacts. Changes unique to the analysis of potential impacts from transportation are described below.

- 2000 Census population density data and updated rail and truck transportation networks. DOE used the TRAGIS computer program to determine representative transportation routes to the repository. The Department used 2000 Census data to estimate population densities along the routes. In the

FEIS, the TRAGIS program used 1990 Census data, which was escalated on a state-by-state basis to reflect the most current basis.

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 using 2000 Census data.

- 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 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.

  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. Shipping 9,500 rail casks would require about 2,800 trains. As identified in S.2.1.4, the FEIS analyses projected 9,600 rail cask shipments and 1,000 truck cask shipments.

- Radionuclide inventories. 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.*

- Sabotage. DOE reanalyzed impacts from potential sabotage events using spent nuclear fuel release fraction data that were not available at the time the Yucca Mountain FEIS was prepared.

S.3.3.1 National Transportation Impacts

Shipments of spent nuclear fuel and high-level radioactive waste would represent a very small fraction of total national highway and railroad annual traffic (less than 0.1 percent).

The analysis of potential impacts associated with national transportation of spent nuclear fuel and high-level radioactive waste includes evaluation of incident-free impacts (normal operations), transportation risk (an assessment of potential accident consequences taking into account the probabilities of each accident), and the estimated consequences of a maximum reasonably foreseeable accident. The overall national transportation impacts include those that would be expected at the generator sites from loading TAD canisters and transportation casks and address projected exposures of workers and the public to both radiological and non-radiological hazards (traffic accidents and vehicle emissions).

For incident-free transportation, 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 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 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 estimated nonradiological impacts of accidents (traffic fatalities) would be 3 fatalities during as many as 50 years of shipments to the proposed repository.

The maximum reasonably foreseeable transportation accident analyzed in this Repository SEIS is estimated to occur with a frequency of about 8×10^{-6} per year. This accident would involve a long-duration, high-temperature fire that would engulf a rail cask. If the accident occurred in an urban area, DOE estimated that there would be 9 cancer fatalities in the exposed population. If the accident occurred in a rural area, DOE estimated that the probability of a single latent cancer fatality in the exposed population would be 0.012 (1 chance in 80) in the exposed population.

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 NWPA, would use NRC-certified shipping casks. Spent nuclear fuel is protected by the robust metal structure of the shipping 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 (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 (Appendix J, Section J.3.3.1), DOE evaluated the ability of large aircraft parts to penetrate shipping casks and found that 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.

In the Yucca Mountain FEIS, DOE estimated the potential consequences if a sabotage event in which a high energy density device penetrates a rail or truck cask. For this Repository SEIS, DOE obtained more recent estimates of the fraction of spent fuel materials that would be released (release fractions). Based on the more recent information, DOE estimated that there would be 28 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 0.055 (1 chance in 20). 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).

The Department would continue to modify its approach to ensuring safe and secure shipments of spent nuclear fuel and high-level radioactive waste between now and the time of shipments.

S.3.3.2 Nevada Transportation Impacts

The Rail Alignment EIS analyzes the potential impacts of rail line construction and operation along common segments and alternative segments within the Caliente and Mina rail corridors for the purpose of determining an alignment for the construction and operation of a railroad for shipments of spent nuclear fuel, high-level radioactive waste, and other materials from an existing rail line in Nevada to a geologic repository at Yucca Mountain. The Rail Alignment EIS also analyzes the potential impacts of constructing and operating support facilities. The impacts of this proposal have been included in the summary tables presented in Section 9.1, Major Conclusions. Additional detail regarding the impacts of constructing and operating a railroad in Nevada can be found in the Rail Alignment EIS.

S.4 No-Action Alternative and Its Impacts

Under the No-Action Alternative, DOE would not construct a repository at Yucca Mountain. Consistent with Section 113(c)(3) of the NWPA, DOE would curtail work at the site and undertake site reclamation to mitigate any significant adverse environmental impacts.

This Repository SEIS summarizes, incorporates by reference, and updates the Yucca Mountain FEIS analysis of environmental impacts associated with the No-Action Alternative. To assess potential health and safety impacts, DOE has used updated radiation dose coefficients and an updated latent cancer fatality conversion factor.

For this Repository SEIS, DOE has reconsidered its evaluation of the No-Action Alternative analytical scenarios and has elaborated on the uncertainties, and therefore unpredictability, of future actions under them. It has also considered developments related to a potential private fuel storage facility in Utah.

The immediate impacts of the No-Action Alternative are straightforward. Decommissioning and reclamation of the Yucca Mountain site would begin as soon as practicable and could take several years

to complete. DOE would remove or shut down surface and subsurface facilities and restore disturbed lands. Short-term impacts on resource areas would be small.

Beyond that timeframe, developments become speculative, because DOE cannot predict the future course that Congress and commercial utilities and other parties would take in the absence of a repository. The possibilities could include these:

- 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 site for a geologic repository,
- Development of new technologies, and
- Reconsideration of alternatives to geologic disposal.

Because the uncertainties and range of possibilities are so large, the Yucca Mountain FEIS focused its analysis on the potential impacts of two scenarios:

- 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 four sites. Commercial utilities would continue to manage their spent fuel at current locations. All sites would remain under institutional control, which would ensure protection of workers and the public under current federal regulations. Storage facilities would undergo one major repair during the first 100 years and replacement every 100 years after that. Replacement facilities would be sited next to existing facilities.
- No-Action Scenario 2. For the first 100 years, this scenario would be identical with Scenario 1. The scenario assumes no institutional control beyond that time. After about 100 years and up to 10,000 years, storage facilities at all sites would begin to deteriorate, and they would eventually release radioactive materials to the environment.

This Repository SEIS estimates the potential impacts of the No-Action Alternative at commercial and DOE sites for both scenarios for the first 10,000 years and for periods up to a million years. Under Scenario 1, which assumes the existence of institutional controls, the estimated radiological health impacts to workers and the public for the first 10,000 years would be about 18 latent cancer fatalities. For Scenario 2, which assumes the lack of institutional controls after 100 years, the evaluation of the 10,000-year period in the Yucca Mountain FEIS found that the original storage facility and containment vessels would be compromised. Radionuclides would enter the accessible environment with, eventually, catastrophic consequences for human health. This SEIS estimates the radiological health impacts to the public during the 10,000-year period to be over 1,000 latent cancer fatalities.

For estimates of impacts up to 1 million years for Scenario 1, the integrated impacts over the million-year period would be approximately 100 times those of the estimated 10,000-year impacts. For Scenario 2, however, the projection of estimated impacts would be more speculative. Beyond 10,000 years, the

unchecked deterioration and dissolution of the materials would continue and increase impacts even further than those estimated for the 10,000-year period. 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.

S.5 Cumulative Impacts of the Proposed Action

For this Repository SEIS, DOE updated the Yucca Mountain FEIS evaluation of cumulative preclosure impacts from the construction, operation, monitoring, and closure of a geologic repository at Yucca Mountain, and cumulative postclosure impacts after repository closure. DOE also updated the evaluation of cumulative impacts from transportation of spent nuclear fuel and high-level radioactive waste to the repository both nationally and within the state of Nevada. The SEIS analysis reflects the longer time period assumed for repository operations and transportation, DOE's decision to ship most waste by rail, and updated assumptions about waste inventories.

Cumulative Impacts

A cumulative impact is "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" (Council on Environmental Quality Regulations, 40 CFR 1508.7). Cumulative impacts can result from individually minor but collectively potentially significant actions that occur over time.

DOE's assessment of the environment around the Yucca Mountain site took into account the cumulative impacts of past and present actions in the area the Proposed Action would affect. Reasonably foreseeable future actions include the disposal of inventories of spent nuclear fuel and high-level radioactive waste that exceed the Proposed Action inventory of 70,000 MTHM, along with activities at the Nevada Test and Training Range and Nevada Test Site, DOE waste management and transmission/distribution activities, and Nye County activities, including the implementation of the Gateway Area Concept Plan, designed to manage the development of land south of the analyzed land withdrawal area.

DOE is preparing the *Programmatic Environmental Impact Statement for the Global Nuclear Energy Partnership*. The Global Nuclear Energy Partnership (GNEP) would encourage expansion of domestic and international nuclear energy production while reducing nuclear proliferation risks, and reduce the volume, thermal output, and radiotoxicity of spent nuclear fuel before disposal in a geologic repository. DOE 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.

Overall, development of a GNEP fuel cycle has the potential to decrease the amount (number of assemblies) of spent nuclear fuel that would require geologic disposal, but could increase the number of canisters of high-level radioactive waste requiring geologic disposal in the longer term. Consequently, the proposed recycling of commercial spent nuclear fuel could affect the nature of the inventory that represents the balance of Inventory Module 1 (as discussed below). Nevertheless, given the uncertainties inherent at this time in estimating the amount of spent nuclear fuel and high-level radioactive waste that would result from full or partial implementation of GNEP, this Repository SEIS analyzes the

transportation and disposal of about 130,000 MTHM of commercial spent nuclear fuel, 2,500 MTHM of DOE spent nuclear fuel and about 36,000 canisters of high-level radioactive waste (Inventory Module 1).

S.5.1 INVENTORY MODULES 1 AND 2

Section 114(d) of the NWPA provides that no more than 70,000 MTHM of spent nuclear fuel and high-level radioactive waste may be disposed of in a first repository until a second repository is operating. DOE evaluated the emplacement of the total projected inventory of commercial spent nuclear fuel and DOE spent nuclear fuel and high-level radioactive waste (Inventory Module 1) and emplacement of that total inventory plus the inventories of commercial Greater-Than-Class-C waste and DOE Special-Performance-Assessment-Required waste (also referred to by DOE as "Greater-Than-Class-C-like" waste (Inventory Module 2). This Repository SEIS updates the inventories of the modules evaluated in the Yucca Mountain FEIS.

INVENTORIES

Proposed Action
- 63,000 MTHM of commercial spent nuclear fuel and a very small quantity of commercial high-level waste
- 2,333 MTHM of DOE spent nuclear fuel
- 4,667 MTHM (9,334 canisters) of DOE high-level radioactive waste

Inventory Module 1
- 130,000 MTHM of commercial spent nuclear fuel
- 2,500 MTHM of DOE spent nuclear fuel
- 36,000 canisters of DOE high-level radioactive waste

Inventory Module 2
- 130,000 MTHM of commercial spent nuclear fuel
- 2,500 MTHM of DOE spent nuclear fuel
- 36,000 canisters of DOE high-level radioactive waste
- 2,000 cubic meters (70,000 cubic feet) of Greater-Than-Class-C waste
- 4,000 cubic meters (140,000 cubic feet) of Special-Performance-Assessment-Required waste (Greater-Than-Class-C-like low-level radioactive waste)

The emplacement of Inventory Module 1 or 2 at Yucca Mountain would require legislative action by Congress. The emplacement of commercial Greater-Than-Class-C and DOE Special-Performance-Assessment-Required wastes could require either legislative action or a determination by NRC to classify these materials as high-level radioactive waste.

The emplacement of Inventory Module 1 or 2 would increase the size of the subsurface repository facilities and, thus, the amount of land disturbed. Because over twice as much radiological materials would be handled during the emplacement of Inventory Module 1 or 2, these actions would produce greater health impacts to workers and the public, increase energy use, create larger amounts of waste, and increase transportation impacts. While impacts in all resource areas would still be low, the specific impacts to health and safety at the repository and from transportation are discussed below.

S.5.2 IMPACTS TO WORKERS AND THE PUBLIC

Impacts from industrial hazards. The total estimated impacts from industrial hazards for Inventory Module 1 or 2 would be 50 percent larger than those for the Proposed Action. The potential number of reportable injuries and illnesses could be about 2,700, and the estimated number of fatalities would be 1.2.

Radiological impacts to workers. Latent cancer fatalities for repository workers during the construction, operation, monitoring, and closure periods for Module 1 or 2 could be about 9 fatalities, about double that estimated for the Proposed Action.

Preclosure radiological impacts to the public. The likelihood that the maximally exposed individual would experience a latent cancer fatality would be less than 0.0006 for emplacement of Inventory Module 1 or 2, the same as for the Proposed Action. As for the Proposed Action, over 99 percent of this impact would result from the release of naturally occurring radon.

Postclosure radiological impacts. Postclosure cumulative impacts to public health could occur from radionuclides released from Yucca Mountain, from past weapons testing on the Nevada Test Site, and from past, present, and future disposal of radioactive waste in disposal sites on the Nevada Test Site and in regulated facilities near Beatty, Nevada. The mean annual dose estimated to occur within 10,000 years from disposal of the Proposed Action inventory is 0.24 millirem per year to the RMEI. Since the Module 1 inventory of commercial spent nuclear fuel would be approximately twice that of the Proposed Action, the mean annual dose resulting from disposal of the Module 1 inventory is also estimated to double. Module 2 impacts would add an additional fraction of 1 percent to the Module 1 impacts. As illustrated in the Yucca Mountain FEIS, the past weapons testing and radioactive waste disposal actions are not expected to make an additional noticeable contribution to the cumulative postclosure radiological impacts.

S.5.3 TRANSPORTATION

The SEIS analysis assumes that, to ship Inventory Module 1 or 2 to the repository, DOE would use the transportation routes described for the Proposed Action and would make a larger number of shipments, over a longer period of time. This would result in increased industrial hazards, traffic fatalities, and latent cancer fatalities. Impacts for national transportation for the Proposed Action are estimated to be about 8 total fatalities. For Module 1, DOE estimates about 18 total fatalities and for Module 2 about 19 total fatalities. The majority (about 80 percent) would be from radiation exposure of workers and traffic fatalities.

Additional impacts would result from transportation of construction materials, repository components, and consumables to the repository; workers who commute to the repository; and transportation of site-generated waste from the repository. Under the Proposed Action, DOE estimates there would be about 13 fatalities from exposure to vehicle emissions and 44 to 46 traffic fatalities. For Module 1 or 2, DOE estimates an increase to about 14 fatalities from exposure to vehicle emissions and 47 to 50 traffic fatalities.

During the national transportation of radioactive materials from 1943 to 2073 *not* associated with the Proposed Action, DOE estimated that there would be about 220 latent cancer fatalities among exposed workers and about 210 latent cancer fatalities among exposed members of the public. When these

impacts were combined with the impacts of the Proposed Action, Module 1, and Module 2, DOE estimated that there would be about 230 latent cancer fatalities among exposed workers and about 210 latent cancer fatalities among exposed members of the public.

During the national transportation of radiological materials from 1943 to 2073 not associated with the Proposed Action, DOE estimated that there would be about 100 traffic fatalities. When these impacts were combined with the impacts of the Proposed Action, Module 1, and Module 2, DOE estimated that there would be about 100 to 110 traffic fatalities.

S.6 Mitigating Potential Adverse Environmental Impacts

DOE is fully committed to sound stewardship practices that protect the resource areas analyzed in this Repository SEIS. It has applied monitoring and mitigation measures throughout the Yucca Mountain Project. For the Proposed Action, DOE would meet this commitment by adapting and expanding its Environmental Management System for the repository project, as part of its existing Integrated Safety Management System. That system is designed to ensure that DOE achieves its missions while protecting the public, workers, and the environment. The structured framework provided by an Environmental Management System permits the systematic identification, evaluation, and mitigation of environmental impacts. As stated by the Council on Environmental Quality, Environmental Management Systems and NEPA are complementary processes.

As part of the planning process, DOE would establish measurable environmental objectives and set measurable goals and targets tailored to the Proposed Action (for example pollution prevention goals for reductions in waste generation). DOE would then implement programs, procedures, and controls for monitoring and measuring progress. It would document progress and, if appropriate, determine appropriate mitigation measures and implement them.

In implementing the Proposed Action, DOE would adhere to NRC safety requirements in 10 CFR Part 63 for the construction, operation, monitoring, and closure of a geologic repository and meet 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.

DOE would implement best management practices to mitigate potential environmental impacts it identified during construction, operation, monitoring, and closure of the repository.

S.7 Unavoidable Adverse Impacts; Short-Term Uses and Long-Term Productivity; and Irreversible or Irretrievable Commitments of Resources

The construction, operation, 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 DOE 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.

- The permanent withdrawal of approximately 600 square kilometers (230 square miles) of land for the repository would be likely to prevent human use of the withdrawn lands for other purposes.
- Death or displacement of individual members of some animal species, including the desert tortoise, as a result of site clearing and vehicle traffic would be unavoidable.
- Injuries to workers or worker fatalities could result from facility construction and operation.
- Transportation of spent nuclear fuel and high-level radioactive waste would have the potential to affect workers and the public through exposure to radiation and vehicle emissions, and through traffic accidents.
- Electric power, fossil fuels, and construction materials would be irreversibly committed to the project.
- DOE would use fossil fuel from the nationwide supply system to transport spent nuclear fuel and high-level radioactive waste to the repository.

Further, in the view of American Indian tribes in the Yucca Mountain region, construction of the proposed repository and related facilities would degrade the environmental setting. Even after repository closure and site reclamation, the presence of the repository would, from their perspective, result in an irreversible impact to traditional lands and values.

S.8 Statutory and Other Applicable Requirements

Many statutes and regulations would apply to the licensing, development, operation, and closure of a geologic repository. These include the NWPA, NEPA, the *Atomic Energy Act*, the *Federal Land Policy and Management Act of 1976*, site-specific public health and environmental radiation protection standards established by EPA, site-specific technical licensing regulations established by NRC, and site suitability guidelines established by DOE.

DOE is subject to other requirements, including those promulgated under the *Clean Air Act; Clean Water Act; Emergency Planning and Community Right-to-Know Act of 1986; National Historic Preservation Act; Archaeological Resources Protection Act; Endangered Species Act;* and applicable Nevada statutes and regulations. In accordance with federal authorities, DOE would apply for new permits, licenses, and approvals to construct, operate, monitor, and eventually close the proposed Yucca Mountain Repository.

Under the authority of the *Atomic Energy Act*, DOE is responsible for establishing a comprehensive health, safety, and environmental program for its activities and facilities. Under Executive Order 13148, DOE is responsible for developing and implementing an Environmental Management System. The Department has established a framework for managing its facilities through the promulgation of regulations and the issuance of DOE Orders. In general, DOE Orders set forth policies, programs, and procedures for implementing policies. Many DOE Orders contain specific requirements in the areas of radiation protection, nuclear safety and safeguards, and security of nuclear material. Because NRC is authorized to license the proposed Yucca Mountain repository, DOE issued Order 250.1 exempting such a repository from compliance with provisions of DOE Orders that overlap or duplicate NRC licensing requirements.

DOE has interacted with agencies authorized to issue permits, licenses, and other regulatory approvals, as well as those responsible for protecting such significant resources as endangered species, wetlands, or historic properties. DOE also has coordinated with the affected units of local government, NRC, U.S. Air Force, U.S. Navy, U.S. Department of Agriculture, U.S. Department of Transportation, EPA, U.S. Department of the Interior including its Bureaus (U.S. Fish and Wildlife Service, National Park Service, and Bureau of Land Management), the Council on Environmental Quality, Nevada Department of Transportation, and Native American tribes.

S.9 Conclusions

S.9.1 MAJOR CONCLUSIONS OF THE REPOSITORY SEIS

The Proposed Action would cause preclosure environmental impacts from construction, operation, monitoring, and closure of the repository. There could also be postclosure impacts to the health and safety of future generations. The preclosure and postclosure impacts from the repository are provided in Table S-1. Potential impacts associated with the transportation of spent nuclear fuel and high-level radioactive waste nationally and in Nevada are presented in Table S-2. These impacts include those estimated for the construction and operation of a railroad in Nevada.

As reported in Table S-1, the Repository SEIS analysis demonstrated that the postclosure performance of the proposed repository over the first 10,000 years after closure would result in a mean and median annual individual dose that would not exceed 0.24 millirem and 0.12 millirem, respectively, to the 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 2.3 millirem and 0.98 millirem, respectively, to the RMEI at the same location. There would be no adverse health effects to individuals from these projected doses.

Estimated impacts of the No-Action Alternative are presented in Table S-3 to provide a basis of comparison with the Proposed Action.

The compilation of all preclosure impacts resulting from the repository and National and Nevada transportation is presented in Table S-4. The table illustrates the aggregation of impacts within each resource area that overlap within the repository region of influence.

Considering the preclosure and postclosure impacts presented in this Repository SEIS, DOE concludes that the potential impacts associated with the current repository design and operational plans are similar in scale to impacts presented in the Yucca Mountain FEIS.

S.9.2 AREAS OF CONTROVERSY

In the Yucca Mountain FEIS, DOE acknowledged that areas of controversy exist regarding the Proposed Action and the analyses of its impacts. DOE believes that several of these areas remain of concern and reflect differing points of view or irreducible uncertainties.

Table S-1. Potential preclosure and postclosure impacts from repository construction, operations, monitoring, and closure.

Resource area	Preclosure impacts	Postclosure impacts
Land use and ownership	Small; about 9.1 km^2 (2,200 acres) of disturbed land; 600 km^2 (150,000 acres) of land withdrawn from public use.	Small; potential for limited access into the area; reclamation of disturbed land would restore preconstruction conditions; the only surface features remaining would be markers.
Air quality	Small; releases 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 land withdrawal area boundary.	Small; population doses from release of gaseous radionuclides would be on the order of 1×10^{-8} person-rem in the 80-km (50-mile) radius around the repository.
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 constructed above flood zones or diversion channels would be constructed to keep flood waters away; floodplain assessment concluded impacts would be small.	Small; potential sources for surface water contamination would no longer be present.
Groundwater	Small to moderate; minimal potential to change recharge rates and for contaminants to be released and reach groundwater; peak water demand (430 acre-feet per year) below the lowest estimate of the groundwater basin's perennial yield (580 acre-feet); after construction, water demand would decrease to 260 acre-feet per year or less. Groundwater would be withdrawn from existing wells and possibly a new well to support Gate 510 facilities.	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 0.12 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 2.3 millirem and 0.98 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.
Biological resources and soils	Small; loss of up to 9.1 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.	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.

Table S-1. Potential preclosure and postclosure impacts from repository construction, operation, monitoring, and closure (continued).

Resource area	Preclosure impacts	Postclosure impacts
Cultural resources	Small; ground disturbances and activities that could destroy or modify the integrity of archaeological or cultural resource sites would be minimized through avoidance of sites and mitigation. Indirect impacts that could result from easier physical access to the land withdrawal area, such as unauthorized excavation and collection of artifacts, would be mitigated by training, monitoring and establishing long-term management of sites. Opposing Native American viewpoint exists.	Small; potential for limited access into the area; opposing American Indian viewpoint.
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 1.52 percent above baseline in Nye County.	Small; no workers, no impacts.
	Operations: Small impacts in region; peaks are 0.06 percent above baseline in Clark County and 2.0 percent above baseline in Nye County.	
Peak real disposable income (million dollars)	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.	Small; no workers, no impacts.
	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.	
Peak incremental Gross Regional Product (million dollars)	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.	Small; no workers, no impacts.
	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.	
Occupational and public health and safety		
Public, Radiological		
MEI (probability of an LCF)	0.00029	1.4×10^{-7}
Population (LCFs)	8	Not calculated.

Table S-1. Potential preclosure and postclosure impacts from repository construction, operation, monitoring, and closure (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.	Small; exposures well below regulatory limits.
Workers (involved and noninvolved)		
Radiological (LCFs)	4.4	No workers; no impacts.
Nonradiological fatalities (includes commuting traffic fatalities)	37	No workers; no impacts.
Accidents, Radiological		
Public MEI (probability of an LCF)	7.2×10^{-11} to 1.4×10^{-5}	Not applicable.
Public Population (LCFs)	2.6×10^{-7} to 0.16	Not applicable.
Workers	6.6×10^{-5} to 2.3 rem (4.0×10^{-8} to 1.4×10^{-3} LCF)	Not applicable.
Noise and vibration	Small; impacts to public would be low due to large distances to residences; workers exposed to elevated noise levels—controls and protection would be used as necessary.	Small; no activities, therefore, no noise or ground vibration.
Aesthetics	Small; the presence of exhaust ventilation stacks on the crest of Yucca Mountain could 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.	Small; the only constructed surface features remaining would be markers.
Utilities, energy, materials, and site services	Small; use of materials would be small in comparison to amounts used in the region; electric power delivery system to the Yucca Mountain site would need enhancement.	Small; no use of materials or energy.

Table S-1. Potential preclosure and postclosure impacts from repository construction, operation, monitoring, and closure (continued).

Resource area	Preclosure impacts	Postclosure impacts
Waste and hazardous materials	Construction/demolition debris – 476,000 cubic meters (AA cubic yards) Industrial wastewater – 1.2 million cubic meters (BB gallons) Sanitary sewage – 2.0 million cubic meters (CC gallons) Sanitary/industrial waste – 100,000 cubic meters (DD cubic yards) Hazardous waste – 8,900 cubic meters (EE cubic yards) Low-level radioactive waste – 7,400 cubic meters (FF cubic yards) None of the projected volumes of waste would exceed regional capacities for disposal or management.	Small; no waste generated or hazardous materials used.
Environmental justice	No identified high and adverse potential impact to population; no identified subsections of the population, including minority or low-income populations that would receive disproportionate impacts. DOE acknowledges the opposing American Indian viewpoint.	Small; no disproportionately high and adverse impacts to minorities or low-income populations; opposing American Indian viewpoint.
Airspace restrictions	Small; if deemed necessary, DOE would obtain exclusive control of a lightly used 48-km^2 (19 square miles) airspace and implement specific restrictions to the Nevada Test Site restricted airspace; airspace restrictions could be lifted once operations were complete.	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.	Not applicable.
Occupational and public health and safety	Small; 1,700 reportable occupational injuries and illnesses and 0.61 fatality over entire manufacturing campaign.	Not applicable.
Socioeconomics	Moderate; the area of a typical manufacturing site could see increases of up to 4.6 percent in the average annual output; up to 2.5 percent in the average annual income; and up to 0.63 percent in the average annual employment.	Not applicable.

Table S-1. Potential preclosure and postclosure impacts from repository construction, operation, monitoring, and closure (continued).

Resource area	Preclosure impacts	Postclosure impacts
Materials use	Moderate; annual use of chromium and nickel in component manufacturing would each be roughly 3 percent of U.S. production, or imports in the case of nickel. Annual use of titanium would be 22 percent of U.S. imports in 2006 when there was limited domestic production, but increased domestic production is forecast for the future.	Not applicable.
Waste generation	Small; a typical manufacturing facility would generate 7.5 metric tons (8.3 tons) of liquid waste and 1 metric ton (1.1 tons) of solid waste per year.	Not applicable.
Environmental justice	Disproportionately high and adverse impacts to minority or low-income populations would be unlikely from the manufacturing activities.	Not applicable.

km = kilometer.
km^2 = square kilometer.
LCF = Latent cancer fatality.
MEI = Maximally exposed individual.
NRC = U.S. Nuclear Regulatory Commission.

Table S-2. 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 kilometers (281 to 312 miles).
Land use and ownership	Small[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: 1.3 to 1.8 km^2 (320 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 0.014 km^2 (2.7 to 3.5 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: 14 to 71. Area of affected private land: 0.33 to 0.72 km^2 (82 to 178 acres).	Private parcels the rail line would cross: 1 to 40. Area of affected private land: 0.21 to 0.59 km^2 (52 to 146 acres).
		Active grazing allotments the rail line would cross: 24 to 27. Animal unit months lost: 1,019 to 1,050. (An animal unit month represents enough dry forage for one mature cow for 1 month.)	Active grazing allotments the rail line would cross: 5 to 8. Animal unit months lost: 159 to 246.
		Sections with unpatented mining claims that would be crossed: 32 to 37.	Sections with unpatented mining claims that would be crossed: 23 to 30.
Air quality	Small[b]	Rail line construction would result in PM_{10}, $PM_{2.5}$, and NO_x, increases greater than the 2002 county-wide burden for Lincoln and Nye Counties and in NO_x increase greater than the 2002 county-wide burden for Esmeralda County. 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 construction would result in CO, VOC, $PM_{2.5}$, PM_{10}, and NO_x increases greater than the 2002 county-wide burden for Esmeralda County; NO_x increase greater than the 2002 county-wide burden for Nye County; and CO, $PM_{2.5}$, PM_{10} and NO_x increases greater than the 2002 county-wide burdens for Mineral County. Rail line construction would not add any criteria air pollutants greater than the 2002 county-wide burden for Churchill and Lyon counties. 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 add less than about 20 percent to the 2002 county-wide 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 county-wide burden of all criteria air pollutants for both Esmeralda and Nye counties and less than about 1 percent to the 2002 county-wide burden of all criteria air pollutants for Churchill and Lyon counties.

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

Resource area	National transportation	Nevada transportation[a]	
		Caliente implementing alternative	Mina implementing alternative
Air quality (continued)			Rail line operations would add less than about 2 percent to the 2002 county-wide emissions for SO_2, CO, $PM_{2.5}$, PM_{10} and VOCs and about 80 percent for NO_x emissions for Mineral County. Rail line operations would not lead to an exceedance of air quality standards.
		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 quarry in Esmeralda County during construction of the rail line shows no air pollutant would exceed 60 percent of the NAAQS for any averaging period. Operation of a proposed quarry in Mineral County could result in exceeding 24-hour PM_{10} and $PM_{2.5}$ standards, but measures required by the Surface Disturbance Permit would greatly reduce PM_{10} and $PM_{2.5}$ emissions making exceedances of the NAAQS unlikely. Construction of the Staging Yard at Hawthorne in Mineral County could result in exceeding 24-hour PM_{10} and $PM_{2.5}$ standards in the immediate vicinity under some conditions. Lincoln County. Not applicable.
Hydrology			
Surface water	Small[b]	Approximately 0.33 km^2 (81 acres) of wetlands could be filled.	Not more than 28 m^2 (300 square feet) of wetlands would be filled.
Groundwater	Small[b]	Physical impacts to existing groundwater resource features such as existing wells or springs resulting from railroad construction and operation would be small.	Physical impacts to existing groundwater resource features such as existing wells or springs from railroad construction and operations would be small.
		Groundwater withdrawals during construction in some areas could impact 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 withdrawals during 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.

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

Resource area	National transportation	Nevada transportation[a]	
		Caliente implementing alternative	Mina implementing alternative
Hydrology (continued)		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.	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[b]	Short-term impact to 0.12 to 0.24 km^2 (30 to 59 acres) wetland/riparian habitat. Long-term impact to 0.11 to 0.23 km^2 (27 to 57 acres) wetland/riparian habitat. Impacts would vary by alternative segment, be localized, and could include: • Short-term moderate impact on riparian • and wetland vegetation • Long-term moderate impacts on riparian and wetland vegetation • Small to moderate impacts on raptor nesting sites • Short-term moderate impacts to desert big horn sheep	Short-term impact to 0.01 to 0.05 km^2 (2.5 to 12 acres) wetland/riparian habitat. Long-term impact up to 0.01 km^2 (0 to 2.5) wetland/riparian habitat. Impacts would vary by alternative segment, be localized, and could include: • Short-term moderate impact on riparian and wetland vegetation • Short-term moderate impacts to Lahontan cutthroat trout • Small to moderate long-term impacts to Inter-Mountain mixed salt desert scrub and Inter-Mountain Basins Greasewood Flat • Moderate long-term impact to Inter-Mountain mixed salt desert scrub • Short-term and long-term moderate 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 • Short-term moderate impacts to desert big horn sheep
Cultural resources	Small[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 National Register-eligible sites 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 National Register-eligible sites and to other sites that might be identified during the complete survey. No direct impacts to known paleontological resources.

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

Resource area	National transportation	Nevada transportation[a]	
		Caliente implementing alternative	Mina implementing alternative
Socioeconomics			
New jobs (percent of workforce in affected counties	Small[b]	Construction: Ranges from 0.1-percent increase in Clark County to 5.6-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 less than 0.1-percent increase in Clark County to 3.9-percent increase in Lincoln County.	Operation: Ranges from 0.01-percent increase in Lyon County to 14-percent increase in Esmeralda County.
Peak real disposable income (million dollars)	Small[b]	Construction: Ranges from 0.2-percent increase in Clark County to 7.6-percent increase in Esmeralda County.	Construction: Ranges from 0.03-percent increase in Lyon County to 27-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.	Operation: Ranges from 0.01-percent increase in Lyon County to 10-percent increase in Esmeralda County.
Peak incremental Gross Regional Product (million dollars)	Small[b]	Construction: Ranges from 0.2-percent increase in Clark County to 28-percent increase in Lincoln County.	Construction: Ranges from 0.04-percent increase in Lyon County to 57-percent increase in Esmeralda County.
		Operation: Ranges less than 0.1-percent increase in Clark County to 5.2-percent increase in Lincoln County.	Operation: Ranges less than 0.01-percent increase in Lyon County to 24-percent increase in Esmeralda County.
Occupational and public health and safety			
Public, Radiological			
MEI (probability of an LCF)	1.3×10^{-4}	4.7×10^{-6}	4.7×10^{-6}
Population (LCFs)	0.63 to 0.69	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)	9.8 to 10	0.78	0.77 to 0.79
Nonradiological fatalities (includes commuting traffic and vehicle emissions fatalities)	63 to 65	21	22

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

Resource area	National transportation	Nevada transportation[a]	
		Caliente implementing alternative	Mina implementing alternative
Noise and vibration	Small[b]	Noise from construction activities would exceed Federal Transit Administration guidelines in two locations. Noise from rail construction would be temporary. There would be no adverse noise or vibration impacts from construction trains or from operational train activity.	Noise impacts from construction would be considered temporary adverse impacts at two locations. Noise from operations would create adverse noise impacts at two locations. There would be no vibration impacts from construction trains or from operational train activity.
Aesthetics	Small[b]	Small to moderate 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 moderate 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.
Utilities, energy, materials, and site services	Small[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 provided 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 provided at construction camps and operations facilities; small impact on public systems from population increase attributable to construction and operation employees.
		Telecommunications: Dedicated telecommunication systems; minimal reliance on communications providers.	Telecommunications: Dedicated telecommunication systems; minimal reliance on communications providers.
		Electricity: Peak demand would be within capacity of regional providers.	Electricity: Peak demand would be within capacity of regional providers.
		Fossil fuels: Fossil-fuel demand would be approximately 6.5 percent of state-wide use during construction and less than 0.25 percent of state-wide 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 state-wide 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 state-wide 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 state-wide use during operation. Demand could be met by existing regional supply systems and suppliers.

Table S-2. 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 (continued)		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[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[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.

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 to the impacts of other nationwide transportation activities

c. Based on a worker who would receive the administrative dose limit of 500 millirem per year.

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.
SO_2 = Sulfur dioxide.
VOC = Volatile organic compounds.

Table S-3. Potential impacts from the No-Action Alternative.

Resource area	Repository	Commercial and DOE sites		
		Short-term	Long-term (100 to 10,000 years)	
		100 years	Scenario 1	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 (9.8 – 98 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 manage 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 storm water holding ponds; active monitoring would ensure quick response to leaks or releases; commercial and DOE sites for storage likely would be outside of 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 (9.8 – 98 acres).

Table S-3. Potential impacts from the No-Action Alternative (continued).

Resource area	Repository	Commercial and DOE sites		
		Short-term	Long-term (100 to 10,000 years)	
		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-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.	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)		5.2×10^{-6}[a]	1.6×10^{-6}[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 S-3. Potential impacts from the No-Action Alternative (continued).

Resource area	Repository	Commercial and DOE sites		
		Short-term	Long-term (100 to 10,000 years)	
		100 years	Scenario 1	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, with 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 to total regional use.	Small; materials and energy use would be small in comparison to 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 landfills. DOE would minimize waste by salvaging most equipment and many materials.	Small; waste generated and materials used would be small in comparison to total regional generation and use.	Small; waste generated and materials used would be small in comparison to total regional generation and use.	No generation of waste or use of hazardous materials; therefore, no impacts.

Table S-3. 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 potentially 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.
FEIS = Yucca Mountain Final Environmental Impact Statement.
km^2 = square kilometer.
LCF = Latent cancer fatality.
MEI = Maximally exposed individual.
SEIS = Repository Supplemental Environmental Impact Statement.

Table S-4. 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 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, (2.7 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 71; area of private land affected would range from 0.21 to 0.72 km^2 (52 to 178 acres). Active grazing allotments the rail line would cross would range from 5 to 27. Animal unit months lost would range from 159 to 1,050. Sections with unpatented mining claims that would be crossed would range from 23 to 37.	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.	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 84 percent of the regulatory limit. The simultaneous operation of the repository and railroad would not exceed regulatory limits.

Table S-4. 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 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 constructed above flood zones or diversion channels would be constructed to keep flood waters away; floodplain assessment concluded impacts would be small. Up to 0.33 km^2 (81 acres) of wetlands could be filled.	At least two of the drainage channels and floodplains (Busted Butte Wash and Drill Hole Wash) crossed by the railroad would also be affected by construction of repository surface facilities.
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 (430 acre-feet per year) 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 260 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 640 acre-feet would result from the combined Nevada transportation and repository needs, assuming construction periods overlapped. This high level would last only 1 year and occur the year repository construction started. The average annual water demand for the combined construction period would be 440 acre-feet. With the exception of the first peak year, all of the 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 year 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 S-4. Summary of potential preclosure impacts of the Proposed Action (continued).[a]

Resource area	Summary of all preclosure impacts (all preclosure impacts from the repository, national transportation, and Nevada transportation)	Summary of repository and Nevada transportation impacts in 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 Lahontan cutthroat trout, western snowy plover, and desert tortoise. Short-term impact of up to 0.24 km^2 (59 acres) wetland/riparian habitat. Long-term impact of up to 0.23 km^2 (57 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, up to 60 National Register-eligible sites, along segments of alignments subject to sample inventory and 3 sites in the repository region of influence. Opposing Native American 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 National Register-eligible prehistoric sites; opposing Native American viewpoint.
Socioeconomics		
New jobs (percent of workforce in affected counties	Construction: Peaks range from 0.15 percent above baseline in Clark County to 14-percent increase in Esmeralda County. Operation: Peaks 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 overlap.
Peak real disposable income (million dollars)	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 S-4. Summary of potential preclosure impacts of the Proposed Action (continued).[a]

Resource area	Summary of all preclosure impacts (all preclosure impacts from the repository, national transportation, and Nevada transportation)	Summary of repository and Nevada transportation impacts in 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 (million dollars)	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)	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
	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)	

Table S-4. Summary of potential preclosure impacts of the Proposed Action (continued).[a]

Resource area	Summary of all preclosure impacts (all preclosure impacts from the repository, national transportation, and Nevada transportation)	Summary of repository and Nevada transportation impacts in overlapping regions of influence
Occupational and public health and safety		
Public, Radiological		
MEI (probability of an LCF)	2.9×10^{-4} (repository) 1.3×10^{-4} (transportation)	See Summary of all preclosure impacts column.
Population (LCFs)	8.6–8.7 (total)	See Summary of all preclosure impacts column.
Public, Nonradiological		
Fatalities due to emissions	Small; exposures well below regulatory limits.	Small; exposures well below regulatory limits.
Workers (involved and noninvolved)		
Radiological (LCFs)	14	See Summary of all preclosure impacts column.
Nonradiological fatalities (includes commuting traffic and vehicle emissions fatalities)	64 to 66 (total)	See Summary of all preclosure impacts column.
Accidents		
Public, Radiological		
MEI (probability of an LCF)	7.2×10^{-11} to 1.4×10^{-5}	See Summary of all preclosure impacts column.
Population (LCFs)	2.6×10^{-7} to 0.16	See Summary of all preclosure impacts column.
Workers, Radiological	6.6×10^{-5} to 2.3 rem (4.0×10^{-8} to 1.4×10^{-3} LCF)	See Summary of all preclosure impacts column.
Noise and vibration	Impacts to public would be low 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 would exceed Federal Transit Administration guidelines in two locations. Noise from rail construction would be temporary. There would be no adverse vibration impacts from construction or operations.	Impacts to public would be low due to large distances from the repository to residences; workers exposed to elevated noise levels – controls and protection used as necessary.
Aesthetics	The exhaust ventilation stacks on the crest of Yucca Mountain could be an aesthetic aggravation to American Indians. If the Federal Aviation Administration required beacons atop the stacks, they could be visible for several miles, especially west of Yucca Mountain. Aesthetic impacts would range from small to moderate 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 could be an aesthetic aggravation to American Indians. If the Federal Aviation Administration required beacons atop the stacks, they could be visible for several miles, especially west of Yucca Mountain.

Table S-4. Summary of potential preclosure impacts of the Proposed Action (continued).[a]

Resource area	Summary of all preclosure impacts (all preclosure impacts from the repository, national transportation, and Nevada transportation)	Summary of repository and Nevada transportation impacts in overlapping regions of influence
Utilities, energy, materials, and site services	Use of materials would be small in comparison to 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 state-wide use during construction and less than 2 percent of state-wide 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 to 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 state-wide use during construction and less than 2 percent of state-wide 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, or 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, or Agreement State site, or an NRC-licensed site.
Environmental justice	No identified high and adverse potential impact to population; no identified subsections of the population, including minority or low-income populations that would receive disproportionate impacts. 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 spend 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.
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 have been completed.	Small impacts to airspace use; airspace restriction could be lifted once operations have 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).

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

S.9.2.1 American Indian Viewpoint

Certain American Indian tribes believe that the repository itself, regardless of its respective impacts, would adversely disturb the natural and cultural environment.

S.9.2.2 Transportation

Disagreement exists about factors relevant to the analyses of the potential environmental impacts from the transportation of spent nuclear fuel and high-level radioactive waste including for example, the specific routing chosen for analysis and the definition of the maximum reasonably foreseeable accident.

S.9.2.3 Evaluation of Postclosure Performance

Uncertainty exists about how to best represent the behavior of natural systems and complex engineered barriers in estimating repository performance over very long time periods extending hundreds of thousands of years into the future.

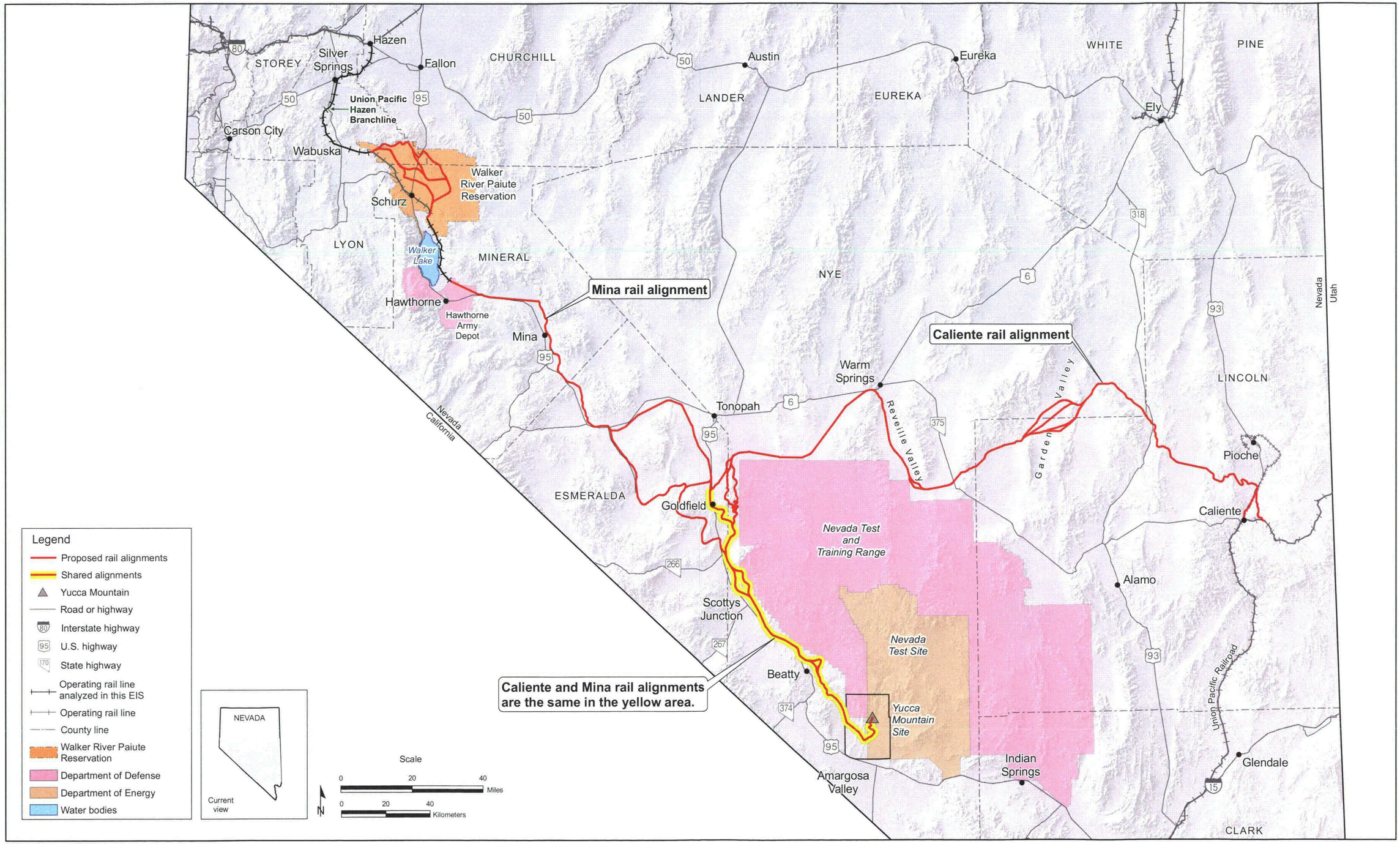
S.9.2.4 Water Rights

Water use and water development projects will continue to be a major concern in the region of influence regardless of the water demands associated with the proposed repository or the railroad. Growth in water demand in Nevada has been very rapid: water use against the backdrop of regional water transfer plans remains an overarching controversial issue.

S.9.3 ISSUES TO BE RESOLVED

For DOE to implement the Proposed Action, these primary issues would have to be resolved:

- DOE would have to complete an application for construction authorization, submit it to NRC, and fully satisfy NRC regulatory and licensing requirements.
- DOE would have to select a rail alignment for the railroad it would build and operate in Nevada and issue a Record of Decision documenting that selection.
- Congress would have to withdraw from public access the land that DOE would need to use for a repository, related facilities, and a buffer zone.
- EPA and NRC would have to finalize their proposed standards regarding the time of compliance for DOE's repository performance assessment.


Hazen
Silver Springs
Fallon
STOREY
CHURCHILL
Austin
Eureka
WHITE
PINE
LANDER
EUREKA
Ely
Union Pacific Hazen Branchline
Carson City
Wabuska
Walker River Paiute Reservation
Schurz
LYON
Walker Lake
MINERAL
NYE
Mina rail alignment
Hawthorne
Hawthorne Army Depot
Mina
Caliente rail alignment
Warm Springs
LINCOLN
Tonopah
Reveille Valley
Garden Valley
Nevada
California
Nevada
Utah
Pioche
ESMERALDA
Goldfield
Caliente
Nevada Test and Training Range
Alamo
Scottys Junction
Nevada Test Site
Union Pacific Railroad
Beatty
Yucca Mountain Site
Caliente and Mina rail alignments are the same in the yellow area.
Indian Springs
Glendale
Amargosa Valley
CLARK
Legend
Proposed rail alignments
Shared alignments
Yucca Mountain
Road or highway
Interstate highway
U.S. highway
State highway
Operating rail line analyzed in this EIS
Operating rail line
County line
Walker River Paiute Reservation
Department of Defense
Department of Energy
Water bodies
NEVADA
Current view
Scale
0 20 40 Miles
0 20 40 Kilometers
N