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7

Environmental Impacts of the No-Action Alternative

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7. ENVIRONMENTAL IMPACTS OF THE NO-ACTION ALTERNATIVE

This chapter describes the potential impacts associated with the No-Action Alternative described in Chapter 2. Under the No-Action Alternative and consistent with the Nuclear Waste Policy Act, as amended [NWPA, Section 113(c)(3)], the U.S. Department of Energy (DOE) would terminate activities at Yucca Mountain and undertake site reclamation to mitigate any significant adverse environmental impacts. Commercial utilities and DOE would continue to manage spent nuclear fuel and high-level radioactive waste at 77 sites in the United States.

DOE analyzed the No-Action Alternative to serve as a basis for comparing the magnitude of potential environmental impacts in the Proposed Action. Under the No-Action Alternative, and consistent with the NWPA, DOE would terminate activities at Yucca Mountain and undertake site reclamation to mitigate any significant adverse environmental impacts. In addition, DOE would prepare a report to Congress, with its recommendations for further action to ensure the safe, permanent disposal of spent nuclear fuel and high-level radioactive waste, including the need for new legislative authority. Under any future course that would include continued storage at the generator sites, commercial utilities and DOE would have to continue managing spent nuclear fuel and high-level radioactive waste in a manner that protected public health and safety and the environment. However, the future course that Congress, DOE, and the commercial utilities would take if Yucca Mountain were not approved is uncertain.

DOE recognizes that a number of possibilities could be pursued, including continued storage of spent nuclear fuel and high-level radioactive waste at its present location, or at one or more centralized location(s); the study and selection of another location for a deep geologic repository (Chapter 1 identifies the process and alternative sites previously selected by DOE for technical study as potential geologic repository locations); the development of new technologies (for example, transmutation); or reconsideration of alternatives to geologic disposal (as discussed in Chapter 2, Section 2.3.1). The environmental considerations of these possibilities have been analyzed in other contexts in other documents to varying degrees. DOE also recognizes that under the No-Action Alternative, there would be an increased probability of shutdown of operating reactors before operating license expiration due to the lack of adequate spent nuclear fuel storage capacity, with an attendant loss of electric power generation for that area or region. While the Department recognizes that many environmental impacts could result from shutting down nuclear power reactors, a full evaluation of such impacts (such as generation of additional air pollution from replacement sources of electricity) would be highly speculative because the choice of a replacement power source (importation, solar, gas, coal, etc.) would be regionally dependent, and the affected utilities would make the ultimate decision. Because the determination of local and regional impacts resulting from the loss of electric generating capacity for shutdown reactors, including the potential for increased electricity prices, would be speculative, the EIS does not include a detailed discussion.

Table 7-1 lists representative studies related specifically to centralized or regionalized interim storage, including alternatives evaluated in DOE National Environmental Policy Act documents, and summarizes the relevant environmental considerations. Those studies contain more information on the potential environmental impacts of centralized or regional interim storage.

In light of these uncertainties, DOE decided to illustrate the possibilities by focusing the analysis of the No-Action Alternative on the potential impacts of two scenarios—long-term storage of spent nuclear fuel and high-level radioactive waste at the current sites with effective institutional control for at least 10,000 years (Scenario 1), and long-term storage with no effective institutional control after about 100 years (Scenario 2). Although the Department agrees that neither of these scenarios is likely, it selected them for analysis because they provide a basis for comparison to the impacts of the Proposed Action and because they reflect a range of the impacts that could occur.

Table 7-1. Documents that address centralized or regionalized storage of spent nuclear fuel and high-level radioactive waste[a] (page 1 of 5).

Title and scope of storage analysis	Environmental and other considerations
Final Environmental Impact Statement, Management of Commercially Generated Radioactive Waste (DIRS 104832-DOE 1980, all)	
Evaluates a proposal to provide interim storage of spent nuclear fuel from U.S. power reactors before final disposal. The proposal would include acceptance of a limited amount of foreign spent fuel if such actions would contribute to U.S. nonproliferation goals. Evaluates several generic interim storage facility alternatives, including centralized storage at a few large ISFS facilities.	Analyses include a description of a *generic interim storage site environment* based primarily on data for the midwestern United States, and potential environmental effects of such a facility for ISFS facilities. Impacts evaluated include: natural resources, radiological impacts, land use, water use, ecological resources, air quality, traffic, noise, socioeconomics, waste management, utilities, aesthetics, transportation (including both to ISFS facilities and from ISFS facilities to the disposition facility), and safeguards and security.
Recommendations on the Proposed Monitored Retrievable Storage Facility (DIRS 103173-Clinch River 1985, all)	
Evaluates DOE proposal to consider the Clinch River Breeder Reactor and ORR sites in Tennessee for an MRS facility. Performed by the Clinch River MRS Task Force, which included three study groups: environmental, socioeconomic, and transportation. Public meetings and site visits were conducted by the study groups. Separate reports by each study group are summarized in findings, concerns, anticipated impacts, and recommended mitigations.	The Environmental Study Group's final report presented concerns and recommended mitigations for MRS construction impacts, damage to ecosystem from construction, special nuclear risks of construction, highway construction impacts, radiation protection of workers and the public, airborne effluents, aqueous releases, hazards from cask rupture, earthquakes, flooding, long-term radionuclide containment, secondary waste stream, local control, offsite emergency response, past contamination of the ORR, environmental data from the ORR, and MRS becoming a permanent waste storage site. The Socioeconomic Study Group's final report identified concerns or potentially negative impacts of an MRS and possible mitigations for business recruitment and expansion, residential recruitment and retention, institutional trust, pre- and postoperational impacts and costs, tourism and aesthetics, site neighbors, and legislative issues. The Transportation Study Group's final report defined areas of potential major impacts (for example, independent inspections, upgrades of railroad tracks, routing and upgrades to preferred highway truck routes, escorts, emergency response plans and training, and requirements applicable to private carriers), and presented findings and recommendations on accident probabilities, barge transport, cask safety and contents, prenotification, and safeguards.

Table 7-1. Documents that address centralized or regionalized storage of spent nuclear fuel and high-level radioactive waste[a] (page 2 of 5).

Title and scope of storage analysis	Environmental and other considerations
Monitored Retrievable Storage Submission to Congress, Volume 2: Environmental Assessment for a Monitored Retrievable Storage Facility (DIRS 104731-DOE 1986, Volume 2, all)	
Evaluates a proposal for the construction of a facility for monitored retrievable storage. Evaluates two facility design concepts at each of three candidate sites in Tennessee (Clinch River Breeder Reactor, ORR, and TVA Hartsville Nuclear Power Plant).	Evaluates impacts common to all three sites and unique to each site, including radiological, air quality, water quality and use, ecological resources, land use, socioeconomics, resource requirements, aesthetics, and transportation. Also evaluates relative advantages and disadvantages of the six site design combinations.
MRS System Study Summary Report (DIRS 104838-DOE 1989, all)	
Evaluates the role of the MRS facility in the waste management system.	Provides additional support to the general conclusion that an MRS facility provides tangible benefits to a waste management system, as articulated in the DOE 1986 MRS proposal to Congress (DIRS 104731-DOE 1986, Volume 2, all). Examines various system configurations in a series of separate publications: • Scenario development and system logistics • Facility design/schedule/cost implications • Alternative MRS storage concepts • Location of high-level radioactive waste packaging • Waste package designs • Transportation impact analyses • Role of waste storage in operations of the waste management system • Licensing impacts of an MRS facility • System reliability
Nuclear Waste Management Systems Issues Related to Transportation Cask Design: At-Reactor Spent Fuel Storage, Monitored Retrievable Storage and Modal Mix (DIRS 104889-Hoskins 1990, all)	
Provides the State of Nevada evaluation of the DOE MRS proposal and the Tennessee studies and position in response.	Addresses the DOE MRS proposal, which evaluated the option of implementing an integral MRS facility as part of a waste management system and the option of "no-MRS facility" as part of the waste management system. The criteria for the evaluation included health and safety, economic, environmental, political (for example, acceptability, public confidence, local and state attitudes), social (for example, fears and anxieties), fairness (for example, equity, intergenerational, utilities/ratepayer, liability, geographic, interutility, and government-utility), repository scheduling, and flexibility (technical and institutional factors).

Table 7-1. Documents that address centralized or regionalized storage of spent nuclear fuel and high-level radioactive waste[a] (page 3 of 5).

Title and scope of storage analysis	Environmental and other considerations
Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement (DIRS 101802-DOE 1995, all)	
Analyzes transportation and centralized interim storage of existing and projected inventories of DOE spent nuclear fuel (including naval spent nuclear fuel) at one site. Considers five interim storage sites (Hanford, INEEL, ORR, SRS, and the Nevada Test Site).	Focuses on key discriminator disciplines at each of the five sites, including socioeconomics, utilities (electricity), materials and waste management, occupational and public health and safety (radiation effects and accidents), transportation, and uncertainties and conservatism. Discusses cumulative impacts and impacts of no action. Does not provide detailed discussions of land use, cultural resources, aesthetic/scenic resources, geologic resources, air quality, water resources, ecological resources, noise, and utilities and energy because there would be small impacts for these areas that would be indistinguishable among the alternatives.
Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel (DIRS 101812-DOE 1996, all)	
Evaluates a proposal to manage FRR spent nuclear fuel. Evaluates a management alternative for acceptance and management of FRR spent fuel in the United States that includes regionalized storage at SRS, INEEL, Hanford, ORR, and the Nevada Test Site. Basic implementation components of the proposal include policy duration, financing arrangements, amount of FRR spent fuel, location for taking title to FRR spent fuel, marine transport, ports of entry, ground transport, FRR spent fuel management sites, and storage technologies.	Analyzes impacts from policy considerations, marine transport, port activities, ground transport, and fuel management sites. More specifically, for fuel management sites, analyzes impacts for occupational and public health and safety, waste management, cumulative impacts, mitigation measures, and environmental justice. Covers impacts for land use, socioeconomics, cultural resources, aesthetics, scenic resources, geology, water resources, air quality, ecology, noise, utilities and energy, and waste management in general.
Final Waste Management Programmatic Environmental Impact Statement For Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste (DIRS 101816-DOE 1997, all)	
Evaluates programmatic alternatives for managing various DOE wastes including HLW. Regionalized and centralized storage are among the management options evaluated. Under the regionalized alternatives, canisters from West Valley would be transported either to SRS or to Hanford, and HLW canisters would continue to be stored at Hanford, SRS, and INEEL until acceptance at the geologic repository. Under the centralized storage alternative, canisters would be transported from West Valley, INEEL, and SRS to Hanford, where they would be stored until acceptance at a geologic repository.	Describes regionalized and centralized sites based on available site-specific data and existing and planned storage facilities for HLW canisters. Impacts evaluated include health risks (includes transportation), air quality, water resources, ecological resources, economics, population, environmental justice, land use, infrastructure, cultural resources, and costs.

Table 7-1. Documents that address centralized or regionalized storage of spent nuclear fuel and high-level radioactive waste[a] (page 4 of 5).

Title and scope of storage analysis	Environmental and other considerations
Environmental Report for the Private Fuel Storage Limited Liability Company's (PFS) Proposed Independent Spent Fuel Storage Installation (ISFSI) License Application (DIRS 103436-PFS 1997, all)	
Evaluates the impacts of a privately owned dry fuel storage facility proposed to be built in western Utah on the Skull Valley Goshute Indian Reservation. The facility would receive and store as much as 40,000 MTHM from several commercial nuclear reactor plants. In June of 2000, the NRC published a Draft EIS to support its licensing process for this facility.	Provides detailed descriptions and environmental impact analyses associated with construction and operation of the site and transportation corridors for geography, land use, and demography; ecological resources; climatology and meteorology (including air quality); hydrological resources; mineral resources; seismology; socioeconomics (including environmental justice analysis); noise and traffic; regional historic and cultural resources; scenic and natural resources; background radiological characteristics; and transportation (radiological and nonradiological impacts). Addresses installation siting and design alternatives based on several specific evaluation criteria (geography and demography; ecology; meteorology; hydrology; geology; regional historic/archaeological/architectural/scenic, cultural/natural features; noise; radiological characteristics).
Centralized Interim Storage Facility Topical Safety Analysis Report (DIRS 103375-DOE 1998, all)	
Analyzes an above-ground temporary storage facility for up to 40,000 MTHM of commercial reactor spent nuclear fuel. The non-site-specific analysis concludes that DOE could construct and operate the commercial interim storage facility in a manner that protects public health and safety.	Describes generic site characteristics and design criteria developed to bound, to the extent possible, site-specific values once a CISF is selected. Generic site characteristics include meteorology, surface hydrology, geology, and seismology. Principal design parameters evaluated for normal and accident conditions include type of fuel, storage systems, fuel characteristics, tornado (wind and missile load), straight wind, floods, precipitation, snow and ice, seismicity (ground motion and surface faulting), volcanic eruption (ash fall), explosions, aircraft impact, proximity to uranium fuel cycle operations, ambient temperature, solar load, confinement, radiological protection, nuclear criticality, decommissioning, materials handling, and retrieval capability.

Table 7-1. Documents that address centralized or regionalized storage of spent nuclear fuel and high-level radioactive waste[a] (page 5 of 5).

Title and scope of storage analysis	Environmental and other considerations
Draft Environmental Impact Statement for the Construction and Operation of an Independent Spent Fuel Storage Installation on the Reservation of the Shull Valley Band of Goshute Indians and the Related Transportation Facility in Tooele County, (DIRS 152001-NRC 2000, all)	
Evaluates the impacts of a privately owned dry fuel storage facility proposed to be built in western Utah on the Skull Valley Goshute Indian Reservation. The facility would receive and store as much as 40,000 MTHM from several commercial nuclear reactor plants.	Provides detailed descriptions and environmental impact analyses associated with construction and operation of the site and transportation corridors for geography, land use, and demography; ecological resources; climatology and meteorology (including air quality); hydrological resources; mineral resources; seismology; socioeconomics (including environmental justice analysis); noise and traffic; regional historic and cultural resources; scenic and natural resources; background radiological characteristics; and transportation (radiological and nonradiological impacts). Addresses installation siting and design alternatives based on several specific evaluation criteria (geography and demography; ecology; meteorology; hydrology; geology; regional historic/archaeological/architectural/scenic, cultural/natural features; noise; radiological characteristics). Provides impact analyses for the No-Action Alternative where NRC would not approve the license application to construct and operate the proposed storage facility and utilities would continue to store spent nuclear fuel at their reactor sites until it is shipped to a permanent geological repository.

a. Abbreviations: ISFS = independent spent fuel storage; ORR = Oak Ridge Reservation; MRS = monitored retrievable storage; TVA = Tennessee Valley Authority; INEEL = Idaho National Engineering and Environmental Laboratory; SRS = Savannah River Site; FRR = Foreign Research Reactor; HLW = high-level radioactive waste; MTHM = metric tons of heavy metal; NRC = U.S. Nuclear Regulatory Commission; CISF = centralized interim storage facility.

Chapter 2 describes the scenarios more fully. Appendix K contains detailed descriptions of the assumptions for each scenario. For consistency, the No-Action analysis considered the same spectrum of environmental impacts as the analysis of the Proposed Action. However, because of the DOE commitment to manage spent nuclear fuel and high-level radioactive waste safely and the uncertainties typical in predictions of the outcome of complex physical and biological phenomena over long periods, DOE decided to focus the No-Action analysis on the short- and long-term health and safety of workers and members of the public.

To ensure a consistent comparison with the Proposed Action for the cumulative effects analysis, the analysis included the impacts of the continued storage of spent nuclear fuel and high-level radioactive waste in excess of 70,000 metric tons of heavy metal (MTHM). This additional material, with the 70,000 MTHM under the Proposed Action (collectively called Module 1), includes 105,000 MTHM of commercial spent nuclear fuel, 2,500 MTHM of DOE spent nuclear fuel, and 22,280 canisters of high-level radioactive waste.

In view of the almost unlimited possible future states of society and the importance of these states to future risk and dose, the National Research Council recommended the use of a particular set of assumptions about the biosphere (for example, how people get their food and water and from where) for compliance calculations such as those performed to evaluate long-term repository performance. Further, the National Research Council recommended the use of assumptions that reflect current technologies and living patterns (DIRS 100018-National Research Council 1995, p. 122). For consistency with the methods used to analyze environmental impacts from the proposed repository, the No-Action analysis selected current technologies and living patterns for the long-term impact evaluation, even though they might not represent an accurate prediction of future conditions.

DEFINITION OF METRIC TONS OF HEAVY METAL

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

Under Scenario 1, 77 sites around the country would store spent nuclear fuel and high-level radioactive waste. For this scenario, the analysis assumed that institutional control for at least 10,000 years would ensure regular maintenance and continuous monitoring at the facilities, which would safeguard the health and safety of facility employees, surrounding communities, and the environment. All maintenance, including routine industrial maintenance and maintenance unique to a nuclear materials storage facility, would be performed under standard operating procedures or best management practices to ensure minimal releases of contaminants (industrial and nuclear) to the environment and minimal exposures to workers and the public. With institutional control, the facilities would be maintained to ensure that workers and the public received adequate protection in accordance with current Federal regulations such as 10 CFR Part 20 and Part 835 and DOE Order requirements (see Chapter 11, Tables 11-1, 11-3, and 11-4).

In addition, the Scenario 1 analysis assumed that storage facilities would undergo replacement every 100 years and would undergo major repairs halfway through the first 100-year cycle, because the storage facilities at any site would be built for a facility life of less than 100 years. (Federal regulations [10 CFR 72.42(a)] require license renewal every 20 years.) Figure 7-1 shows facility timelines for Scenarios 1 and 2.

DOE and commercial organizations intend to maintain control of the nuclear storage facilities as long as necessary to ensure public health and safety. However, to provide a basis for evaluating the upper limits of potential adverse human health impacts, Scenario 2 assumes no effective institutional control of the storage facilities after approximately the first 100 years. Therefore, after about 100 years and up to 10,000 years, the scenario assumes that spent nuclear fuel and high-level radioactive waste storage facilities at 72 commercial sites and 5 DOE sites would begin to deteriorate and that the radioactive materials in the spent nuclear fuel and high-level radioactive waste would eventually be released to the environment, contaminating the local soil, surface water, and groundwater. Appendix K contains the details of this long-term analysis.

For this environmental impact statement (EIS), DOE performed analyses to 10,000 years from the present. To parallel the repository analysis, the No-Action analysis considered both short- and long-term impacts. Short-term impacts would be those experienced during about the first 100 years, and long-term impacts would be those experienced during the remaining 9,900 years. Short-term impacts would be the

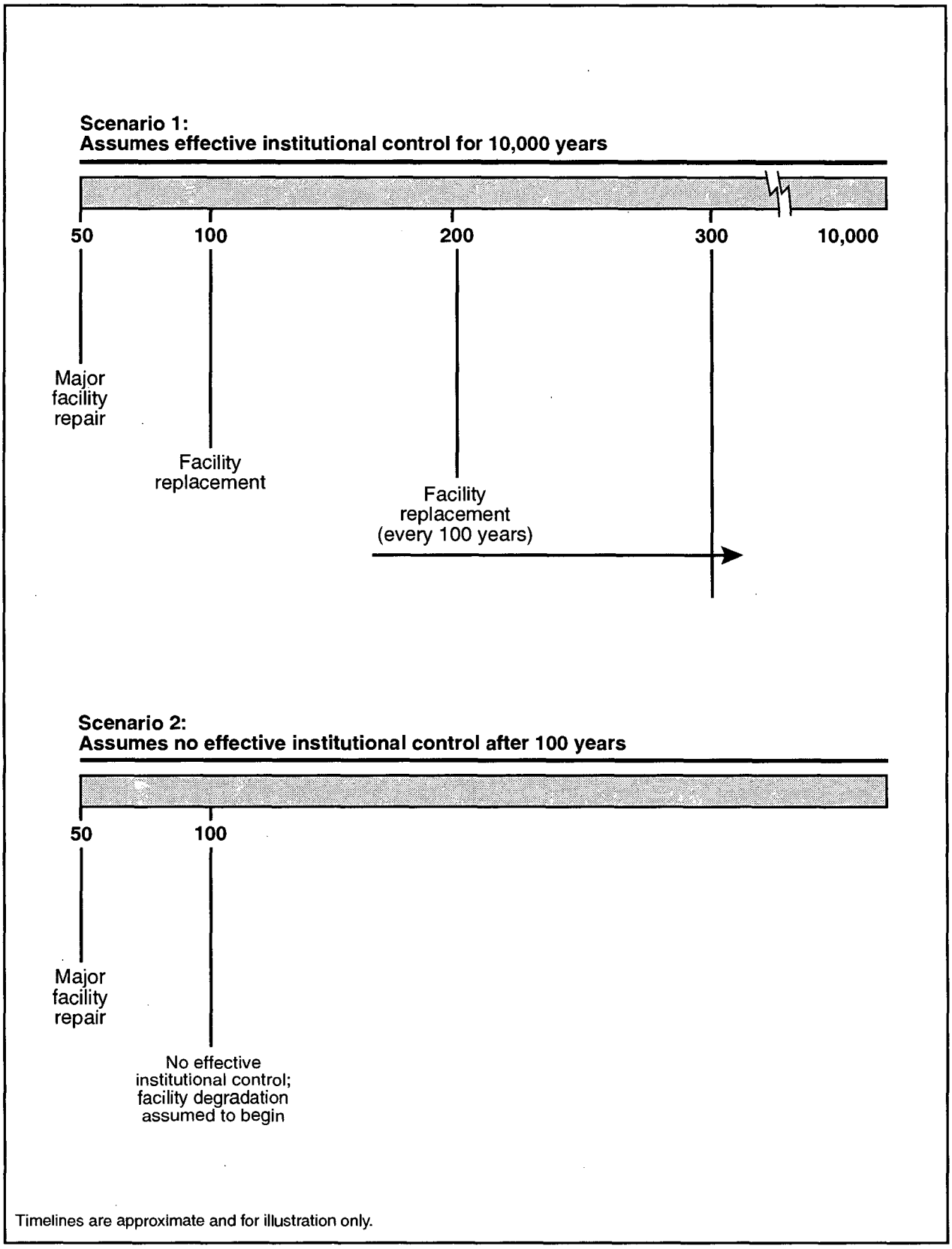


Figure 7-1. Facility timeline assumptions for No-Action Scenarios 1 and 2.

same under Scenarios 1 and 2 because both scenarios assume institutional control during this period. The short-term No-Action Alternative impacts include those resulting from the termination of activities at Yucca Mountain and decommissioning and reclamation of the site, so there would be no long-term impacts at the Yucca Mountain site. In addition, the short-term No-Action Alternative impacts at Yucca Mountain would be the same for both scenarios.

Impacts at the 77 sites after approximately 100 years (long-term) under Scenario 1 primarily would affect facility workers. Long-term impacts at the storage sites after approximately 100 years under Scenario 2 would affect only members of the public because the facility would close and there would be no workers (Scenario 2 assumes no effective institutional control after about 100 years).

To permit a comparison of both short- and long-term impacts from the construction, operation and monitoring, and eventual closure of a proposed repository at Yucca Mountain and from the No-Action Alternative, DOE took care to maintain as much consistency as possible in the methods used to analyze environmental impacts from the proposed repository and the No-Action Alternative. Important consistencies include the following:

- Identical spent nuclear fuel and high-level radioactive waste inventories:
  - Proposed Action: 63,000 metric tons of heavy metal (MTHM) of commercial spent nuclear fuel, 2,333 MTHM of DOE spent nuclear fuel, 8,315 canisters of high-level radioactive waste, and surplus weapons-usable plutonium (as mixed-oxide fuel or immobilized plutonium)
  - Module 1: Proposed Action materials plus an additional 42,414 MTHM of commercial spent nuclear fuel, 167 MTHM of DOE spent nuclear fuel, and 13,965 canisters of high-level radioactive waste resulting in a total of 105,000 MTHM of commercial spent nuclear fuel, 2,500 MTHM of DOE spent nuclear fuel, and 22,280 canisters of high-level radioactive waste.

    This inventory includes surplus plutonium in the form of mixed-oxide fuel or immobilized plutonium (see Appendix A, Figure A-2).
- Identical evaluation periods of 100 years (short-term impacts) and of 100 to 10,000 years (long-term impacts)
- Consistent spent nuclear fuel and high-level radioactive waste corrosion and dissolution models
- Identical radiation dose and risk conversion factors
- Similar assumptions regarding the habits and behaviors of future population groups (that is, they would not be greatly different from those of populations today)

Since issuing the Draft EIS, DOE has continued to evaluate design features and operating modes that would improve long-term repository performance and reduce uncertainty. The result of the design evolution process was the development of the flexible design (DIRS 153849-DOE 2001, all), which was evaluated in the Supplement to the Draft EIS. This design focuses on controlling the temperature of the rock between waste emplacement drifts. As a result of these design changes, this Final EIS evaluates a range of repository operating modes (higher- to lower-temperature). The lower-temperature operating mode has the flexibility to remain open and under *active institutional control* for up to 300 years after emplacement. Although Chapter 4 of this EIS includes an evaluation of impacts for this period, DOE did not evaluate the 300-year institutional control case for the No-Action Alternative. The primary reason for not updating this part of the analysis was because if the institutional control period for the analysis of the No-Action Alternative were extended to 300 years, the short-term environmental impacts would have

INSTITUTIONAL CONTROL

Institutional control implemented by commercial utilities and DOE provides monitoring and maintenance of storage facilities to ensure that radiological releases to the environment and radiation doses to workers and the public remain within Federal limits and DOE Order requirements. Having attained this goal, institutional control ensures the maintenance of incurred doses as low as reasonably achievable, taking social and economic factors into account. Because the future course of action taken by the Nation and by commercial utilities would be uncertain if Yucca Mountain were not recommended as a repository site, the continued storage analysis evaluated two hypothetical scenarios with different assumptions about institutional control to bound potential environmental impacts.

The assumption for Scenario 1 is that DOE and commercial utilities would maintain institutional control of the storage facilities to ensure minimal releases of contaminants to the environment for at least 10,000 years.

Scenario 2 assumes no effective institutional control after approximately 100 years. DOE based the choice of 100 years on a review of generally applicable U.S. Environmental Protection Agency regulations for the disposal of spent nuclear fuel and high-level radioactive waste (40 CFR Part 191), U.S. Nuclear Regulatory Commission regulations for the disposal of low-level radioactive material (10 CFR Part 61), and the National Research Council report on standards for the proposed Yucca Mountain Repository (DIRS 100018-National Research Council 1995, p. 106), which generally discount the consideration of institutional control for longer periods in performance assessments for geologic repositories.

increased by as much as 3 times. DOE did not want to appear to overstate the impacts from the No-Action Alternative.

Since the publication of the Draft EIS, DOE modified the spent nuclear fuel cladding corrosion rates and failure mechanisms used in the performance analysis in Chapter 5 of the Final EIS. DOE did not update these models for the No-Action Alternative Scenario 2 analysis because the outcome would have been an increase in the long-term radiation doses and potential health impacts, however, the increase would be within the uncertainties discussed in Appendix K, Section K.4. In addition, the radionuclide inventories for commercial spent nuclear fuel were updated for the Final EIS (see Appendix A, Tables A-8 and A-9) to reflect the higher initial enrichments and burnup projected for commercial nuclear facilities. Although these revised inventories were used to estimate potential short-term repository impacts in the Final EIS (Chapter 4), DOE chose not to update the No-Action inventories because, again, the effect on the outcome would be about a 15-percent increase in health impacts in this chapter.

Affected populations for the No-Action Alternative were, in general, based on 1990 census estimates and not projected to 2035 as was done for the Proposed Action. However, if the population across the Nation had been projected to 2035, the collective impacts resulting from radiation exposure would have increased by less than a factor of 1.5, which is the average expected increase in national population from 1990 to 2035 (DIRS 152471-Bureau of the Census 2000, all).

7.1 Short-Term Impacts in the Yucca Mountain Vicinity

Chapter 3, Section 3.3, discusses the conditions at the sites that formed the basis for identifying potential impacts associated with the No-Action Alternative. The conditions include the relatively small incremental impacts resulting from continued characterization activities in the Yucca Mountain vicinity until 2002. Under the No-Action Alternative, DOE would terminate characterization activities at the site

and would begin site decommissioning and reclamation. Decommissioning and reclamation would include dismantling and removing structures, shutting down some surface facilities, and rehabilitating land disturbed during characterization activities. DOE would salvage usable equipment and materials. Drill holes would be sealed, subsurface drifts and rooms would be left in place, and the portals would be gated. The piles of excavated rock from the tunnel would be landscaped. Areas disturbed by surface studies or used as laydown yards, borrow areas, or the like would be restored. Holding ponds would be backfilled or capped. DOE would not remove foundations or infrastructure such as access roads, parking lots, and sewage systems. The analysis assumed that reclamation activities would take about 1 year. Chapter 2, Section 2.2, describes the No-Action Alternative at Yucca Mountain.

The short-term impacts from reclamation of the Yucca Mountain site would occur regardless of the No-Action Alternative scenario and would be the same for both scenarios.

7.1.1 LAND USE AND OWNERSHIP

Land ownership and control could revert to the original controlling authority.

Under the No-Action Alternative, decommissioning and reclamation would begin as soon as practicable at the Yucca Mountain site, which DOE anticipates would happen in 2002. No new land would be required to support the decommissioning and reclamation activities. Because DOE stored topsoil and material from the mountain during site characterization, it would need no additional land to provide soil for reclaiming the material taken from the mountain or for backfilling holding ponds or the reclamation of other previously disturbed areas. Therefore, the No-Action Alternative would not require the disturbance of additional land at the site. The disturbed land would be restored to its approximate preconstruction condition about 100 years earlier than would occur under the Proposed Action.

7.1.2 AIR QUALITY

Transient effects on air quality would result from the exhausts of the heavy equipment that DOE would use during the decommissioning and reclamation activities that the Department expects to complete over a 1-year period. Recontouring and revegetation activities would generate dust containing particulate matter less than 10 micrometers in diameter (PM_{10}). Impacts on air quality would be about the same as those associated with the construction phase during the Proposed Action for the flexible design, as discussed in Chapter 4, Section 4.1.2, because less land would be disturbed by fewer vehicles during decommissioning and reclamation activities. Because the air quality impacts described in Section 4.1.2 represent a small fraction of the regulatory limit (that is, less than 10 percent of regulatory limits), the No-Action Alternative would not adversely affect air quality.

7.1.3 HYDROLOGY

7.1.3.1 Surface Water

The No-Action Alternative would not adversely affect surface water. During decommissioning and reclamation, adherence to such best management practices as stormwater pollution prevention plans would ensure that cleared areas and exposed earth would be seeded, graveled, or paved to control runoff and minimize soil erosion. To prevent contamination from heavy equipment, workers would monitor the equipment for leaks and would contain and clean up inadvertent spills of industrial fluids following established spill prevention and cleanup plans. DOE would dismantle and remove most surface structures, equipment, and building materials (DIRS 102188-YMP 1995, p. 2-8), including such items as fuel storage tanks and facilities where petroleum products or potentially hazardous materials like paints and solvents were stored before removal. Hazardous materials removed or generated during decommissioning would be taken from the site and reused, recycled, or disposed of in accordance with

applicable regulations (DIRS 102188-YMP 1995, p. 2-8). After closure, contaminant sources would be gone so there could be no movement of contaminants to surface water. The analysis assumed that reclamation activities would be complete about 1 year after the decision to implement the No-Action Alternative, which DOE anticipates would occur in 2002.

As part of the reclamation activities, DOE would recontour the landscape to match its precharacterization conditions, ensuring natural drainage patterns. Because the North and South Portal ramps of the Exploratory Studies Facility slope upward to prevent ingress of surface water, they would not appreciably affect natural drainage patterns. Seeding and other erosion control measures would ensure normal infiltration rates. Under the No-Action Alternative, DOE anticipates that the restoration of natural drainage patterns would be complete about 100 years earlier than under the Proposed Action.

7.1.3.2 Groundwater

The No-Action Alternative would not adversely affect groundwater. DOE would remove all sources of contaminants (such as petroleum products and potentially hazardous materials like paints and solvents) from the site. The entrance ramps of the open portals of the Exploratory Studies Facility are sloped such that surface water would drain away from the openings. During reclamation activities (which would take about 1 year), the Exploratory Studies Facility portals would be closed.

7.1.4 BIOLOGICAL RESOURCES AND SOILS

Approximately 1.4 square kilometers (350 acres) of habitat has been disturbed; most of the disturbance is associated with the Exploratory Studies Facility, the storage area for the material removed from the tunnel, the topsoil storage area, borrow pits, boreholes, trenches, and roads. Site reclamation activities would include removal of structures and equipment, soil stabilization, and revegetation plantings at many of the disturbed sites (DIRS 102188-YMP 1995, all). Proper soil stabilization would prevent erosion. Once the area was reclaimed, stabilized, and planted with natural vegetation, and once activities at the site decreased, the precharacterization floral and faunal diversity would begin to reestablish itself. Some animal species could take advantage of abandoned tunnels for shelter; for example, the tunnels could provide attractive roosting and nesting sites for bats. Individuals of the threatened desert tortoise species could be adversely affected during the decommissioning and reclamation of the site. The No-Action Alternative would have no other adverse effects on biological resources or soils. In addition, the reclamation would result in the restoration of 1.4 square kilometers of habitat.

7.1.5 CULTURAL RESOURCES

The potential effects of other uses of the Yucca Mountain site on cultural resources are not known because no other uses have been identified; therefore, no assessment of the effects is possible. If the land were to revert to the previous controlling authorities, the stewardship of cultural resources would be consistent with applicable policies, regulations, and procedures.

Because no additional land would be required for decommissioning and reclamation activities, disturbances to cultural resources on undisturbed land in the area would be unlikely. Leaving access roads in place could have an adverse impact on cultural resources if the site boundaries are not secure. Preserving the integrity of important archaeological sites and resources important to Native Americans could be difficult if the public had increased access to the site.

7.1.6 SOCIOECONOMICS

Many of the repository workers would shift to decommissioning and reclamation tasks. An average annual workforce of about 1,800 would complete decommissioning and reclamation tasks at the

repository site. After decommissioning and reclamation, the Nevada Test Site would assume the responsibility of preventing inadvertent entry to the North and South Portal areas. A small workforce would protect these areas after reclamation.

After the 1-year decommissioning and reclamation period, the decommissioning and reclamation workforce, along with about 1,400 project-related workers employed away from the repository site, would lose their jobs. The total direct employment reduction, therefore, would be about 3,200 at the completion of decommissioning and reclamation. For every direct job lost, about 0.46 indirect job would also be lost (DIRS 104508-CRWMS M&O 1999, all). *Indirect jobs* are those created as a result of direct employment; examples would include jobs that provide essential services, such as medical and police protection, to the individuals directly employed by the project. Therefore, the overall impact of the No-Action Alternative would be the loss of approximately 4,700 jobs in the region of influence.

As stated in Chapter 3, Section 3.1.7.1, approximately 79 percent of workers at the Yucca Mountain site reside in Clark County, 19 percent reside in Nye County, and less than 1 percent reside in Lincoln County or elsewhere. Thus, ending characterization activities would have the greatest potential impact in Clark County. If the region (Clark, Lincoln, and Nye Counties) continued to add about 2,800 new jobs every month, impacts would be offset by continued economic growth (Chapter 3, Section 3.1.7.2). Therefore, terminating site characterization activities would have a very minor impact on socioeconomic factors.

The cessation of repository activities would result in the loss of payments by the Federal Government in lieu of taxes. Nye County collects most of the monies associated with the repository project. The 1997 Nye County budget totaled approximately $83.8 million (county government and school district). During the same period, Nye County received approximately $5.4 million as payment in lieu of taxes (DIRS 105001-CRWMS M&O 1999, all).

7.1.7 OCCUPATIONAL AND PUBLIC HEALTH AND SAFETY FOR ROUTINE OPERATIONS

Chapter 2, Section 2.2.1, describes the actions DOE would take at Yucca Mountain under the No-Action Alternative. During the decommissioning and reclamation phase, these actions would expose workers and members of the public to the nonradioactive and radioactive contaminants discussed in Chapter 4, Section 4.1.3.1. In addition, these actions would place workers at risk for occupational (industrial safety) incidents such as illnesses, injuries, and fatalities. Appendix F, Section F.2.2.2, describes the statistics used to estimate health and safety impacts from industrial safety incidents. Because the activities that workers would perform under the No-Action Alternative would involve risks similar to those during the construction and closure phases of the Proposed Action, DOE used these statistics to estimate worker health impacts.

Worker exposures to nonradioactive contaminants of concern (diesel engine exhaust and mineral dusts potentially containing respirable erionite and crystalline silica) during decommissioning and reclamation activities would be limited by administrative and engineering means. Exposures would be maintained below occupational levels that could affect worker health adversely, as specified by the Occupational Safety and Health Administration and detailed in the project health and safety plan (DIRS 105032-CRWMS M&O 1999, all). Accordingly, worker exposures to nonradioactive contaminants would not contribute to adverse health impacts.

Tables 7-2 and 7-3 summarize the estimated total impacts from workplace industrial hazards and from radiological exposure, respectively, for reclamation activities. Table 7-4 summarizes impacts to members of the public.

Involved and noninvolved worker group losses under the No-Action Alternative would be about 94 total recordable cases of injury and illness, resulting in about 45 lost workday cases and no fatalities (Table 7-2).

Table 7-2. Estimated industrial safety impacts for surface and subsurface workers during decommissioning and reclamation activities at Yucca Mountain.[a]

Group	Total recordable cases	Lost workday cases	Fatalities
Involved workers	80	38	0
Noninvolved workers	13	7	0
Totals	***94***	***45***	***0***

a. Source: For impact statistics, Appendix F, Tables F-9 and F-10 (1 year of construction, higher-temperature operating mode, uncanistered packaging scenario).

Worker population radiation exposures during the year of decommissioning and reclamation activities would result from exposure to radioactive radon decay products that would emanate from the tunnel's rock matrix and from ambient radiation. Exposures to the subsurface workers could result in a collective dose of about 150 person-rem (Table 7-3). Doses to the maximally exposed involved subsurface worker and noninvolved worker could be as high as about 260 millirem and 70 millirem, respectively.

Table 7-3. Estimated radiation doses and health effects for surface and subsurface workers from decommissioning and reclamation activities at Yucca Mountain.[a,b]

Group	Maximally exposed individual (millirem)	LCF[c] risk to the maximally exposed individual	Collective worker dose[d] (person-rem)	LCF[e]
Involved workers	260	0.00010	140	0.055
Noninvolved workers	70	0.00027	7.4	0.0030
Totals	***NA***[f]	***NA***	***150***	***0.057***

a. Source: Appendix F, Table F-11; data adjusted for 1 year of construction activity.
b. The impacts listed would be the result of 1 year of decommissioning and reclamation activities; adapted from construction phase impacts. Worker doses would result from exposure to radon and other terrestrial radiation sources.
c. LCF = latent cancer fatality.
d. The calculation of doses and health effects assumes no worker rotation for exposure control purposes.
e. Expected number of cancer fatalities for populations. Based on a risk of 0.0004 latent cancer per rem for workers (DIRS 101857-NCRP 1993, p. 112).
f. NA = not applicable.

Public radiation exposures during decommissioning and reclamation would result from radon emissions from the subsurface facilities. These exposures could result in an annual dose to the hypothetical maximally exposed individual, about 18 kilometers (11 miles) south of the repository, of 0.43 millirem. The maximum collective dose to the projected population of 76,000 within 80 kilometers (50 miles) would be about 1.7 person-rem (Table 7-4).

Table 7-4. Estimated public radiation doses and health effects from decommissioning and reclamation activities at Yucca Mountain.[a]

Group	Maximally exposed individual (millirem per year)	Annual increase in risk for contracting an LCF[b]	Collective public dose[c] (person-rem)	LCF
Public	0.43	0.00000022	1.7	0.00085

a. The impacts listed would be the result of 1 year of decommissioning and reclamation activities (Table 4-2, higher-temperature operating mode, which was assumed to equate to 1 year of initial construction activities).
b. LCF = latent cancer fatality; expected number of cancer fatalities for populations. Based on a risk of 0.0005 latent cancer per rem for members of the public (DIRS 101857-NCRP 1993, p. 112), and a life expectancy of 70 years for a member of the public.
c. The collective dose to 76,000 individuals living within 80 kilometers (50 miles) would be from radon emissions from the subsurface facilities.

The increased likelihood of the maximally exposed individual worker experiencing a latent cancer fatality would be very small.

7.1.8 ACCIDENTS

Under the No-Action Alternative, DOE would not ship spent nuclear fuel and high-level radioactive waste to Yucca Mountain, and there would be only limited quantities of nonradioactive hazardous or toxic substances. Therefore, accident impacts would be limited to those from traffic and industrial hazards.

Table 7-2 lists impacts from industrial accident scenarios and Section 7.1.14 discusses impacts from traffic accident scenarios.

7.1.9 NOISE

Noise levels during decommissioning and reclamation activities would be no greater than those of site characterization activities. After the decommissioning and reclamation activities were complete, ambient noise would return to levels consistent with a desert environment where natural phenomena account for most background noise (see Chapter 3, Section 3.1.9.1). The No-Action Alternative would not adversely affect the noise levels of the Yucca Mountain region.

7.1.10 AESTHETICS

Site decommissioning and reclamation activities would improve the scenic value of the site. Borrow pits and holding ponds would be filled or graded, stabilized, and revegetated. Most structures would be removed down to their foundations. The North and South Portals would be gated. The surface area of these disturbed areas would represent a small fraction of the total surface area of the repository site and, therefore, would be unlikely to cause adverse impacts to the overall scenic value of the area. Under the No-Action Alternative, the site would be returned to a state as close as possible to the predisturbed state; therefore, DOE would not expect adverse impacts to the scenic value of the area. Site restoration would occur about 100 years earlier than under the Proposed Action.

7.1.11 UTILITIES, ENERGY, AND MATERIALS

Decommissioning and reclamation activities would consume electricity, diesel fuel, and gasoline. Much equipment and many materials would be salvaged and recycled. DOE would recycle buildings as practicable. After the site closed, minimal surveillance activities would require some electricity and gasoline. The No-Action Alternative would not adversely affect the utility, energy, or material resources of the region.

7.1.12 WASTE MANAGEMENT

The decommissioning and reclamation of the Yucca Mountain site would generate some waste requiring disposal, including sanitary sewage, sanitary and industrial solid waste, small amounts of demolition debris, and very small amounts of hazardous waste. DOE would dispose of the wastes as it has during the site characterization activities.

DOE would minimize waste generation by salvaging most of the equipment and many materials and redistributing them to other DOE sites or selling them at public auction. Remaining chemical supplies would be redistributed through the DOE excess program, which collects equipment and materials no longer in use for reassignment to other DOE sites or Federal facilities, donation to state governments, or sale to the public. DOE would preserve, rather than demolish, certain facilities that could be useful in the future, such as the electrical distribution and water supply systems. Sanitary sewage would be disposed

of in the onsite septic system. At the end of reclamation activities, DOE would cap the inlets to the septic system and leave the system in place. DOE would dispose of sanitary and industrial solid waste and demolition debris in existing Nevada Test Site landfills, where disposal capacity would be available for about 70 years (DIRS 101803-DOE 1995, p. 8).

7.1.13 ENVIRONMENTAL JUSTICE

An examination of analyses from other technical disciplines associated with terminating characterization and construction activities at Yucca Mountain and decommissioning and reclaiming the site shows no potential for large impacts in areas other than cultural resources and socioeconomics. The cultural resources analysis identified the possibility that increased public access (if roads were left open and site boundaries were not secure) could threaten the integrity of archaeological sites and resources important to Native Americans. The socioeconomic analysis identified a potential loss of as many as 4,700 jobs (see Section 7.1.6).

Disproportionate impacts to minority or low-income populations from potential job losses would not be expected because there is no reason to believe that minority or low-income employees would be any more likely to be affected by job loss.

7.1.14 TRAFFIC AND TRANSPORTATION

Fatalities from project-related traffic would be unlikely during decommissioning and reclamation. As a gauge of the probability of 1 fatality, decommissioning and reclamation activities would require about 1 year to complete, or about one-fifth of the time to construct the repository. The analysis in Appendix J estimated less than 0.7 fatality from traffic accidents during repository construction, so less than 0.15 traffic fatality would be likely during decommissioning and reclamation (see Appendix J, Tables J-64 and J-65, for details).

7.1.15 SABOTAGE

There would be no nuclear materials at the Yucca Mountain site, so sabotage concerns would not be pertinent.

7.2 Commercial and DOE Sites

This section analyzes short- and long-term impacts of continued storage of spent nuclear fuel and high-level radioactive waste at 72 commercial and 5 DOE sites for 10,000 years (the period considered for the Proposed Action). The analysis includes No-Action Scenarios 1 and 2.

The following paragraphs discuss short-term impacts under No-Action Scenario 1. Because the analysis assumed that all sites would maintain institutional control for the first approximately 100 years, the short-term impacts for Scenarios 1 and 2 would be the same. For consistency with the Proposed Action, this analysis assumed the No-Action scenarios would begin in 2002. This analysis considered the Idaho National Engineering and Environmental Laboratory to be a site for naval spent nuclear fuel because the Laboratory stores such fuel.

Under the No-Action Alternative, commercial utilities would manage their spent nuclear fuel at 72 facilities. DOE would manage its spent nuclear fuel and high-level radioactive waste at five facilities (the Hanford Site, the Idaho National Engineering and Environmental Laboratory, Fort St. Vrain (spent nuclear fuel only) the West Valley Demonstration Project (high-level radioactive waste only), and the Savannah River Site). The No-Action analysis evaluated the DOE spent nuclear fuel and high-level radioactive waste at existing sites or at sites where existing Records of Decisions have placed or will

place these materials. For example, the Record of Decision (60 FR 18589, April 12, 1995) for the Final Supplemental Environmental Impact Statement, Defense Waste Processing Facility (DIRS 103191-DOE 1994, all) decided to complete construction and operate the Defense Waste Processing Facility and associated facilities at the Savannah River Site to pretreat, immobilize, and store high-level radioactive waste. Similarly, the Hanford Site Final Environmental Impact Statement for the Tank Waste Remediation System (DIRS 103214-DOE 1996, all) identified as the preferred alternative ex situ vitrification of high-level radioactive waste with onsite storage until final disposition in a geologic repository. For DOE spent nuclear fuel, the Record of Decision (60 FR 28680, June 1, 1995) for the Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement (DIRS 101802-DOE 1995, all) decided that Hanford production reactor fuel would remain at the Hanford Site; aluminum-clad fuel would be consolidated at the Savannah River Site; and non-aluminum-clad fuels (including spent nuclear fuel from the Fort St. Vrain reactor and naval spent nuclear fuel) would be transferred to the Idaho National Engineering and Environmental Laboratory. Therefore, the analysis evaluated DOE aluminum-clad spent nuclear fuel at the Savannah River Site and DOE non-aluminum-clad fuel at the Idaho National Engineering and Environmental Laboratory; most of the Fort St. Vrain spent nuclear fuel at the Colorado generating site; and high-level radioactive waste at the generating sites (the West Valley Demonstration Project, the Idaho National Engineering and Environmental Laboratory, the Hanford Site, and the Savannah River Site).

The No-Action Alternative assumes that the spent nuclear fuel and high-level radioactive waste would be treated, packaged, and stored in a condition ready for shipment to a repository. The amount (inventory) of spent nuclear fuel and high-level radioactive waste considered in this analysis would be the same as that for the Proposed Action—70,000 metric tons consisting of 63,000 MTHM of commercial spent nuclear fuel, 2,333 MTHM of DOE spent nuclear fuel, 8,315 canisters of solidified high-level radioactive waste. The 70,000 MTHM would include surplus plutonium in the form of mixed-oxide fuel and immobilized plutonium. In addition, DOE recognizes that more than 107,000 MTHM of commercial and DOE spent nuclear fuel and more than 22,000 canisters of high-level radioactive waste could require storage if a disposal site is not available. Section 7.3 describes the assumptions and analytical methods used to estimate impacts for the total projected inventory of spent nuclear fuel and high-level radioactive waste, referred to as Inventory Module 1, and evaluates the potential impacts of the continued storage of the total projected inventory of commercial and DOE spent nuclear fuel and high-level radioactive waste.

Storage Packages and Facilities at Commercial and DOE Sites

A number of designs for storage packages and facilities at the commercial and DOE sites would provide adequate protection from the environment for packages containing spent nuclear fuel and high-level radioactive waste. Because it has not selected specific designs for most locations, DOE selected a representative range of commercial and DOE designs for analysis, as described in the following paragraphs. In addition, for purposes of analysis, the No-Action Alternative assumed that the commercial and DOE sites have sufficient land to construct the initial and replacement storage facilities and that the initial construction of all dry storage facilities would be complete and the facilities filled by 2002.

Spent Nuclear Fuel Storage Facilities

Most commercial sites currently store their spent nuclear fuel in water-filled basins (fuel pools) at the reactor sites. Because they have inadequate storage space, some commercial sites have built what are called *independent spent fuel storage installations,* in which they store dry spent nuclear fuel above ground in metal casks or in welded canisters inside reinforced concrete storage modules. Other commercial sites plan to build independent spent fuel storage installations so they can proceed with the decommissioning of their nuclear plants and termination of their operating licenses (for example, the Rancho Seco and Trojan plants). Because commercial sites could elect to continue operations until their fuel pools became full and then cease operations, the EIS analysis initially considered ongoing wet storage in existing fuel pools to be a potentially viable option for spent nuclear fuel storage. However,

dry storage is almost certainly the preferred option for long-term spent fuel storage at commercial sites for the following reasons (DIRS 101899-NRC 1996, pp. 6-76 and 6-85):

- Dry storage is a safe economical method of storage.
- Fuel rods in dry storage are likely to be environmentally secure for long periods.
- Dry storage generates minimal, if any, low-level radioactive waste.
- Dry storage units are simpler and easier to maintain.

Accordingly, this EIS assumes that all commercial spent nuclear fuel would be stored in dry configurations in independent spent fuel storage installations at existing locations (Figure 7-2 is a photograph of a typical independent spent fuel storage installation). This assumption includes spent nuclear fuel at sites that no longer have operating nuclear reactors. Although most utilities and DOE have not constructed independent spent fuel storage installations or designed dry storage containers, this analysis evaluates the impacts of storing all commercial and some DOE spent nuclear fuel in horizontal concrete storage modules (Figure 7-3) on a concrete pad at the ground surface. Concrete storage modules have openings that allow outside air to circulate and remove the heat of radioactive decay. The analysis assumed that spent nuclear fuel from both pressurized-water and boiling-water reactors would be stored in a dry storage canister inside the concrete storage module. Figure 7-4 shows a typical dry storage canister, which would consist of a stainless-steel outer shell, welded end plugs, pressurized helium internal environment, and criticality-safe geometry for 24 pressurized-water or 52 boiling-water reactor fuel assemblies.

The combination of the dry storage canister and the concrete storage module would provide safe storage of spent nuclear fuel as long as the fuel and storage facilities were maintained properly. The reinforced concrete storage module would provide shielding against the radiation emitted by the spent nuclear fuel. In addition, the concrete storage module would provide protection from damage resulting from accidents such as aircraft crashes and from natural hazard phenomena such as earthquakes or tornadoes.

This analysis assumed that DOE would store dry spent nuclear fuel at the Savannah River Site, the Idaho National Engineering and Environmental Laboratory, and Fort St. Vrain in stainless-steel canisters inside above-grade reinforced concrete storage modules. In addition, it assumed that the design of DOE above-ground spent nuclear fuel storage facilities would be similar to the independent spent fuel storage installations at commercial sites.

The analysis assumed that DOE would store spent nuclear fuel at Hanford in a dry cask in below-grade storage facilities. DOE would store Hanford N-Reactor fuel in the Canister Storage Building, which would consist of three below-grade concrete vaults with air plenums for natural convective cooling. The vaults would contain vertical storage tubes made of carbon steel. Each storage tube, which would hold two spent nuclear fuel canisters, would be sealed with a shield plug. DOE would cover the vaults with a structural steel shelter.

High-Level Radioactive Waste Storage Facilities

With one exception, this analysis assumed that DOE would store solidified high-level radioactive waste in dry below-grade, high-level radioactive waste storage facilities (Figure 7-5). At the West Valley Demonstration Project, the analysis assumed that DOE would use a dry storage system similar to a commercial independent spent nuclear fuel storage installation for high-level radioactive waste.

A high-level radioactive waste storage facility consists of four areas: below-grade storage vaults, an operating area above the vaults, air inlet shafts, and air exhaust shafts. The canister cavities are galvanized-steel large-diameter pipe sections arranged in a grid. Canister casings are supported by a concrete base mat. Space between the pipes is filled with overlapping horizontally-stepped steel plates that direct most of the ventilation air through the storage cavities.

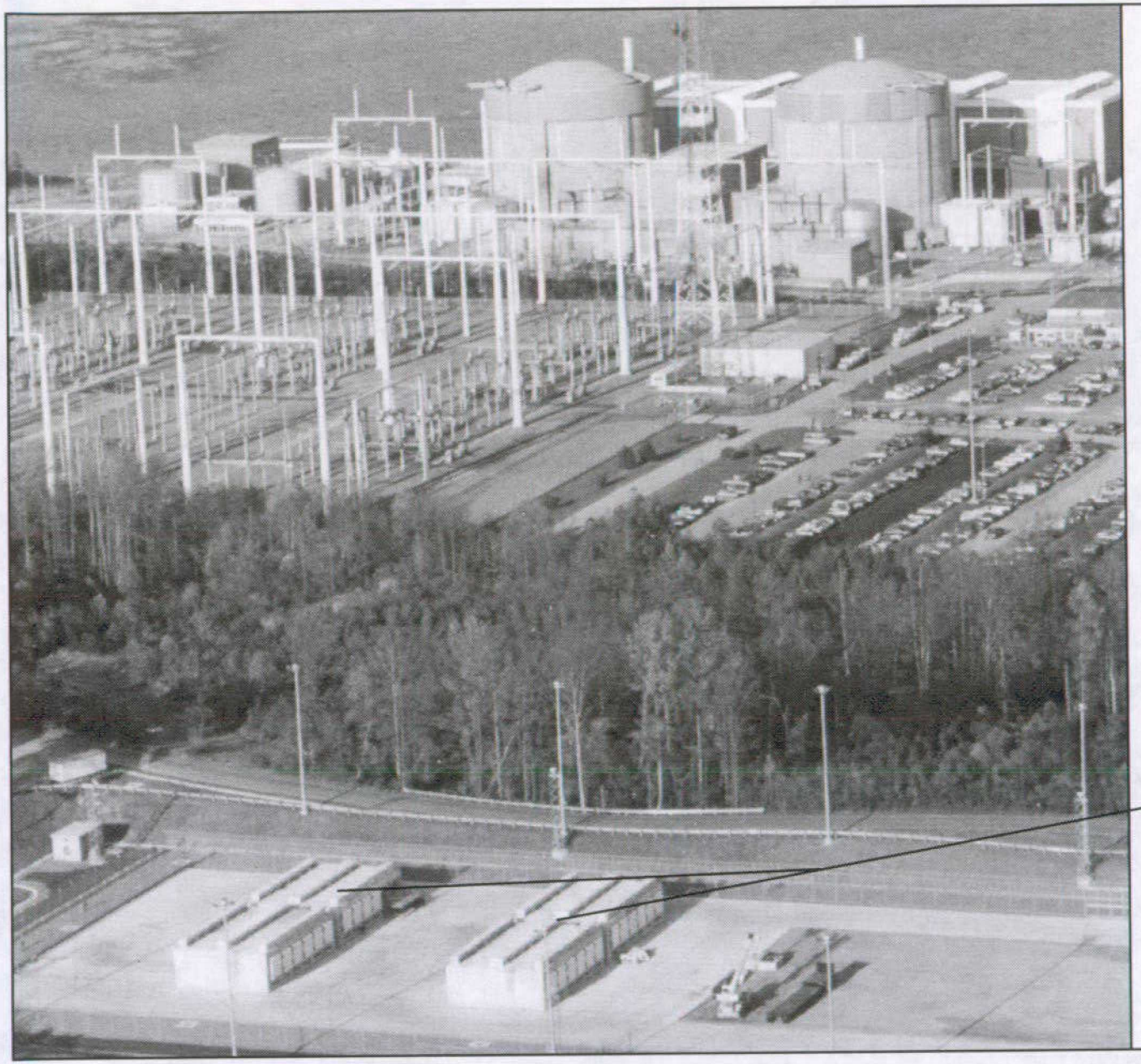


Figure 7-2. Typical independent spent fuel storage installation.

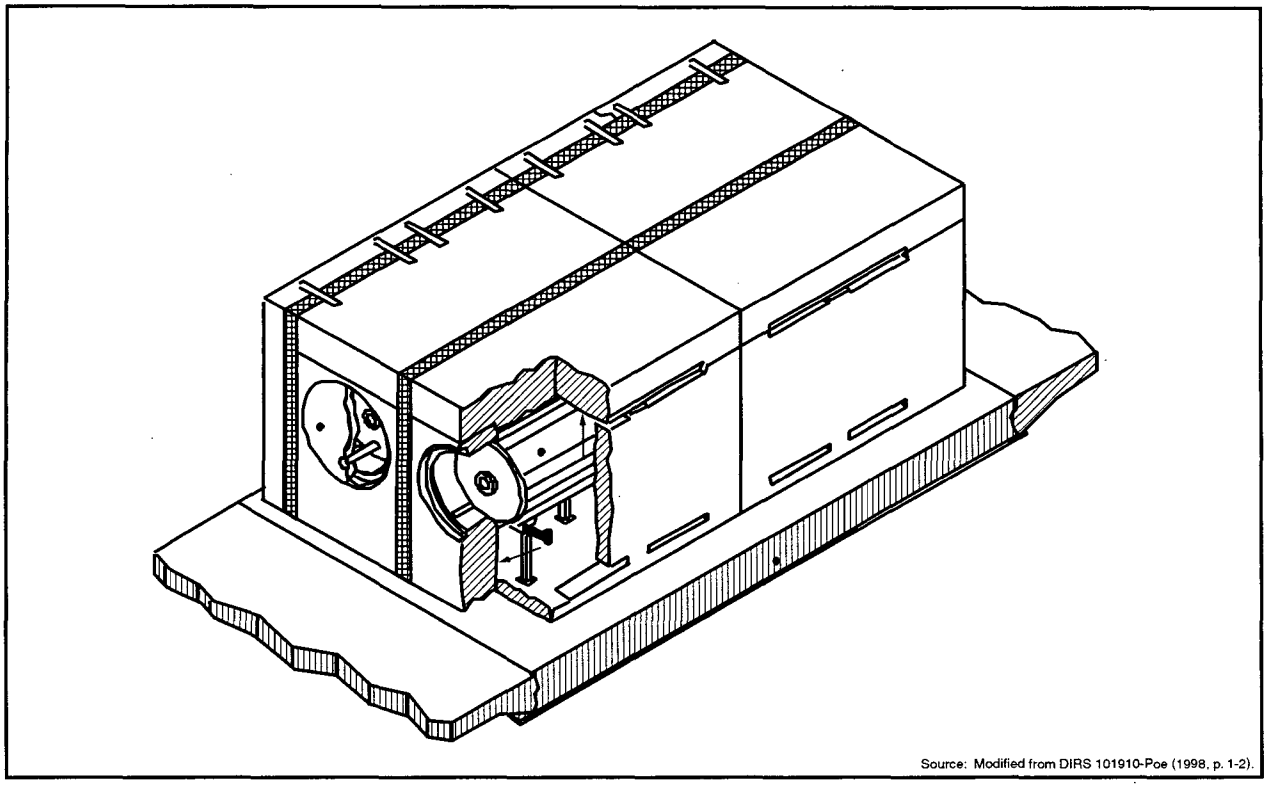


Figure 7-3. Spent nuclear fuel concrete storage module.

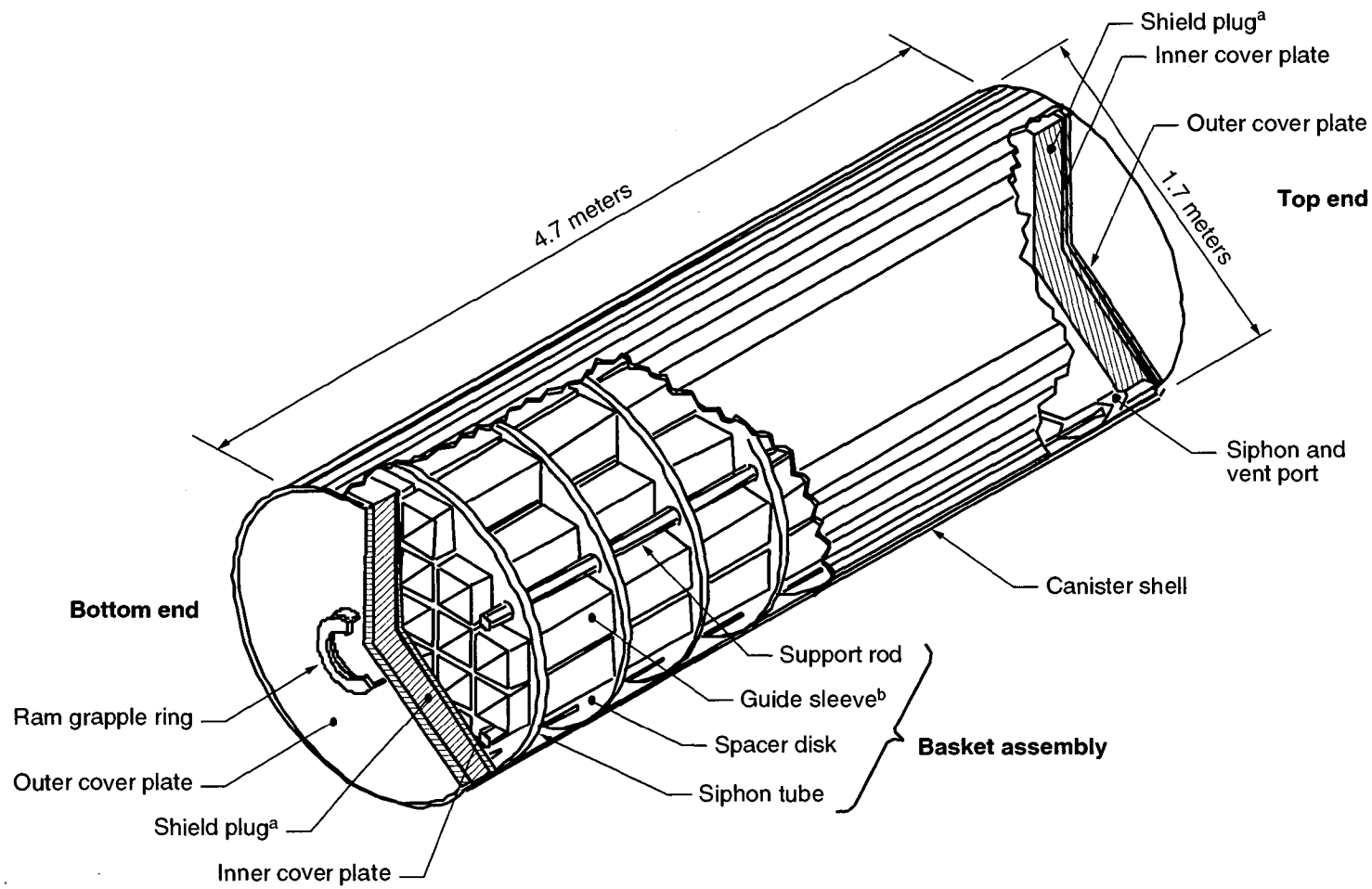
The below-grade storage vault would be below the operating floor, which would be slightly above grade. The storage vault would be designed to withstand earthquakes and tornadoes. In addition, the operating area would be enclosed by a metal building, which would provide weather protection and prevent the infiltration of precipitation. The storage vault would be designed to store the canisters and protect the operating personnel, the public, and the environment for as long as the facilities were maintained. The surrounding earth, concrete walls, and a concrete deck that would form the floor of the operating area would provide radiation shielding. Canister cavities would have individual precast concrete plugs.

Each vault would have an air inlet, air exhaust, and air passage cells. The storage facility's ventilation system would remove the heat of radioactive decay from around the canisters. The exhaust air could pass through high-efficiency particulate air filters before it discharged to the atmosphere through a stack. As an alternative, natural convection cooling without filters could be used. The oversized diameter of the pipe storage cavities would allow air to pass around each cavity.

7.2.1 NO-ACTION SCENARIO 1

Under Scenario 1, 72 commercial sites and 5 DOE sites would store spent nuclear fuel and high-level radioactive waste for 10,000 years. Institutional control, which would be maintained for the entire 10,000-year period, would ensure regular maintenance and continuous monitoring at these facilities that would safeguard the health and safety of facility employees, surrounding communities, and the environment. The spent nuclear fuel and immobilized high-level radioactive waste would be *inert* material encased in durable, robust packaging and stored in above- or below-grade concrete facilities. Release of contaminants to the ground, air, or water would not be expected during routine operations.

DOE and commercial utility workers would perform all maintenance including routine industrial maintenance and maintenance unique to a nuclear materials storage facility under standard operating



All materials 304 stainless steel except as noted.

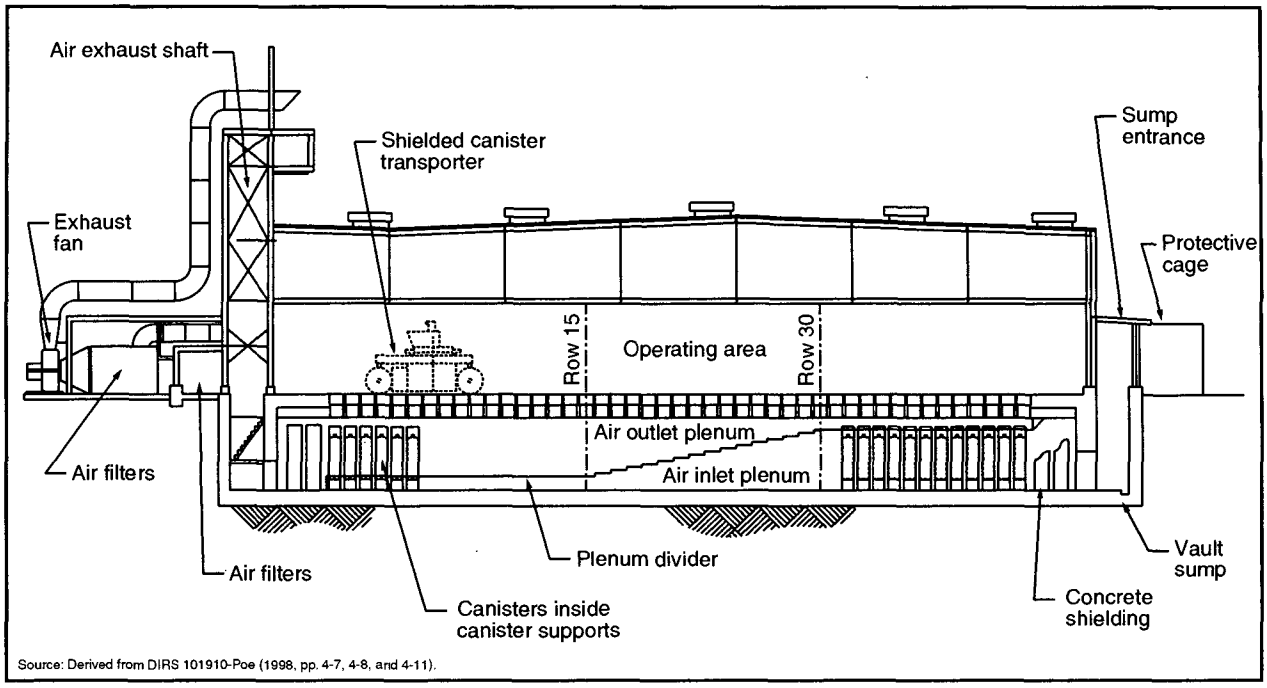
a. Shield plug would be lead.

b. Borated neutron absorber plate for boiling-water reactor spent nuclear fuel assemblies.

To convert meters to feet, multiply by 3.2808.

Source: Modified from DIRS 101910-Poe (1998, p. 1-5).

Figure 7-4. Spent nuclear fuel dry storage canister.



Source: Derived from DIRS 101910-Poe (1998, pp. 4-7, 4-8, and 4-11).

Figure 7-5. Conceptual design for solidified high-level radioactive waste storage facility.

procedures and best management practices to ensure minimal releases of contaminants (industrial and nuclear) to the environment and minimal exposures to workers and the public. This analysis assumed that DOE would manage these facilities in accordance with Departmental rules (10 CFR Part 835) and Orders (see Chapter 11) and that commercial facilities would meet applicable environmental safety and health requirements. It also assumed that storage facilities would require replacement every 100 years and that they would undergo major repairs halfway through the first 100-year cycle. Chapter 2, Section 2.2, provides additional information pertaining to Scenario 1. The following sections treat short- and long-term impacts separately where appropriate.

7.2.1.1 Land Use and Ownership

The storage facilities for spent nuclear fuel and high-level radioactive waste would be at commercial and DOE sites. Facilities would require replacement every 100 years (beginning about 2110), which would occur on land immediately adjacent to the existing facilities. The land required for a storage facility typically would be a few acres, a small percentage of the land available at current sites. An environmental assessment of an independent spent fuel storage installation determined that operation of the facility would require no more land than it occupied (DIRS 101898-NRC 1991, p. 20).

At the end of each 100-year cycle, a new facility constructed next to the old one would contain the spent nuclear fuel or high-level radioactive waste. The old facility would be demolished and the land reclaimed and maintained for the next 100 years. By alternating the facility between two adjacent locations, minimal land would be required.

Storage facilities would be on land owned by either DOE or a utility. Storage at these sites would be unlikely to affect land use and ownership.

7.2.1.2 Air Quality

As a part of routine operations, best management practices and effective monitoring procedures would ensure that any contaminant releases to the air would be minimal and would not exceed current regulatory limits (40 CFR Part 61 for hazardous air pollutant emissions and Part 50 for air quality standards). Therefore, the No-Action Alternative would not produce adverse impacts to air quality during routine operations.

The analysis assumed that the storage facilities would require complete replacement every 100 years. During the construction of the replacement facility, exhaust from construction vehicles would temporarily increase local levels of hydrocarbons, carbon monoxide, and oxides of nitrogen, but these and other atmospheric pollutants would be likely to remain within National Ambient Air Quality Standards (see Chapter 3, Table 3-5). Temporary increases in particulate matter would result from these construction activities. Mitigation measures such as watering unpaved roads would limit the generation of fugitive dust. In addition, after replacement the old site would be seeded, graveled, or paved to reduce air emissions. Detrimental air quality impacts would be short-term, minimal, and transient.

Very small air quality impacts would be likely from repackaging materials removed from dry storage containers that could degrade to the point that they no longer met licensing requirements; these impacts were not included in the overall impact estimates. Long-term dry storage canister degradation would be highly variable and difficult to estimate from site to site, and DOE did not want to overestimate the accompanying air quality impacts from repackaging.

7.2.1.3 Hydrology

7.2.1.3.1 *Surface Water*

As part of routine operations, best management practices such as stormwater pollution prevention plans and stormwater holding ponds would ensure that, in the unlikely event of an inadvertent contaminant release, contaminants did not reach surface-water systems. Effective monitoring procedures would ensure that operation of the facility did not adversely affect surface waters and that no discharges would contaminate surface waters in excess of drinking water regulatory limits (40 CFR Part 141). Detention basins would capture all runoff, which would be monitored for contamination and treated, as necessary, before it was released to the environment. If the storage facility required active cooling systems, those systems would be designed to contain any inadvertent spill of operating fluids so they could not reach the environment. Therefore, No-Action Scenario 1 would be unlikely to produce adverse impacts to surface-water quality during routine operations.

During construction of the replacement storage facilities, adherence to stormwater pollution prevention plans would ensure that cleared areas and exposed earth would be seeded, graveled, or paved to control runoff and minimize soil erosion that could adversely affect surface-water quality. Surface-water runoff detention ponds would prevent eroded material from entering surface water systems. These erosion control practices would ensure minimal impacts to surface-water quality during construction. To prevent contamination from construction equipment, workers would monitor the equipment for leaks. Inadvertent spills of industrial fluids would be contained and cleaned up in accordance with established spill prevention and cleanup plans. Therefore, the No-Action Alternative would be unlikely to produce adverse impacts to surface-water quality during construction operations.

7.2.1.3.2 *Groundwater*

During routine operations, best management practices such as spill prevention and cleanup plans and procedures and effective monitoring procedures would ensure that inadvertent contaminant releases

would not reach groundwater. Therefore, the No-Action Alternative would be unlikely to produce adverse impacts to groundwater quality during routine operations.

The spent nuclear fuel storage facilities at the commercial sites would be surface structures with shallow foundations such that their construction would not disturb groundwater systems. Some DOE storage facilities would be subsurface structures for which construction might require minimal dewatering of the groundwater aquifer. However, the area occupied by the structure would be small in relation to the size of the aquifer, so no adverse impacts would be likely to result from dewatering activities.

Excavations would remove the soil buffer between surface activities and groundwater, increasing the likelihood of groundwater contamination from an inadvertent spill or leak of construction-related fluids (for example, diesel fuel, oil, hydraulic fluids). Construction activities would be as described above for surface water; thus, the penetration of spilled construction fluids to groundwater would be unlikely. Therefore, the No-Action Alternative would be unlikely to produce adverse impacts to groundwater quality during construction operations.

7.2.1.4 Biological Resources and Soils

Impacts to biological resources or soils from the construction and operation of spent nuclear fuel and high-level radioactive waste storage facilities would be minimal. Heat from the storage modules would not affect nearby vegetation. The storage facilities would be fenced to keep wildlife out. However, some smaller animal species could take advantage of the warm air from storage facility vents in winter, and individual animals could receive adverse impacts, including death, from direct exposure to radiation. As the heat of radioactive decay decreased, these sites would become less attractive to animals seeking warm environments.

The storage facilities would have a minimal effect on the soil. Because the operating and decommissioned facilities would alternate between two locations, the amount of soil disturbed by construction would be very small. By adhering to best management practices and standard operating procedures, DOE expects that spills would be minimal. A spill would be contained and cleaned up immediately, thus minimizing the area of soil affected.

7.2.1.5 Cultural Resources

Replacement spent nuclear fuel and high-level radioactive waste storage facilities would generally be on undeveloped land in rural areas owned by DOE or the commercial utilities. The size of each facility and supporting infrastructure would be small enough to avoid known cultural resources. If construction activities uncovered previously unknown archaeological sites, human remains, or funerary objects, DOE or the commercial utility would comply with Executive Orders and Federal and state regulations for the protection of cultural resources (see Chapter 11, Section 11.2.5, for details). Therefore, the No-Action Alternative would be unlikely to produce adverse impacts to cultural resources during construction and operations.

7.2.1.6 Socioeconomics

Storage facilities for spent nuclear fuel and high-level radioactive waste would be at existing DOE and commercial sites. A staff of about eight workers (two individuals on duty per shift, 24 hours per day) would monitor and maintain each facility (DIRS 104596-Orthen 1999, Table 2, p. 4). The analysis assumed that facilities would require replacement every 100 years, and that there would be a major facility repair halfway through the first 100-year cycle. Facility replacement every 100 years would require approximately 40 workers for 2 years (DIRS 104596-Orthen 1999, Table 2 and Table 6). Major

repairs halfway through the first 100-year cycle would require about 40 workers for 1 year (DIRS 104596-Orthen 1999, Table 2 and Table 6).

Each of the 77 sites that stores spent nuclear fuel or high-level radioactive waste employs monitoring and maintenance personnel. Additional staffing for facility replacement [and the one-time major repair (see DIRS 104596-Orthen 1999, Tables 1 and 2)] would be temporary and comprise about 40 employees at a site during construction. (Construction of DOE facilities could require more workers, but the Department would have only five of these facilities reconstructed every 100 years.) This temporary increase in employment would be small in proportion to the existing workforces in affected communities. Therefore, the No-Action Alternative would be unlikely to have adverse effects on socioeconomic factors such as infrastructure and regional economy.

7.2.1.7 Occupational and Public Health and Safety

7.2.1.7.1 *Nonradiation Exposures*

Maintenance, repairs, repackaging, and construction at the storage facilities would be conducted in accordance with requirements of the Occupational Health and Safety Administration and National Institute of Occupational Safety and Health. Administrative controls and design features would minimize worker exposures to industrial nonradioactive hazardous materials during the construction and operation of the storage facilities so exposures would remain below hazardous levels.

7.2.1.7.2 *Industrial Hazards*

The industrial hazards evaluated were (1) total recordable injury and illness cases, (2) lost workday cases associated with workplace injuries and illnesses, and (3) workplace fatalities. The estimates of these traumas were based primarily on the staffing level of involved workers assigned to spent nuclear fuel and high-level radioactive waste management tasks, coupled with representative workplace loss indicators maintained by the Bureau of Labor Statistics (DIRS 148091-BLS 1998, all) or the DOE Computerized Accident/Incident Reporting System database (DIRS 147938-DOE 1999, all). Involved worker risk exposure estimates were based on crew sizes to determine the number of full-time equivalent work years assigned to construction and to operations, surveillance, and maintenance tasks. DOE used representative historic total recordable case, lost workday case, and fatality incident data to project the associated trauma incidence based on the number of workers and their job functions.

This analysis assumed that replacement facilities would be constructed every 100 years and that a major repair and upgrade of the initial facilities would be required once after the first 50 years. Impacts from decommissioning retired facilities were included as part of construction.

For the approximately 100-year construction and operation cycle (2002 to 2116), about 72,000 full-time equivalent work years of effort would be required to maintain and repair about 6,600 concrete storage modules and 4 below-grade storage vaults at the 72 commercial and 5 DOE sites (DIRS 104596-Orthen 1999, Tables 1, 6, and 7). Based on this level of effort, as listed in Table 7-5, about 2,300 industrial safety incidents would be likely, resulting in about 1,000 lost workday cases and 2 fatalities (an average of 1 fatality every 50 years).

In addition, for the remaining 9,900 years, Table 7-5 indicates about 290,000 estimated industrial safety incidents, of which about 130,000 would be lost workday cases and 320 would involve fatalities (an average of 1 fatality every 30 years or about one every 2,500 years at each of the 77 sites). Surveillance tasks would consume 94 percent of the total worker level of effort, construction tasks would consume nearly all of the remaining 6 percent, and operations tasks would consume less than 0.001 percent (DIRS 104596-Orthen 1999, Table 2).

7.2.1.7.3 *Radiation Exposures*

For Scenario 1, the analysis assumed that the facilities would undergo major repairs once during the first 100 years and would be replaced every 100 years thereafter. Very low exposures to future construction workers would occur as they built replacement facilities adjacent to the existing facilities. Transferring the dry storage canisters from old to new concrete storage modules would result in some additional exposures to workers.

Table 7-5. Estimated industrial safety impacts at commercial and DOE sites during the first 100 years and the remaining 9,900 years of the 10,000-year analysis period under Scenario 1.[a]

Industrial safety impacts	Short-term[b] (100 years) construction and operation	Long-term (9,900 years)[c] construction and operation
Total recordable cases	2,300	290,000
Lost workday cases	1,000	130,000
Fatalities	2.4	320

a. Source: DIRS 104596-Orthen (1999, Tables 6 and 7).
b. The estimated impacts would result from a single 100-year period of storage module construction (renovation), operation, surveillance, and repair.
c. Period from 100 to 10,000 years.

During normal operations, facility workers would be exposed to low levels of external radiation while performing routine surveillance and monitoring activities, changing high-efficiency particulate air filters on ventilation systems (for high-level radioactive waste storage facilities), transferring dry storage canisters between concrete storage modules, and maintaining and repairing the facilities. In addition, individuals employed at the nearby nuclear powerplant but not directly involved with activities at the spent nuclear fuel storage facility (noninvolved workers) would be exposed to low levels of external radiation emanating from the filled concrete storage modules. Activities within the facility boundaries would be in accordance with DOE or Nuclear Regulatory Commission guidelines for nuclear facility worker protection (10 CFR Part 835 and 10 CFR Part 20). Table 7-6 lists estimated maximum annual individual doses and the total average collective dose for worker populations during the 100- and 10,000-year analysis periods for commercial and DOE sites.

The Scenario 1 analysis treated the dose rates from DOE spent nuclear fuel as equivalent to commercial spent nuclear fuel on a volume basis. This simplifying assumption had minimal effect on estimated individual and population doses because of the relatively small quantities of DOE spent nuclear fuel (less than 10 percent of the total) and essentially equal radiation exposure rates in comparison to commercial spent nuclear fuel on a volume basis. The analysis separated the calculation of dose rates from high-level radioactive waste because of the difference in source materials.

For Scenario 1, dose rates from high-level radioactive waste were estimated based on the isotopic distributions provided in Appendix A, Tables A-28, A-29, and A-30. As with commercial and DOE spent nuclear fuel, estimated dose rates to facility workers considered shielding provided by the concrete facility structures and decay over the 10,000-year analysis period. However, because of the relatively large distance from the storage facilities to the site boundary [typically more than 3 kilometers (2 miles) at the Hanford Site, the Idaho National Engineering and Environmental Laboratory, and the Savannah River Site], doses to the public were not included. Although the distance to the site boundary at the West Valley Demonstration Project is less than 3 kilometers, not including public exposures from above-grade storage facilities would result in a very small underestimation of impacts because DOE stores only about 4 percent of the high-level radioactive waste at that facility.

Very small air quality impacts would be likely from repackaging materials removed from dry storage containers that could degrade to the point that they no longer met licensing requirements. However, overall impact estimates did not include these impacts because long-term dry storage canister degradation would be highly variable and difficult to estimate from site to site, and DOE did not want to overestimate the accompanying air quality impacts from repackaging.

Table 7-6. Estimated radiological impacts (dose) and consequences from construction and routine operation of commercial and DOE spent nuclear fuel and high-level radioactive waste storage facilities – Scenario 1.[a]

Receptor	Short-term (100 years) construction and operation	Long-term (9,900 years) construction[b] and operation
Population[c]		
MEI[d] (millirem per year)	0.20	0.06
Dose[e] (person-rem)	810	5,200
LCFs[f]	0.41	2.6
Involved worker[g]		
MEI[h] (millirem per year)	170	50
Dose[e] (person-rem)	2,600	24,000
LCFs[f]	1.0	10
Noninvolved workers[i]		
MEI[j] (millirem per year)	13	0[k]
Dose[e] (person-rem)	36,000	0[k]
LCFs[f]	15	0[k]

a. Source: Adapted from DIRS 101898-NRC (1991, all); DIRS 104596-Orthen (1999, all).
b. Assumes construction of 6,600 concrete storage modules and three below-grade vaults at 77 sites every 100 years (DIRS 104596-Orthen 1999, Table 1).
c. Members of the general public living within 3 kilometers (2 miles) of the facilities; estimated to be 140,000 over the first approximately 100 years and approximately 14 million over the duration of the analysis period [estimated using DIRS 102204-Humphreys, Rollstin, and Ridgely (1997, all)].
d. MEI = maximally exposed individual; assumed to be approximately 1.4 kilometers (0.8 mile) from the center of the storage facility (DIRS 101898-NRC 1991, p. 22).
e. Estimated doses account for radioactive decay.
f. LCF = latent cancer fatality; expected number of cancer fatalities for populations. Based on a risk of 0.0004 and 0.0005 latent cancer fatality per rem for workers and members of the public, respectively (DIRS 101857-NCRP 1993, p. 112), and a life expectancy of 70 years for a member of the public and a 50-year career for workers.
g. Involved workers would be those directly associated with construction and operation activities (DIRS 101898-NRC 1991, pp. 23 to 25). For this analysis, the involved worker population would be approximately 1,400 individuals (700 individuals at any one time) at 77 sites over 100 years (DIRS 104596-Orthen 1999, Table 6). This population would grow to about 160,000 over 10,000 years.
h. Based on maximum construction dose rate of 0.11 millirem per hour and 1,500 hours per year (DIRS 101898-NRC 1991, p. 23).
i. Noninvolved workers would be employed at the powerplant but would not be associated with facility construction or operation. For this analysis, the noninvolved worker population would be 80,000 individuals who would receive exposures until the powerplants were decommissioned (50 years).
j. Based on a projected area workforce of 1,200 and an average estimated annual dose of 16 person-rem (DIRS 101898-NRC 1991, p. 24).
k. During this period the powerplants would have ended operation, so there would be no noninvolved workers.

As listed in Table 7-6, the estimated dose to the hypothetical maximally exposed offsite individual during the short-term operational period between 2002 and 2116 would be about 0.20 millirem per year (DIRS 101898-NRC 1991, p. 22). For the remaining 9,900 years of the analysis period (long-term impacts), the dose to the hypothetical maximally exposed individual would decrease to about 0.060 millirem per year because of radioactive decay of the source material. During about the first 100 years, the dose (accounting for radioactive decay) could result over a 70-year lifetime of exposure in an increase of 0.0000043 in the lifetime risk of contracting a fatal cancer, an increase over the lifetime natural fatal cancer incidence rate of 0.0018 percent. During the remaining 9,900 years of the analysis period, the dose could result in an increase of 0.0000013 in the lifetime risk of contracting a fatal cancer, an increase of 0.00055 percent over the lifetime natural fatal cancer incidence rate.

Based on the Nuclear Regulatory Commission computer program SECPOP (DIRS 102204-Humphreys, Rollstin, and Ridgely 1997, all), in 1990 approximately 100,000 people lived within 3 kilometers (2 miles) of some type of commercial nuclear facility (DIRS 101917-Rollins 1998, p. 9). Over the 100-year

analysis period, the total number of people that would be exposed would be approximately 140,000 because more than one 70-year lifetime would be spanned during the 100-year period. As listed in Table 7-6, between 2002 and 2116 these people would be likely to receive a total collective dose of 810 person-rem.

Long-term doses and latent cancer fatalities for the approximately 9,900-year period between 2116 and 12010 were based on the assumptions described above, with a few notable exceptions. Impacts to noninvolved workers were not calculated because all of the nuclear powerplants would be closed by the beginning of this period. In addition, the total exposed populations of workers and the public would increase by a factor of 100 above the 100-year exposed population because this period would span 140 lifetimes of 70 years. As noted above, for the first 100 years of operation approximately 140,000 people living within 3 kilometers (2 miles) of the storage facilities (100,000 people multiplied by 1.4 consecutive 70-year average human lifetimes [the average number of 70-year lifetimes in 100 years]) would be exposed to external radiation. Over 10,000 years the exposed population would total approximately 14 million people. Therefore, for the period between 2116 and 12010, the offsite population would receive an estimated total collective dose of 5,200 person-rem (adjusted for radioactive decay).

Population statistics indicate that in 1990 cancer caused about 24 percent of the deaths in the United States (DIRS 153066-Murphy 2000, p. 5). If this percentage of deaths from cancer continued, about 24 people out of every 100 in the U.S. population would contract a fatal cancer from some cause. For approximately the first 100 years, the radiation exposure dose from the storage facilities could cause an additional 0.41 latent cancer fatality in the surrounding populations. This would be in addition to about 33,000 cancer fatalities that would be likely in the exposed population of 140,000 from all other causes, or an increase in the natural incidence rate of 0.0012 percent. For the remaining 9,900 years of the analysis, the radiation exposure dose from the storage facilities could result in an additional 2.6 latent cancer fatalities in the surrounding populations. This would be in addition to about 3.3 million cancer fatalities that would be likely to occur in the exposed population of 14 million, or an increase of 0.000079 percent over the natural incidence rate.

The analysis assumed the maximally exposed individual in the involved worker population would be involved in constructing and loading replacement facilities. Assuming a maximum dose rate of 0.11 millirem per hour and an average exposure time of 1,500 hours per year, this construction worker would receive about 170 millirem per year. During about the first 100 years, the dose could result (over 3 years of construction) in an increase in the lifetime risk of contracting a fatal cancer of 0.00020, an increase of 0.090 percent over the national fatal cancer incidence rate of about 24 percent. During the remaining 9,900 years of the analysis period, the dose could result (over 3 years of construction) in an increase in the risk of contracting a fatal cancer of 0.000060, an increase of 0.030 percent over the natural fatal cancer incidence rate.

For the involved worker population of 1,400 individuals, approximately 330 would be likely to contract a fatal cancer from some cause other than occupational exposure. In this population (during the first 100 years), the collective dose of 2,600 person-rem (correcting for decay) between 2002 and 2116 could result in about 1 additional latent cancer fatality (DIRS 104596-Orthen 1999, Table 6), an increase of 0.33 percent over the natural incidence rate of fatal cancers from all causes. During the remaining 9,900 years of the analysis period, the approximately 160,000 involved workers would receive a collective dose of 24,000 person-rem (corrected for decay). This dose could result in an additional 10 latent cancer fatalities (about 1 every 1,000 years during the 9,900-year analysis period), an increase of 0.027 percent over the natural incidence rate of fatal cancers.

Noninvolved workers would be those employed at an operating nuclear powerplant but not directly involved with the day-to-day operation of the spent nuclear fuel storage facility. The analysis assumed that noninvolved workers (about 800 for each of the approximately 100 reactor units at 72 commercial

sites) would be generally several hundred to several thousand feet from the storage facilities. In addition, it assumed that noninvolved workers would be at the sites until 2052 (that is, for 50 years).

The Nuclear Regulatory Commission estimated that the dose to noninvolved workers at a nuclear powerplant from a fully loaded independent spent fuel storage installation would be about 16 person-rem per year (DIRS 101898-NRC 1991, p. 24) for the protected-area workforce of 1,200 individuals (DIRS 101898-NRC 1991, p. 26) at the two-unit station of Calvert Cliffs. This collective dose would result in an average maximum dose to the noninvolved worker of 13 millirem per year. Over a 50-year career, this exposure (accounting for radioactive decay) could result in an increase in lifetime risk of contracting a fatal cancer of 0.00018, an increase of 0.077 percent over the natural incidence rate of fatal cancers.

The analysis made the conservative assumption that there are about 80,000 powerplant workers in the United States (800 per reactor unit and about 100 units currently operating), and that these workers would receive radiation exposure from the adjacent storage facilities until powerplant decommissioning, which the analysis assumed will occur in 2052. In the total noninvolved worker population of 80,000 powerplant workers (all sites), the collective dose of 36,000 person-rem (accounting for radioactive decay) between 2002 and 2116 could result in 15 additional latent cancer fatalities. This would be about 0.079 percent more than the 19,000 cancer fatalities that would be likely to occur from all other causes in the same worker population.

Figure 7-6 shows the calculated dose to these populations as a function of time, expressed as 70-year doses. For the noninvolved worker population, the population dose would occur during only the first 70-year interval. The public dose would decrease over time due to the inherent radioactive decay that will occur in the spent nuclear fuel and high-level radioactive waste as time elapses. Many of the radioactive constituents have half-lives substantially less than 10,000 years; therefore, it is likely that the dose to the public would decrease noticeably over time. The involved worker population dose also would decrease over time because of radioactive decay. The involved worker dose would fluctuate as new concrete storage modules were constructed and radioactive material was transferred from the old to the new modules every 100 years. During those 70-year intervals in which construction and transfer would occur, the dose would be higher; the dose would be lower during those 70-year intervals when these activities did not occur.

Because no liquid or airborne effluents would emanate from the storage facilities, direct and air-scattered radiation would comprise the total source of radiation exposure to the public. For populations more than 3 kilometers (2 miles) from the facilities (as is the case for most DOE facilities), direct and air-scattered external radiation exposure would be small (DIRS 101898-NRC 1991, p. 22).

7.2.1.8 Accidents

For Scenario 1, activities at each facility would include surveillance, inspection, maintenance, and equipment replacement, when required. The facilities and the associated systems, which the Nuclear Regulatory Commission would license, would have certain required features. License requirements would include isolation of the stored material from the environment and its protection from severe accident conditions. The Nuclear Regulatory Commission requires an extensive safety analysis that considers the impacts of plausible accident-initiating events such as earthquake, fire, high wind, and tornado. In addition, the license would specify that facility design requirements include features to provide protection from the impacts of severe natural events. These requirements and analyses must demonstrate that the facilities could withstand the most severe wind loading (tornado winds and tornado-generated missiles) and flooding from the Probable Maximum Hurricane with minimal release of radioactive material. This analysis assumed indefinite maintenance of these features for the storage facilities.

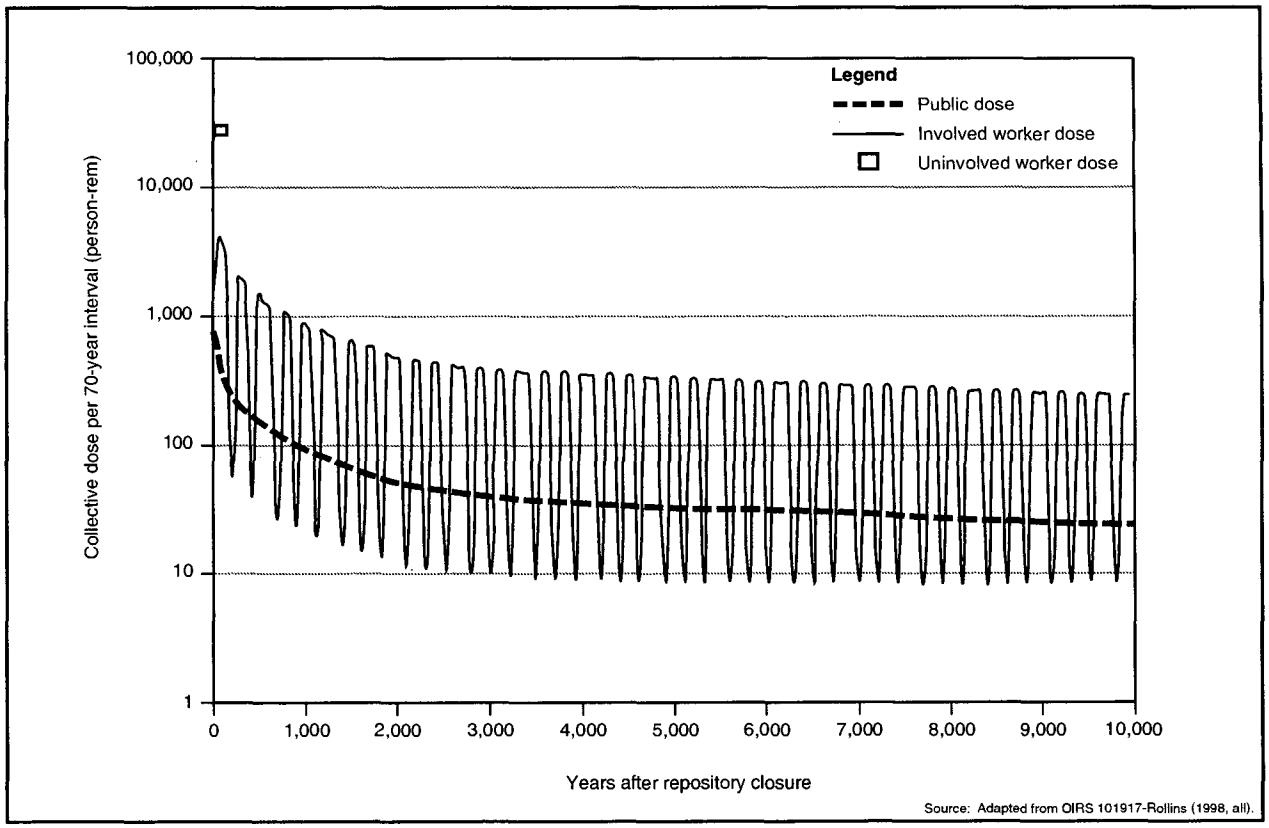


Figure 7-6. Collective dose for 70-year intervals for No-Action Scenario 1.

DOE performed an analysis to identify the kinds of events that could lead to releases of radioactive material to the environment prior to degradation of concrete storage modules and found none. The two events determined to be the most challenging to the integrity of the concrete storage modules would be the crash of an aircraft into the storage facility and a severe seismic event.

- DIRS 103711-Davis, Strenge, and Mishima (1998, all) evaluated the postulated aircraft crash and subsequent fire at a storage facility. The analysis showed that falling aircraft components produced by such an event would not penetrate the storage facility and that a subsequent fire would not result in a facility failure. This conclusion is consistent with representative analyses performed in support of Nuclear Regulatory Commission license applications for above-grade dry storage (DIRS 103449-PGE 1996, all; DIRS 103177-CP&L 1989, all).

  DIRS 103711-Davis, Strenge, and Mishima (1998, all) evaluated aircraft crashes with a velocity of 550 kilometers per hour (340 miles per hour) based on the DOE aircraft crash standard (DIRS 101810-DOE 1996, p. C-7). In a scenario where aircraft velocities could be higher, there would be an increased potential that the intact storage facility could be subject to failure, resulting in a release of radiological materials. DOE has not performed a more detailed analysis of these licensed facilities because the Nuclear Regulatory Commission has a comprehensive program underway to evaluate such events at their licensed facilities, including commercial spent fuel storage facilities. The Commission would be expected to take whatever action is necessary to provide adequate protection to the public from such events.

- For the seismic event, major damage would be unlikely because storage facilities would be designed to withstand severe earthquakes. Even if such an event caused damage, immediate release of radioactive particulates would be unlikely because analyses have identified no mechanism that would

cause fuel pellet damage sufficient to create respirable airborne particles (DIRS 103449-PGE 1996, all; DIRS 103177-CP&L 1989, all). Therefore, the source term would be limited to gaseous fission products, carbon-14, and a very small amount of preexisting fuel-pellet dust. Subsequent repairs to damaged facilities or concrete storage modules would preclude the long-term release of radionuclides.

Criticality events are not plausible for Scenario 1 because water, which is required for criticality, could not enter the dry storage canister. The water would have to penetrate several independent barriers, all of which would be maintained and replaced as necessary under Scenario 1. Therefore, DOE determined that potential accident consequences would be bounded by a severe seismic event (see Appendix K, Section K.2.5). DOE analyzed this event and concluded that such an accident scenario would not result in radiological impacts to members of the public in the immediate vicinity of the storage facility. In addition, there would be limited quantities of nonradioactive hazardous or toxic substances stored at the facilities. Therefore, nonradiological accident impacts would be limited to those from industrial hazards and traffic, as discussed in Sections 7.2.1.7.2 and 7.2.1.14, respectively.

7.2.1.9 Noise

During routine operations, noise levels would not affect workers, the public near the facility, or the environment. Most of the storage facilities would have passive cooling, although a few could have active cooling with fans and blowers. Because the storage facilities would be away from population centers or homes, the noise of blowers, if used, would not affect the nearby public. The noise would not be loud enough to produce adverse impacts on the facility workers' hearing.

The analysis assumed for Scenario 1 that the storage facilities would require complete replacement every 100 years. During construction, noise levels due to construction traffic and activities would exceed ambient noise levels. To protect personnel, Occupational Safety and Health Administration standards would be followed (29 CFR 1910.95). The noise could cause wildlife to leave the immediate vicinity of the construction activities, but would not be loud enough to affect individual animals permanently. Adverse impacts to wildlife would be temporary.

7.2.1.10 Aesthetics

Impacts from the storage facilities to aesthetic or scenic resources would be low. There would be two adjacent locations at each site on land that would already be disturbed. Every 100 years, a new facility would be constructed on the idle site, and the storage containers transferred. The old facility would be demolished and the site would remain idle for the next 100 years. Adverse impacts could occur during construction and demolition activities, but these impacts would be short-term and temporary.

7.2.1.11 Utilities, Energy, and Materials

As mentioned above, spent nuclear fuel and high-level radioactive waste storage facilities would have passive cooling, although a few could have active cooling with fans and blowers. Electricity would be required for these cooling systems and to light the storage facilities, but DOE anticipates that the amount of electricity would be small in comparison to the amount available. Fuel and materials would be needed to maintain and repair the facilities and to construct and demolish facilities every 100 years, but DOE expects impacts to these resources to represent a small fraction of the resources available to each of the 77 sites. Therefore, the No-Action Alternative would not produce adverse impacts on these resources during operation and construction activities.

7.2.1.12 Waste Management

Construction of new facilities and demolition of old facilities every 100 years (and the one-time refurbishment of existing facilities after the first 50 years) would generate construction debris and sanitary and industrial solid waste. In addition, routine repairs and maintenance to the facilities and storage containers, routine radiological surveys, and overpacking of failed containers would generate sanitary and industrial solid and low-level radioactive wastes. Because there would not be a dedicated workforce at the storage facilities, only small amounts of sanitary wastes would be generated except during construction periods. The greatest amount of waste would be generated by the demolition of facilities at the 72 commercial and 5 DOE storage sites every 100 years. The demolition of facilities once every 100 years at all the sites would generate, on average, an estimated 770,000 cubic meters (1 million cubic yards) of nonhazardous demolition debris, recyclable steel, and potentially a small amount of low-level waste if a dry storage canister were to fail while in storage (DIRS 104596-Orthen 1999, Table 7). The debris and wastes would be disposed of at commercial or DOE disposal facilities across the Nation. The impacts to available capacity would be spread nationwide, thus minimizing impacts to any one disposal facility. The capacities of the disposal facilities would accommodate the wastes generated at the storage facilities.

7.2.1.13 Environmental Justice

Potential impacts of continued storage with institutional control would be minimal for all populations living near the storage facilities. Because adverse impacts would be unlikely for any population, effects on minority or low-income populations would be unlikely to be disproportionately high and adverse.

Storage facilities would require small areas and would be on lands already owned by commercial utilities or DOE. Therefore, continued storage at these sites would be unlikely to introduce environmental justice concerns. If the United States determines that it will use continued storage at existing sites for the long-term disposition of spent nuclear fuel and high-level radioactive waste, site-specific analyses of storage facilities would be required to determine if environmental justice issues could result. The Nuclear Regulatory Commission has established this approach (DIRS 101899-NRC 1996, p. 9-16).

7.2.1.14 Traffic and Transportation

DOE analyzed short-term impacts (traffic fatalities) that could result from commuting to and from storage facilities for a single 100-year cycle. The amount of travel was determined from estimates of personnel needed to construct the storage facilities, load and reload the canisters into the storage modules, and conduct routine surveillance and repairs (DIRS 104596-Orthen 1999, all). Because the workforce at each storage facility would be small, opportunities for carpooling would be limited. Therefore, the analysis assumed each worker would commute individually.

An estimated 700 workers (see Section 7.2.1.7.3) would commute to and from work approximately 18 million times during the first 100 years. The analysis assumed an average one-way commute of 19 kilometers (12 miles) based on personal travel reported in the Nationwide Personal Transportation Survey by the Oak Ridge National Laboratory (DIRS 102064-FHWA 1999, p. 9). The analysis also used national data to estimate fatalities [in 1994, 1 fatality per 100 million kilometers (about 62 million miles) traveled by automobile (DIRS 148081-BTS 1999, p. 4)] over a single 100-year period. Based on the expected workforce, estimated number of trips, estimated average distance, and fatality data, approximately 7 traffic fatalities would occur in the workforce at the 77 sites in 100 years (or an average of less than 1 fatality every 10 years) (DIRS 104596-Orthen 1999, Table 6).

In addition, the analysis estimated the long-term traffic fatalities for the remaining 9,900-year analysis period. Using the estimated number of full-time equivalent work years of 7.4 million, about 730 traffic

fatalities would be likely during the 9,900-year analysis period at the 77 sites (or, on average, less than 1 fatality every 10 years).

The analysis also estimated traffic fatalities and latent cancer fatalities from trucks transporting construction materials to and demolition debris from the 77 sites assuming an 80-kilometer (50-mile) roundtrip distance. For the 9,900-year period, during the construction of replacement facilities, construction vehicles would travel about 1.2 billion kilometers (750 million miles), resulting in approximately 17 prompt traffic fatalities, or less than 1 fatality every 600 years (DIRS 103455-Saricks and Tompkins 1999, Table 4, pp. 34 and 35) and about 0.1 latent fatality from vehicle exhaust emissions.

7.2.1.15 Sabotage

Above-ground storage of spent nuclear fuel and high-level radioactive waste for 10,000 years would entail a continued risk of intruder access at each of the 77 sites. Sabotage could result in a release of radionuclides to the environment around the facility. Under Scenario 1, the analysis assumed that safeguards and security measures currently in place would remain in effect during the 10,000-year analysis period, thereby reducing the risk of sabotage.

As Nuclear Regulatory Commission licensees, the individual sites would be required to comply with Commission regulations and maintain the highest level of security as determined by the Commission, and any results from the reexamination of existing physical security and safeguard systems following the terrorist attack of September 11, 2001.

Because it is not possible to predict whether sabotage events would occur, and if they did, the nature of such events, DOE examined various accident scenarios in this Final EIS, which provide an approximation of the consequences that could occur.

7.2.2 NO-ACTION SCENARIO 2

DOE and commercial utilities intend to maintain control of the nuclear storage facilities as long as necessary to ensure public health and safety. However, Scenario 2 assumes no effective institutional control of the storage facilities after approximately the first 100 years to provide a basis for evaluating an upper limit of potential adverse human health impacts to the public from the continued storage of spent nuclear fuel and high-level radioactive waste. After about 100 years, Scenario 2 assumes that there would be no effective institutional control and that the storage facilities would be abandoned. Therefore, there would be no health risks for workers during that period. For the long-term impacts after about 100 years and for as long as 10,000 years, the analysis assumed that the spent nuclear fuel and high-level radioactive waste storage facilities at 72 commercial and 5 DOE sites would begin to deteriorate and that radioactive materials would be released to the environment, contaminating the local atmosphere, soil, surface water, and groundwater. Appendix K provides details of facility degradation, radioactive material environmental transport, and human radiological exposure and dose models.

Because Scenario 2 assumes effective institutional control during the first 100 years of the 10,000-year analysis period, the short-term impacts of that first 100 years would be the same as the impacts described for Scenario 1 (see Section 7.2.1). Therefore, this discussion focuses on long-term impacts (after the first approximately 100 years). However, after about 100 years under Scenario 2, when there would no longer be effective institutional control, construction and operation activities would not occur at the storage sites; therefore, socioeconomic and cultural resources would be unlikely to receive adverse impacts. In addition, noise would not emanate from the facilities; utilities, energy, or materials would not be expended; waste would not be generated; and workers would not commute to the sites. Thus, after approximately the first 100 years, No-Action Alternative Scenario 2 would not adversely affect socioeconomic and cultural resources; scenic resources; noise; utilities, energy and materials; waste

management; or traffic and transportation. Aesthetic resources would not change until the facilities began to degrade, at which time the aesthetic value of the sites would change.

7.2.2.1 Land Use and Ownership

Without maintenance and periodic replacement, facilities, storage containers, and the spent nuclear fuel and high-level radioactive waste would begin to deteriorate. Eventually radioactive materials would contaminate the land surrounding the storage facilities, possibly rendering it unfit for human habitation or agricultural uses for hundreds or thousands of years. The amount of land contaminated would depend on several factors including the climate of the region, the amount of spent nuclear fuel and high-level radioactive waste at the site, and the rate of deterioration. Although the size of the affected area would be impossible to predict accurately for each site, DOE believes it would involve tens to hundreds of acres at each of the 77 sites.

By assuming that there would be no effective institutional control, this scenario also assumes that there would not be an orderly conversion of land use and ownership to other uses or ownership and that all knowledge of the purpose and content of the facilities would be lost. This would increase the likelihood that members of the public would move onto storage facility lands because they would not be aware of the potential radioactive material contamination.

7.2.2.2 Air Quality

As discussed in Appendix K, Section K.2.3, the degraded facilities would provide sufficient protection of the spent nuclear fuel and high-level radioactive waste materials to preclude the release of particulate radioactive materials in sufficient quantities to affect air quality adversely. Small releases of gaseous carbon-14 would be likely in the form of carbon dioxide gas but would not adversely affect ambient air quality.

7.2.2.3 Hydrology

7.2.2.3.1 *Surface Water*

As the concrete storage facilities, storage canisters, and spent nuclear fuel and high-level radioactive waste materials deteriorated, contaminants would enter surface waters from stormwater runoff from the failed facilities and storage containers and exposed radioactive materials. The introduction of contaminants would continue over a long period until the depletion of the source materials. During this release period, contaminant releases to surface waters could be sufficient to produce adverse impacts to human health. Section 7.2.2.5.3 discusses impacts to the public using this water for drinking.

7.2.2.3.2 *Groundwater*

As the concrete storage facilities, storage canisters, and spent nuclear fuel and high-level radioactive waste materials deteriorated, contaminants would enter the groundwater. Once contaminated, aquifers beneath the degraded storage facilities would remain contaminated for the period required for the depletion of the spent nuclear fuel and high-level radioactive waste materials and the migration of the contaminants from the groundwater system. Contaminant concentrations in the groundwater could be sufficient to produce adverse impacts to human health. Section 7.2.2.5.3 discusses impacts to the public using groundwater for drinking, bathing, and irrigation.

7.2.2.4 Biological Resources and Soils

As the concrete storage facilities, storage canisters, and spent nuclear fuel and high-level radioactive waste materials deteriorated, the potential for individual animals to be exposed to radiation at the storage sites would increase. In addition, animals could drink contaminated surface water. Direct radiation from the exposed spent nuclear fuel and high-level radioactive waste storage canisters and concentrations of contaminants in surface waters could produce adverse impacts to animals. While the contaminant exposure could have negative effects, including death, on individual animals, adverse effects to entire populations would be unlikely because the lethal area surrounding the degraded facilities would be limited to a few hundred acres.

Soils at the storage facilities could be contaminated by radioactive materials leaching from the spent nuclear fuel and high-level radioactive waste material. Soils downslope of the facilities could be contaminated by surface-water runoff. Crops grown on these soils would take up some of the contamination, thus making the contaminated soils a pathway for human exposure. Section 7.2.2.5.3 discusses impacts to members of the public from ingesting food grown in or livestock fed from contaminated soils.

7.2.2.5 Occupational and Public Health and Safety

7.2.2.5.1 *Nonradiation Exposures*

Analyses performed for the repository (see Chapter 5, Section 5.6) indicate that concentrations of chemically toxic materials (that is, molybdenum, nickel, vanadium, and chromium) from degraded spent nuclear fuel and high-level radioactive waste packages in the groundwater would be extremely low. Therefore, because of the relatively lower abundance of these materials contained in the stainless steel storage canisters and relatively greater abundance of water and the greater precipitation at the storage locations than at the repository, concentrations of the materials in the groundwater and surface water at the storage sites would likely be much lower than those estimated for the repository. The Department did not attempt to quantify adverse health impacts from chemical toxicity of the waste forms (principally uranium dioxide and *borosilicate glass*) that could occur within the exposed population under Scenario 2. This decision is consistent with the Department's position that care should be taken not to overestimate impacts from the No-Action Alternative.

7.2.2.5.2 *Industrial Hazards*

For about the first 100 years, industrial hazards would be the same as for the first 100 years under Scenario 1 (see Section 7.2.1.7.2). After about 100 years, Scenario 2 assumes there would be no effective institutional control and that the storage facilities would be abandoned and, therefore, there would be no industrial safety impacts.

7.2.2.5.3 *Radiation Exposures*

To simplify the analysis, DOE divided the United States into five regions (Figure 7-7). Regional radiological impacts were estimated by assuming all spent nuclear fuel and high-level radioactive waste in a particular region was stored at a single hypothetical site in that region. Appendix K, Section K.2.1.6, provides details of the methods and assumptions used in the regional analysis.

Radiological impacts to occupational workers and the offsite public from initial construction, routine maintenance and operations, and refurbishment after the first 50 years would be the same as those for the same period under Scenario 1 (see Section 7.2.1.7.3 and Table 7-6).

Figure 7-7. Commercial and DOE sites in each No-Action Alternative analysis region.

For Scenario 2 DOE assumed that after approximately the first 100 years there would be no institutional control and that deterioration of the facilities would occur over time. Based on regional climate and degradation models (see Appendix K), the spent nuclear fuel and high-level radioactive waste storage facilities and dry storage containers would corrode and fail over time, exposing radioactive material to the environment (wind and rain). Once exposed to the environment, the spent nuclear fuel and high-level radioactive waste storage packages and facilities would begin releasing small quantities of radioactive material to the atmosphere (gaseous carbon-14), soil, surface water, and groundwater, resulting in exposures to the public. These released materials could produce chronic exposures to the public, which could result in adverse health impacts. Figure 7-8 shows the conceptual timeline for activities and degradation processes at the storage facilities for Scenario 2.

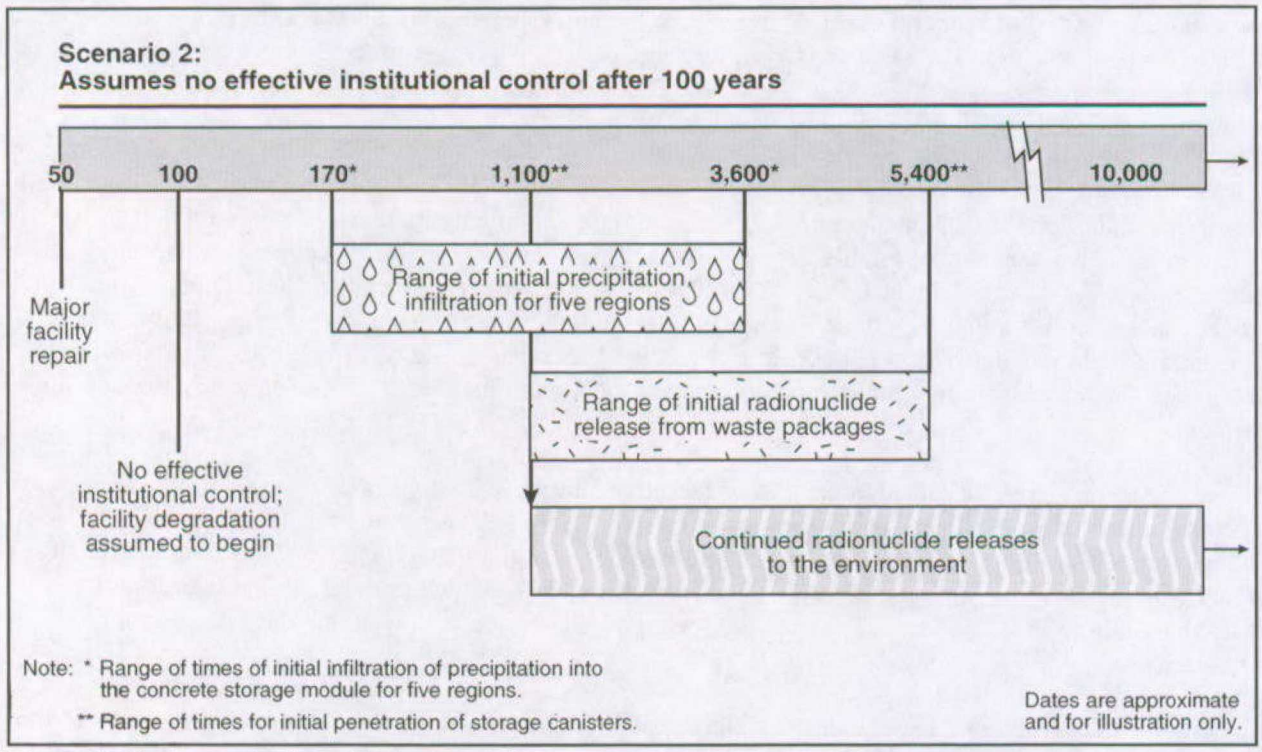


Figure 7-8. Conceptual timeline for activities and degradation processes for No-Action Scenario 2.

Appendix K describes the methods used to estimate impacts to human health from long-term environmental releases and human intrusion. The radiological impacts on human health include internal exposure from intake of radioactive materials in surface water and groundwater.

Table 7-7 lists the estimated radiological drinking water impacts during the 9,900 years under Scenario 2 with the assumption of no effective institutional control. The impacts listed in Table 7-7 are from drinking water only and would result from consuming water from the major waterways contaminated with radioactive materials by groundwater discharge and surface-water runoff from degraded spent nuclear fuel and high-level radioactive waste storage facilities. DOE evaluated

Table 7-7. Estimated long-term collective drinking water radiological impacts to the public from long-term storage of spent nuclear fuel and high-level radioactive waste at commercial and DOE sites – Scenario 2.

9,900-year population dose[a] (person-rem)	9,900-year LCFs[b]	Years to peak impact[c]
6,600,000	3,300	3,400

a. Estimated total population (collective) dose from drinking water pathway (DIRS 101935-Toblin 1999, p. 4).
b. LCFs = latent cancer fatalities; estimated for the exposed population group based on an assumed risk of 0.0005 latent cancer fatality per person-rem of collective dose (DIRS 101857-NCRP 1993, p. 112).
c. Years after period of institutional control when the maximum doses would occur.

other potential impacts to populations (for example, exposure to people living on the contaminated floodplains) and to individuals (for example, consumption of contaminated food) and determined that certain individuals could receive doses as much as three times higher than for drinking water alone but that doses to populations from contaminated floodplains would represent less than 10 percent of the impacts listed in Table 7-7. DOE did not include these impacts in Table 7-7 because the dose to an individual would depend largely on highly variable subsistence habits and because DOE did not want to overestimate the impacts from Scenario 2.

Figure 7-9 shows the locations of the commercial and DOE sites in the United States and the more than 20 major waterways potentially affected. At present, municipal water systems that serve 31 million people have intakes along the potentially affected portions of these waterways. The analysis assumed these populations would remain constant over the entire analysis period (9,900 years). Over the 9,900-year analysis period, about 140 70-year lifetime periods would be affected. Because the analysis estimated that releases would not occur during the first 1,000 years for most regions, the estimated potentially exposed population would be about 3.9 billion.

Table 7-7 indicates that over 9,900 years, a collective drinking water dose of 6.6 million person-rem could result in an additional 3,300 latent cancer fatalities in the total potentially exposed population of 3.9 billion. This latent cancer fatality rate would affect an average of about 24 people per 70-year lifetime, or about 1 latent cancer fatality at each of the 77 sites every 200 years. These radiation-induced latent cancer fatalities would be in addition to about 900 million fatal cancers (using the lifetime fatal cancer risk of 24 percent [DIRS 153066-Murphy 2000, p. 5]) that would be likely from all other causes in the exposed population, an incremental increase over the natural incidence of fatal cancer of about 0.0004 percent.

Figure 7-10 shows the estimated latent cancer fatalities for approximately 140 70-year periods during the 9,900-year period of analysis. The five peaks shown in Figure 7-10 generally result from contributions of each of the five regions (see Appendix K, Figure K-8). The major peak, which would occur about 3,400 years after effective institutional control ended (in 2100), would be due to radionuclide releases at the sites that drain to the Mississippi River and the relatively large populations along the Mississippi and its tributaries.

In addition to the 3,300 potential cancer fatalities under Scenario 2, more than 20 major waterways of the United States that currently supply domestic water to about 31 million people (for example, the Great Lakes; the Mississippi, Ohio, and Columbia Rivers; and many smaller rivers along the Eastern Seaboard) could be contaminated with radioactive material. Under this scenario, the shorelines could be contaminated with long-lived radioactive materials (for example, plutonium, uranium, and americium), resulting in exposures to individuals who came in contact with the sediments and, potentially, an increase in latent cancer fatalities. Because individuals would not be in constant contact with the sediments, these impacts represent a small fraction of the impacts estimated for the drinking water pathways listed in Table 7-7.

For purposes of comparison with impacts associated with the Proposed Action, DOE evaluated potential radiological impacts for a maximally exposed individual by constructing hypothetical exposure scenarios for individuals living near the degraded facilities. The exposure scenarios maximized external and internal exposure over each 70-year lifetime period in the 9,900-year period of analysis. The following paragraphs describe the results of these evaluations.

For Scenario 2, localized impacts to individuals from degraded facilities at the 77 sites could be severe. DOE estimated that within a few hundred years at the several sites where early concrete failure was predicted, hypothetical individuals living close to the storage facilities would receive lethal doses of

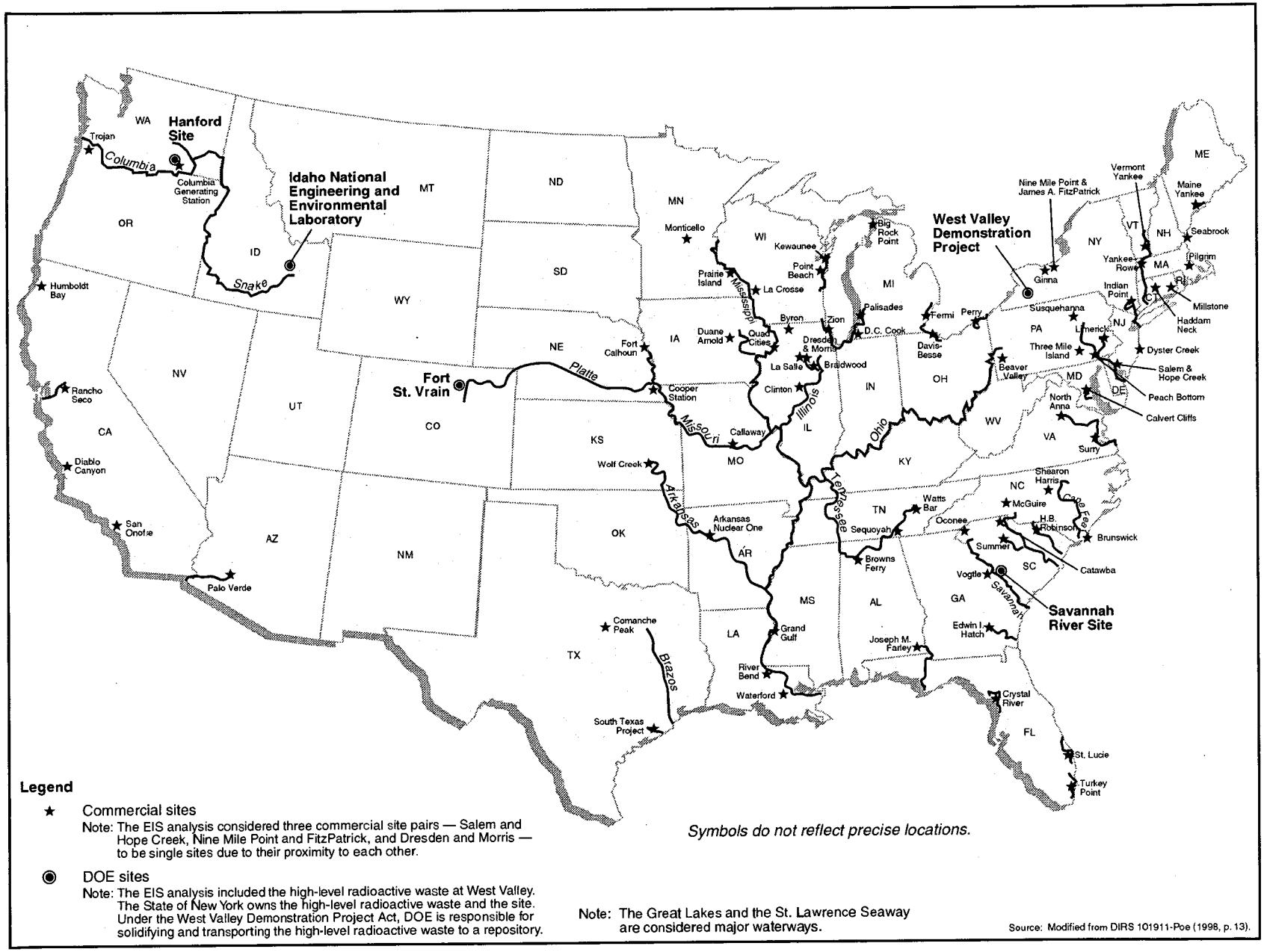


Figure 7-9. Major waterways near commercial and DOE sites.

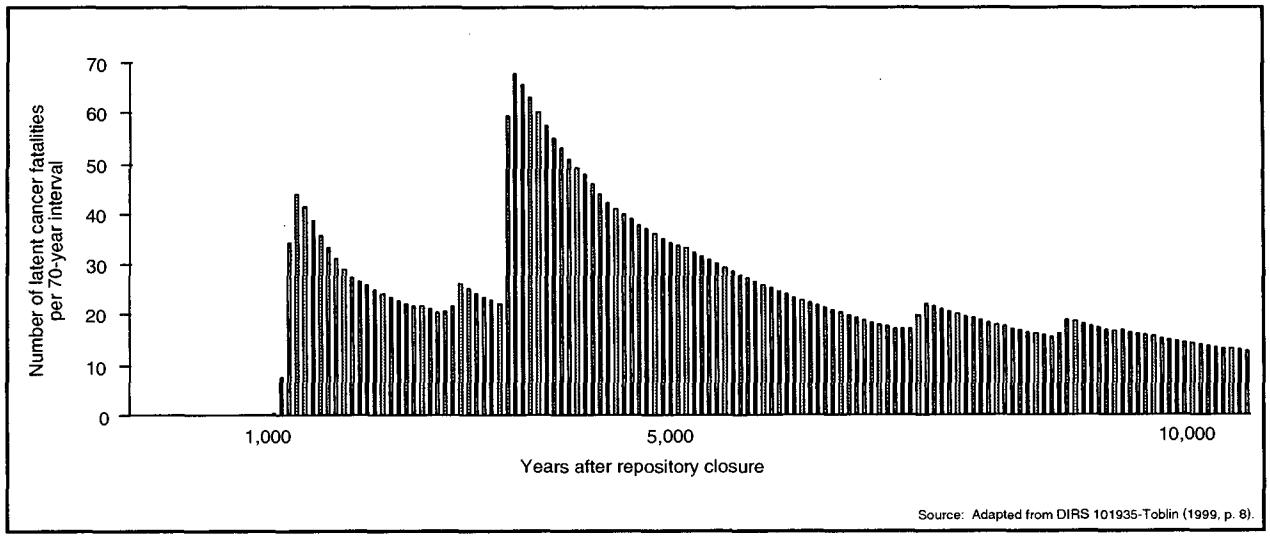


Figure 7-10. Potential latent cancer fatalities throughout the United States from No-Action Scenario 2.

external radiation [800 millirem per hour at a distance of 10 meters (33 feet)] from the exposed dry storage containers (see Appendix K, Section K.2.4.2).

To evaluate impacts from ingestion of radioactive materials, the analysis assumed that individuals would live near the degraded storage facilities and would consume contaminated groundwater and food from gardens irrigated with groundwater withdrawn from the contaminated aquifer directly below their locations. DOE estimated that within 6,000 years from now a hypothetical individual living within several hundred meters of a degraded facility could receive an internal committed effective dose equivalent to several thousand rem per year from ingestion of plutonium-239 and -240 (see Appendix F for further information on committed dose equivalent). Using the National Council on Radiation Protection and Measurements risk factors (DIRS 101857-NCRP 1993, p. 112), ingestion of plutonium at this rate could increase the individual's lifetime risk of contracting a fatal cancer after only a few years of exposure.

In addition, DOE estimated impacts for a hypothetical individual living 5 kilometers (3 miles) from the degraded facility on the downgradient of the contaminated aquifer. Although this individual would be too distant from the facility to receive any appreciable external radiation dose, the internal dose from the consumption of contaminated groundwater and contaminated crops could still be as high as 30 rem per year from ingestion of plutonium-239 and -240. Ingestion of plutonium at this rate could increase the individual's risk of contracting a fatal cancer after several decades of exposure. Appendix K provides details on the methods DOE used to evaluate localized impacts.

Uncertainty

This section contains estimates of the radiological impacts of No-Action Scenario 2, which assumes continued above-ground storage of spent nuclear fuel and high-level radioactive waste at sites across the United States. Associated with the impact estimates are uncertainties typical of predictions of the outcome of complex physical and biological phenomena and of the future state of society and societal institutions over long periods. DOE recognized this fact from the start of the analysis; however, the predictions will be valuable in the decisionmaking process because they provide insight based on the best information and scientific judgments available.
This analysis considered five aspects of uncertainty:

- Uncertainties about the nature of changes in society and its institutions and values, in the physical environment, and of technology as technology progresses

- Uncertainties associated with future human activities and lifestyles
- Uncertainties associated with the mathematical representation of the physical processes and with the data in the computer models
- Uncertainties associated with the mathematical representation of the biological processes involving the uptake and metabolism of radionuclides and the data in the computer models
- Uncertainties associated with accident scenario analysis

For the No-Action Scenario 2 analysis DOE has not attempted to quantify the variability of estimated impacts related to possible changes in climate, societal values, technology, or future lifestyles. To simplify the analysis, DOE did not attempt to quantify these uncertainties even though uncertainties with these changes could undoubtedly affect the total consequences reported in Table 7-7 by several orders of magnitude.

DOE attempted to quantify a range of uncertainties associated with mathematical models and input data, and estimated the effect these uncertainties could have on collective human health impacts. By summing the uncertainties (see Appendix K, Sections K.4.1, K.4.2, and K.4.3 for details), DOE estimated that total collective impacts over 10,000 years could have been underestimated by as much as 3 or 4 orders of magnitude. However, because there are large uncertainties in the models used to quantify the relationship between low doses (less than 10 rem) and the accompanying health impacts (see Appendix F, Section F.1.1.5), especially under conditions in which the majority of the population would be exposed at a very low dose rate, DOE believes the actual collective impact could be small.

On the other hand, impacts to individuals (human intruders) who could move to the storage sites and live close to the degraded facilities could be severe. During the early period (200 to 400 years after the assumed loss of institutional control), acute exposures to external radiation from the spent nuclear fuel and high-level radioactive waste material could result in prompt fatalities. In addition, after a few thousand years onsite shallow aquifers could be contaminated to such a degree that consumption of water from those aquifers could result in severe adverse health effects, including premature death. Uncertainties about these localized impacts are related primarily to the inability to predict accurately how many individuals could be affected at each of the 77 sites over the 10,000-year analysis period. In addition, the uncertainties associated with localized impacts would exist for potential consequences resulting from unusual events, both manmade and natural.

Therefore, uncertainties resulting from surface storage where containers are more readily affected by natural phenomena and human behavior (see Appendix K, Table K-14) that cannot be predicted, process model uncertainties, and dose-effect relationships, taken together, could produce the results listed in Table 7-7, overestimating or underestimating the actual impacts by as much as several orders of magnitude.

7.2.2.6 Atmospheric Radiological Consequences

As discussed in Appendix K, Section K.2.3, the analysis assumed that the configuration of the degraded storage facilities would cause debris to cover the radioactive material, which would remain inside the dry storage canisters. While the dry storage canisters could fail sufficiently to permit water to enter, they would probably retain their structural characteristics, thereby minimizing the dispersion of particulate radioactive material to the atmosphere (DIRS 147905-Mishima 1998, all). However, the radionuclides carbon-14 and iodine-129 would have a potential for gas transport. Although iodine-129 can exist in a gas phase, DOE expects it would dissolve in the precipitation and migrate in surface water and groundwater. DOE also expects the consequences from a release of carbon-14 to be very small based on

the low failure rate of zirconium-clad spent nuclear fuel (see Appendix K, Section K.2.1.4.1 for details) and large atmospheric dilution.

7.2.2.7 Accidents

For Scenario 2, the analysis examined the impacts of an accident scenario that could occur during the above-ground storage of spent nuclear fuel and high-level radioactive waste and concluded that the most severe accident scenarios would be an airplane crash into a concrete storage module. The frequency of such an event was estimated to be 0.0000032 (3 in 1 million) crashes per year.

In Scenario 2, the concrete storage modules would deteriorate with time. DOE concluded that an airplane crash into a degraded concrete storage module would dominate the consequences from external initiating events (see Appendix K, Section K.3.2.1). The analysis evaluated the potential for criticality accidents and concluded that an event severe enough to produce large consequences would be extremely unlikely, and that the consequences would be bounded by the airplane crash consequences. Table 7-8 lists the consequences of an airplane crash on a degraded concrete storage module.

Table 7-8. Estimated consequences of an aircraft crash on a degraded spent nuclear fuel concrete storage module.[a]

Factor	High population site[b]	Low population site[c]
Frequency (per year)	3.2×10^{-6}	3.2×10^{-6}
Collective population dose (person-rem)	26,000	6,100
Latent cancer fatalities	13	3

a. Source: DIRS 103711-Davis, Strenge, and Mishima (1998, p. 11).
b. Within 80 kilometers (50 miles) of site, an average of 330 persons per square mile.
c. Within 80 kilometers of site, an average of 77 persons per square mile.

7.2.2.8 Environmental Justice

Deteriorating facilities, storage containers and packaging, and spent nuclear fuel and high-level radioactive waste could produce adverse effects to the nearby public. Any nearby minority or low-income communities could experience disproportionately high and adverse human health impacts. In addition, financial considerations could make it more difficult for members of any affected minority or low-income populations to obtain uncontaminated resources or to move away from contaminated soils and water. Because subsistence patterns for low-income and minority populations could vary from those of persons not in these groups, any affected low-income and minority populations could be exposed to greater than average doses. The result of differing potentials for exposure could be disproportionately high and adverse impacts to minority or low-income populations.

If the United States determines that it will use continued storage at existing sites for the long-term disposition of spent nuclear fuel and high-level radioactive waste, site-specific analyses of storage facilities would be required to identify if environmental justice issues could result. The Nuclear Regulatory Commission established this approach (DIRS 101899-NRC 1996, p. 9-16). With the assumption of no effective institutional control after about 100 years, potential environmental justice issues identified under Scenario 2 probably would be more severe than those identified under Scenario 1 (see Section 7.2.1.13).

7.2.2.9 Sabotage

For Scenario 2, the storage of spent nuclear fuel and high-level radioactive waste for 10,000 years without institutional control would entail a greater risk of intruder access at the 77 sites than exists under current conditions. Due to the lack of institutional control and degraded facilities, sabotage could result in a release of radionuclides to the environment around the facility. The analysis assumed that safeguards and security measures would not be maintained after approximately the first 100 years. For the remaining

9,900 years of the analysis period, the cumulative risk of intruder attempts would increase. As the *storage containers* degraded, they would become more vulnerable to failure. Any amount of material released from its storage container could contaminate areas with radioactivity. Therefore, the risks of sabotage would increase substantially under this scenario in comparison to Scenario 1.

7.3 Cumulative Impacts for the No-Action Alternative

DOE evaluated the disposal of 70,000 MTHM of spent nuclear fuel and high-level radioactive waste in the Proposed Action analysis. To provide a direct comparison of impacts with the Proposed Action, the No-Action analysis in Sections 7.1 and 7.2 evaluated the impacts of the continued storage of 70,000 MTHM of spent nuclear fuel and high-level radioactive waste at 72 commercial and 5 DOE sites across the United States. DOE chose the volume of 70,000 MTHM for analysis because the NWPA prohibits the Nuclear Regulatory Commission from approving the emplacement of more than 70,000 MTHM in a first repository until a second repository is in operation. This section describes the results of the analysis of the cumulative impacts of the continued storage at the 77 existing sites of all spent nuclear fuel and high-level radioactive waste (called Inventory Module 1) (Table 7-9). Chapter 8 discusses the cumulative impacts of disposing of radioactive waste at the Yucca Mountain Repository in excess of the Proposed Action repository.

Table 7-9. Inventories for Proposed Action and Module 1.[a]

Material	Proposed Action	Module 1
DOE spent nuclear fuel	2,333 MTHM	2,500 MTHM
Commercial spent nuclear fuel[b]	63,000 MTHM	105,000 MTHM
High-level radioactive waste[b]	8,315 canisters	22,280 canisters

a. Source: Appendix A, Section A.1.1.4.1.
b. Surplus plutonium would be included in the inventory in the form of mixed-oxide fuel (treated as commercial spent nuclear fuel) or immobilized plutonium (high-level radioactive waste).

A cumulative impact is defined as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions" (40 CFR 1508.7). Cumulative impact assessment is based on both the geographic (spatial) and time (temporal) considerations of past, present, and reasonably foreseeable actions. Geographic boundaries can vary by discipline depending on the time an effect remains in the environment, the extent to which the effect can migrate, and the magnitude of the potential impact. The proximity of other actions to the spent nuclear fuel storage sites is not the only decisive factor for determining the inclusion of an action in the assessment of cumulative impacts. Another, and for this analysis more important, factor is if the other actions would have some influence on the resources in the same time and space affected by continued storage.

The cumulative impacts of past actions have either passed through the environment or are part of existing baseline conditions. For example, the construction impacts of spent nuclear fuel storage facilities will have passed through the environment before the potential impacts associated with continued storage and refurbishment would first be seen in 2002.

DOE based its estimates of the potential impacts from continued storage of commercial spent nuclear fuel on a representative site. The results of the analysis described in the previous section are consistent with the Nuclear Regulatory Commission's findings in its *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (DIRS 101899-NRC 1996, pp. 6-85 and 6-86). The NRC stated:

> *The Commission's regulatory requirements and the experience with on-site storage of spent fuel in fuel pools and dry storage has been reviewed. Within the context of a license renewal review and*

> *determination, the Commission finds that there is ample basis to conclude that continued storage of existing spent fuel and storage of spent fuel generated during the license renewal period can be accomplished safely and without significant environmental impacts. Radiological impacts will be well within regulatory limits; thus radiological impacts of on-site storage meet the standard for a conclusion of small impact. The nonradiological environmental impacts have been shown to be not significant; thus they are classified as small. The overall conclusion for on-site storage of spent fuel during the term of a renewed license is that the environmental impacts will be small for each plant. The need for the consideration of mitigation alternatives within the context of renewal of a power reactor license has been considered, and the Commission concludes that its regulatory requirements already in place provide adequate mitigation incentives for on-site storage of spent fuel.*

Although this finding is applicable only to the continued storage of existing spent nuclear fuel and spent nuclear fuel generated during the 20-year license renewal period for the nuclear powerplant, DOE has concluded that potential environmental and radiological impacts for the storage facility would remain small for much longer periods. Environmental impacts would remain small because no additional fuel would be generated beyond the operation of the nuclear powerplant (plants are assumed to be closed after the first 20-year license renewal period), and radiological impacts would remain within regulatory limits specified in the storage facility license (10 CFR Part 72).

In general, the analysis of cumulative effects can exclude future actions if:

- The action is outside the geographic boundaries or timeframe established for the cumulative effects analysis.
- The action will not affect resources that are the subject of the cumulative effects analysis.
- Including the action would be arbitrary.

Because the estimated impacts would be small, DOE has not attempted to speculate on other arbitrary generic actions that could influence the cumulative impacts generated at a given site. However, the total incremental impact nationally of selected parameters is presented in the preceding section. In addition, the potential impacts at each site do not overlap because the storage sites are located throughout the United States. Therefore, cumulative impacts among the sites on resources would be unlikely.

For the 5 DOE sites, there is a long legacy of EISs and annual monitoring reports. The incremental impacts associated with continued storage of spent nuclear fuel can be added to the results reported in these documents to obtain an estimate of total impacts. For the 72 diverse commercial sites, information on other present and reasonably foreseeable actions varies in terms of data availability and quality. As a consequence, a comparison of cumulative assessments would be problematic, even if the impacts were not as small as the analyses indicate.

The cumulative analysis in this section includes the total projected inventory of commercial spent nuclear fuel, DOE spent nuclear fuel, and high-level radioactive waste (referred to as Module 1) that could come to the repository. Table 7-9 lists the inventories for the Proposed Action analysis and the Module 1 cumulative analysis.

For consistency with the cumulative impact analysis in Chapter 8, the No-Action analysis considered the same spectrum of environmental impacts as the Proposed Action. However, because of the DOE commitment to manage spent nuclear fuel and high-level radioactive waste safely, the Department decided to focus the No-Action cumulative analysis on the short- and long-term health and safety of workers and members of the public. Therefore, quantitative estimates of the cumulative impacts in this section include occupational and public health and safety, waste management, and traffic and transportation. The qualitative discussions of other disciplines are included for completeness.

DOE recognizes that approximately 2,100 cubic meters (74,000 cubic feet) of commercial low-level radioactive waste will exceed Nuclear Regulatory Commission Class C limits (listed in 10 CFR 61.55, Tables 1 and 2 for long and short half-life radionuclides, respectively). This type of waste, called *Greater-Than-Class-C low-level waste*, is generally not suitable for near-surface disposal (see Appendix A, Section A.2.5, for a detailed description). Similarly, DOE low-level radioactive waste that exceeds the Nuclear Regulatory Commission Class C limits (referred to as *Special-Performance-Assessment-Required waste*) will amount to about 4,000 cubic meters (142,000 cubic feet) (see Appendix A, Section A.2.6, for a detailed description). Together these waste types, added to the Module 1 inventory, comprise the Module 2 inventory.

The NWPA does not specifically consider Greater-Than-Class-C or Special-Performance-Assessment-Required wastes. Therefore, DOE has not included either waste type in the Proposed Action inventory for the consideration of potential impacts that could occur from the disposal of spent nuclear fuel and high-level radioactive wastes in a geologic repository at Yucca Mountain. The disposal of these wastes at Yucca Mountain, however, is part of the cumulative impact analysis (see Chapter 8) because the impacts of that disposal are reasonably foreseeable as the results of future actions.

Further, DOE has not included Module 2 in its consideration of potential impacts under the No-Action Alternative. DOE does not have enough information about Module 2 wastes at present to be able to perform a meaningful analysis with respect to the No-Action Alternative. As discussed in Appendix A, Section A.2.5, Greater-Than-Class-C waste could include, for example, certain commercial nuclear powerplant operating and decommissioning wastes and sealed radioisotope sources. DOE Special-Performance-Assessment-Required waste could include certain production reactor operating wastes, production and research reactor decommissioning wastes, sealed radioisotope sources, and isotope production-related wastes (see Appendix A, Section A.2.6). As just one example of the confounding potential sources of these types of wastes, in 1993 DOE estimated that 2,552 Greater-Than-Class-C low-level waste fixed-gauge and X-ray fluorescence sealed sources (general licensees) and 7,582 sealed sources (for example, calibration, medical, well logging sources) were used and stored by private industry at hundreds of locations in the United States (DIRS 101798-DOE 1994, all).

As this example illustrates, a meaningful analysis would need to consider the sites, or combination of sites, at which these waste types are currently in use and storage. The analytic approach used to construct the regional representative sites for which the continued storage of spent nuclear fuel and high-level radioactive waste was evaluated would not apply to the hundreds of additional locations associated with Greater-Than-Class-C and Special-Performance-Assessment-Required wastes.

For the spent nuclear fuel and high-level radioactive waste analysis in this EIS (see Appendix K, Section K.2.1), DOE collected information from published sources for each of the 77 sites where spent nuclear fuel and high-level radioactive waste is located and, to simplify the analysis, divided the country into five regions. The Department then configured a single hypothetical site in each region (see Appendix K, Section K.2.1.6), which enabled it to estimate the potential release rate of the radionuclide inventory from the spent nuclear fuel and high-level radioactive waste, based on forecast interactions of the environment (rainfall, freeze-thaw cycle) with the engineered barrier (concrete storage modules).

Environmental information at the hundreds of sites in which Greater-Than-Class-C and Special-Performance-Assessment-Required wastes are in use and storage is not readily available and DOE could not obtain it without an exorbitant commitment of resources. Relevant environmental evaluations such as those prepared by the Nuclear Regulatory Commission for operating commercial nuclear powerplants or spent nuclear fuel storage installations are not available for most of the locations at which these waste types are in use or storage. Further, the manner in which Greater-Than-Class-C and Special-Performance-Assessment-Required low-level wastes are stored varies by waste types, and the great

variety of storage methods could not be simplified for analytical purposes without distorting the resulting potential environmental impacts.

Even if such information were gathered and the means of storage could be reduced by the use of simplifying assumptions, the results of the analysis (the impacts) would tend to reinforce the results of the impact analysis performed for the Module 1 inventory. That is, short-term impacts such as those to socioeconomics and land use would not increase appreciably, but health effects probably would increase over the long term because workers and the public would be exposed to these waste types in addition to spent nuclear fuel and high-level radioactive waste at the many locations across the United States.

7.3.1 SHORT-TERM IMPACTS IN THE YUCCA MOUNTAIN VICINITY

Candidate materials would not be transported to the repository. Therefore, impacts from Module 1 would be the same at the Yucca Mountain site as those presented in Section 7.1.

7.3.2 SHORT- AND LONG-TERM IMPACTS AT COMMERCIAL AND DOE SITES

7.3.2.1 Land Use and Ownership

Under Scenario 1 (long-term institutional control), as discussed in Section 7.2.1.1, the land required for storage facilities typically would be a few acres. For the Module 1 inventory, the analysis assumed that the land required would increase, on average, by about 60 percent (the ratio of Proposed Action and Module 1 inventories). This additional land requirement [less than 0.04 square kilometer (10 acres) per site] would represent a small percentage of the land currently available at the sites; therefore, the incremental impacts on land use would be minimal but larger than those for the Proposed Action facilities. These storage facilities would be on land currently owned by DOE or a utility and, therefore, would be unlikely to affect land ownership.

Under Scenario 2 (assumption of no effective institutional control after about 100 years), as discussed in Section 7.2.2.1, without maintenance and periodic replacement, facilities, storage containers, and the spent nuclear fuel and high-level radioactive waste would begin to deteriorate, eventually contaminating the land surrounding the storage facilities and rendering it unfit for human habitation or agricultural uses for hundreds or thousands of years. The additional inventories of Module 1 probably would increase the concentrations of radioactive materials in the soils and the size of the affected areas over those expected for the Proposed Action inventory. As with the Proposed Action, these concentrations and areas would be difficult to estimate but even with the additional inventories of Module 1, DOE believes it would involve less than several hundred acres at each of the 77 sites.

In addition, as with the Proposed Action, because Scenario 2 assumes no effective institutional control after approximately 100 years, there would not be an orderly conversion of land use and ownership to other uses or ownership. Therefore, the potential for members of the public to move onto storage facility lands with Module 1 inventories would be unchanged from that expected for the Proposed Action.

7.3.2.2 Air Quality

As discussed in Section 7.2.1.2, under Scenario 1 best management practices and effective monitoring procedures would ensure that contaminant releases to the air would be minimal and would not exceed current regulatory limits (40 CFR Part 61 for hazardous air pollutants emissions and Part 50 for air quality standards). In addition, DOE expects that these controls would be effective with the additional inventories of Module 1. Therefore, air quality under Scenario 1, Module 1 would not be adversely affected during routine operations.

As discussed in Section 7.2.1.2, during the construction of replacement facilities, exhaust from construction vehicles would temporarily increase local concentrations of hydrocarbons, carbon monoxide, and oxides of nitrogen for a few years during each 100 years. DOE expects that these temporary increases in particulate matter resulting from construction activities would persist for slightly longer periods because of the additional facilities required to store the additional inventories of Module 1. However, mitigation measures such as watering unpaved roads would limit the generation of fugitive dust. As with the Proposed Action, after replacement the old site would be seeded, graveled, or paved to reduce air emissions. Therefore, although adverse air quality impacts during construction would be slightly higher for the Module 1 inventory, DOE expects them to be minimal and transient.

The Module 1 air quality impacts under Scenario 2, as discussed in Section 7.2.2.2, would be minimal because even degraded facilities would limit the release of radioactive particulate material to the atmosphere.

7.3.2.3 Hydrology

7.3.2.3.1 *Surface Water*

For Scenario 1, as discussed in Section 7.2.1.3.1, under long-term institutional control, best management practices such as stormwater pollution prevention plans and stormwater holding ponds would ensure that, in the unlikely event of an inadvertent release, contaminants would not reach surface-water systems. These controls and monitoring procedures would be effective for the additional inventories of Module 1. Therefore, as with the Proposed Action inventory, surface-water quality would not be adversely affected by routine operations.

For long-term impacts from Scenario 2, after about 100 years when there is an assumption of no effective institutional control, the Module 1 contaminants could enter surface water via stormwater runoff from degraded facilities in quantities greater than those expected for the Proposed Action. Section 7.3.2.7.3 discusses the incremental impacts to the public expected from these additional surface water contaminants resulting from the Module 1 inventory.

7.3.2.3.2 *Groundwater*

Under Scenario 1, Module 1 groundwater impacts from the storage of 105,000 MTHM of commercial spent nuclear fuel, 2,500 MTHM of DOE spent nuclear fuel, and 22,280 canisters of high-level radioactive waste would be minimal because best management practices such as spill prevention and cleanup plans and procedures and effective effluent monitoring procedures would ensure that inadvertent contaminant releases did not reach groundwater.

In addition, although the analysis assumed that the average square footage of storage facilities would increase by about 60 percent for the additional Module 1 inventory, the shallow foundations of these surface structures would not disturb groundwater systems. Some additional DOE storage facilities would be subsurface structures for which construction could require minimal dewatering of the groundwater aquifer. However, the larger square footage of the Module 1 structures would be relatively small (a few acres) in relation to the size of the aquifer, so no adverse impacts would result from dewatering activities.

For long-term impacts from Scenario 2, Module 1 contaminants would be likely to enter the underlying groundwater from degraded facilities in quantities greater than those expected for the Proposed Action. Section 7.3.2.7.3 discusses the incremental impacts to the public from these additional groundwater contaminants resulting from the Module 1 inventory.

7.3.2.4 Biological Resources and Soils

For Scenario 1, as discussed in Section 7.2.1.4, under long-term institutional control, impacts to biological resources or soils from the construction every 100 years and operation of the storage facilities would be minimal for the expanded Module 1 inventory. The facilities necessary to store the expanded Module 1 inventory would be fenced to keep wildlife out and replacement facilities would be constructed on previously disturbed soil. In addition, as with the Proposed Action, spills would be contained and cleaned up immediately, thus minimizing the area of soil affected.

For long-term impacts from Scenario 2, the analysis assumed that the potential for individual animals to be exposed to radiation at the storage sites would increase in proportion to the increased Module 1 inventory in comparison to the Proposed Action inventory (approximately 60 percent). While the increased contaminant exposure could have negative effects, including death, on individual animals, adverse impacts to entire populations would be unlikely because the lethal area surrounding the degraded facilities would be limited to a few hundred acres.

Contamination of soils at the storage facilities by radioactive materials leaching from the spent nuclear fuel and high-level radioactive waste material would be likely to increase in proportion to the increase in Module 1 inventory. Appendix K, Section K.2.4, discusses impacts to members of the public from eating food grown in contaminated soils or livestock fed on such soils.

7.3.2.5 Cultural Resources

For Scenario 1, the analysis assumed that the Module 1 replacement of spent nuclear fuel and high-level radioactive waste storage facilities would increase by about 60 percent over the Proposed Action. However, these additional facilities would generally be on undeveloped land owned by DOE or the commercial utilities in rural areas. As with the Proposed Action, the size of the additional facilities and supporting infrastructure would be small enough that the facility probably would avoid known cultural resources. In addition, if previously unknown archaeological sites, human remains, or funerary objects were uncovered during construction, DOE or the commercial utility would comply with Executive Orders and Federal and state regulations for the protection of cultural resources. Therefore, construction and operations would not affect cultural resources.

For long-term impacts from Scenario 2, construction and operation for about the first 100 years would be as described for Scenario 1. After this time, no construction or operation activities would occur at the generating sites; therefore, cultural resources would not be adversely affected.

7.3.2.6 Socioeconomics

For Scenario 1, the total staff required at 77 sites to monitor, maintain, and replace the Module 1 facilities would increase from about 700 for the Proposed Action inventory of 70,000 MTHM to more than 800 for the Module 1 inventory of 105,000 MTHM (DIRS 104596-Orthen 1999, Table 6). This increase is approximately equivalent to adding no more than two individuals at each of the 77 sites. Therefore, the additional storage requirements of the Module 1 inventory would be unlikely to affect socioeconomic factors such as infrastructure and regional economy.

For long-term impacts from Scenario 2, because there is an assumption of no effective institutional control after about 100 years, there would be no workers for either the Proposed Action or Module 1 inventories. Therefore, the Module 1 socioeconomic impacts would be essentially the same as those for the Proposed Action for the first 100 years, but after that approximately 800 jobs would be lost. Because these jobs would be spread over 72 commercial and 5 DOE sites (about 10 jobs per site), socioeconomic impacts would be very small for a given region.

7.3.2.7 Occupational and Public Health and Safety

7.3.2.7.1 *Nonradiation Exposures*

For Scenario 1, Module 1, as with the Proposed Action, maintenance, repairs, repackaging, and construction at the storage facilities would be conducted in accordance with Occupational Health and Safety Administration and National Institute of Occupational Safety and Health requirements (29 CFR). Worker exposures to industrial nonradioactive hazardous materials during construction and operation of the storage facilities would be minimized through administrative controls and design features such that exposures would remain below hazardous levels.

For long-term impacts from Scenario 2, the increased inventory of Module 1 and resultant increase in stainless steel storage canisters would be likely to result in a proportional increase in concentrations of chemically toxic materials (such as chromium) in the groundwater and surface waters at the storage sites. However, as discussed in Section 7.2.2.5.1, these concentrations would remain extremely low and would not result in adverse human health impacts. In addition, as discussed in Section 7.2.2.5.1, the Department did not attempt to evaluate adverse health impacts resulting from dissolution of chemically toxic waste forms because it did not want to overestimate impacts from the No-Action Alternative.

7.3.2.7.2 *Industrial Hazards*

For Scenario 1, as discussed in Section 7.2.1.7.2, the majority of the industrial accidents would occur as a result of surveillance (about 94 percent) and construction tasks. Operations tasks would contribute less than 0.001 percent of the total number of accidents. Therefore, to estimate the number of industrial accidents that would be likely to occur at the storage sites for the Module 1 inventory, the number of additional concrete storage modules required to store the additional inventory was calculated.

For Module 1 during the approximately 100-year construction and operation cycle (2002 to 2116), about 80,000 full-time equivalent work years would be required to maintain about 11,000 concrete storage modules and 8 below-grade storage vaults at the 77 sites (DIRS 104596-Orthen 1999, Table 1). Based on this level of effort, as listed in Table 7-10, about 2,800 industrial safety incidents would be likely, resulting in about 1,200 lost workday cases and 3 fatalities (an average of about 1 fatality every 30 years).

Table 7-10. Estimated Module 1 industrial safety impacts at commercial and DOE sites during the first 100 years and the remaining 9,900-year period of analysis under Scenario 1.[a]

Industrial safety impacts	Short-term (100 years)[b] construction and operation	Long-term (9,900 years)[c] construction and operation
Total recordable cases	2,800	410,000
Lost workday cases	1,200	180,000
Fatalities	3	490

a. Source: DIRS 104596-Orthen (1999, Tables 6 and 7).
b. The estimated impacts would result from a single 100-year period of storage module construction (renovation), operation, surveillance, and maintenance.
c. Period from 100 to 10,000 years.

In addition, for Module 1, Table 7-10 indicates about 410,000 projected industrial safety incidents, of which about 180,000 would be lost workday cases and 490 would involve fatalities (an average of about 1 fatality every 20 years or about 1 every 1,600 years at each of the 77 sites). Surveillance tasks would provide about 94 percent of the total worker level of effort, construction tasks would provide nearly all of the remaining 6 percent, and operations tasks would provide less than 0.001 percent.

7.3.2.7.3 *Radiation Exposures*

For Scenario 1, radiation exposures to offsite populations, involved workers, and noninvolved workers would increase because of the additional Module 1 inventory and the construction of additional facilities required to store the materials. The analysis assumed that radiation exposures to offsite and noninvolved worker individuals would increase by the ratio of the Module 1 inventory to the Proposed Action inventory, a factor of about 1.7. Radiation dose rates for the involved maximally exposed worker (construction) would not increase because of the self-shielding effect of the concrete storage modules. Table 7-11 lists radiological human health impacts resulting from the Module 1 inventory.

Table 7-11. Estimated Module 1 radiological human health impacts for Scenario 1.[a]

Receptor	Short-term (100 years) construction and operation	Long-term (9,900 years) construction[b] and operation
Population[c]		
MEI[d] (millirem per year)	0.34	0.10
Dose[e] (person-rem)	1,400	8,800
LCFs[f]	0.70	4.4
Involved workers[g]		
MEI[h] (millirem per year)	170	50
Dose (person-rem)	4,700	41,000
LCFs	1.9	16
Noninvolved workers[i]		
MEI[j] (millirem per year)	23	0[k]
Dose (person-rem)	61,000	0[k]
LCFs	25	0[k]

a. Source: Adapted from DIRS 101898-NRC (1991, all); DIRS 104596-Orthen (1999, all).
b. Assumes construction of 11,000 concrete storage modules, 1 above-grade vault, and 8 below-grade vaults at 77 sites (DIRS 104596-Orthen 1999, Table 1) every 100 years.
c. Members of the general public living within 3 kilometers (2 miles) of the facilities; estimated to be 140,000 over the first approximately 100 years and approximately 14 million over the 9,900-year long-term analysis period [estimated using DIRS 102204-Humphreys, Rollstin, and Ridgely (1997, all)].
d. MEI = maximally exposed individual; assumed to be approximately 1.4 kilometers (0.8 mile) from the center of the storage facility (DIRS 101898-NRC 1991, p. 22).
e. Estimated doses account for radioactive decay.
f. LCF = latent cancer fatality; expected number of cancer fatalities for populations. Based on a risk of 0.0004 and 0.0005 latent cancer per rem for workers and members of the public, respectively (DIRS 101857-NCRP 1993, p. 112), and a life expectancy of 70 years for a member of the public and a 50-year career for workers.
g. Involved workers would be those directly associated with construction and operation activities (DIRS 101898-NRC 1991, pp. 23 to 25). For this analysis, the involved worker population would be about 1,600 individuals (800 individuals at any one time) at 77 sites over 100 years (DIRS 104596-Orthen 1999, Table 6). This population would grow to more than 190,000 over 10,000 years.
h. Based on maximum construction dose rate of 0.11 millirem per hour and 1,500 hours per year (DIRS 101898-NRC 1991, p. 23).
i. Noninvolved workers would be employed at the powerplant but would not be associated with facility construction or operation. For this analysis, the noninvolved worker population would be 80,000 individuals who would receive exposure until the powerplants were decommissioned (50 years).
j. Based on a projected area workforce of 1,200 and an average estimated annual dose of 16 person-rem (DIRS 101898-NRC 1991, p. 24).
k. During this period the powerplants would have ended operation, so there would be no noninvolved workers.

As listed in Table 7-11, the estimated dose to the hypothetical maximally exposed offsite individual for the Module 1 inventory during the operational period between 2002 and 2116 would be about 0.34 millirem per year [adapted from DIRS 101898-NRC (1991, p. 22)]. For the remaining 9,900 years of the analysis period, the dose to the hypothetical maximally exposed individual would decrease to about 0.10 millirem per year because of radioactive decay of the source material. During about the first

100 years, the dose (accounting for radioactive decay) could result (over a 70-year lifetime of exposure) in an increase in the lifetime risk of contracting a fatal cancer of 0.0000073, an increase over the lifetime natural fatal cancer incidence rate of 0.0031 percent. During the remaining 9,900 years of the analysis period, the dose (accounting for radioactive decay) could result (over a 70-year lifetime of exposure) in an increase in the lifetime risk of contracting a fatal cancer of 0.0000022, an increase over the lifetime natural fatal cancer incidence rate of 0.00092 percent.

For the short-term impacts, over about the first 100 years the offsite exposed population of approximately 140,000 would be likely to receive a total collective dose of 1,400 person-rem (adjusted for radioactive decay). This dose could result in 0.70 latent cancer fatality in addition to the 33,000 fatal cancers likely in the exposed population from all other causes. This represents an increase of about 0.0021 percent over the estimated number of cancer fatalities that would occur in the exposed population from all other causes.

For the long-term impacts from Scenario 1, the radiation dose of 8,800 person-rem from the storage facilities could result in an additional 4.4 latent cancer fatalities in the surrounding population of about 14 million. This would be in addition to about 3.3 million cancer fatalities that would be likely to occur in the exposed population of 14 million, an increase of 0.00013 percent over the natural incidence rate.

The analysis assumed the maximally exposed individual in the involved worker population would be a construction worker involved with construction and loading of replacement facilities. Assuming a maximum dose rate of 0.11 millirem per hour (unchanged from the Proposed Action) and an average exposure time of 1,500 hours per year, this construction worker would receive about 170 millirem per year. During about the first 100 years, this dose could result (over three years of construction) in an increase in the lifetime risk of contracting a fatal cancer of 0.00020, an increase of 0.09 percent over the natural fatal cancer incidence rate. During the remaining 9,900 years of the analysis period, the dose could result (over three years of construction) in an increase in the risk of contracting a fatal cancer of 0.000060, an increase over the natural fatal cancer incidence rate of 0.03 percent.

For the involved worker population of 1,600 individuals, approximately 380 would be likely to contract a fatal cancer from some cause other than occupational exposure. In the involved population of 1,600 storage facility workers (during the first 100 years), the collective dose of 4,700 person-rem (corrected for radioactive decay) between 2002 and 2116 could result in 1.9 additional latent cancer fatalities (DIRS 104596-Orthen 1999, Table 6), which would result in an increase of 0.51 percent over the natural incidence rate of fatal cancers from all causes. During the remaining 9,900 years of the analysis period, the involved estimated worker population of more than 190,000 would receive a collective dose of about 41,000 person-rem (corrected for radioactive decay). This dose could result in 16 latent cancer fatalities in addition to the 45,000 cancer fatalities that would be likely in the exposed population from all other causes. These additional cancers would represent an increase of 0.036 percent over the natural incidence rate of fatal cancers.

The estimated Module 1 collective dose to noninvolved workers at a nuclear powerplant from the Module 1 inventory would be about 27 person-rem per year [adapted from DIRS 101898-NRC (1991, p. 24)] for the protected area workforce of 1,200 individuals (DIRS 101898-NRC 1991, p. 26) at the two-unit station at Calvert Cliffs. This collective dose would result in an average maximum dose to the noninvolved worker of 23 millirem per year. Over a 50-year career, this exposure (corrected for radioactive decay) could result in an increase in the lifetime risk of contracting a fatal cancer of 0.00032. This incremental increase in risk would represent an increase of 0.13 percent over the incidence of fatal cancers from all other causes.

In the total noninvolved worker population of 80,000 powerplant workers (all sites), the estimated Module 1 collective dose of 61,000 person-rem (corrected for decay) between 2002 and 2116 could result

in 25 additional latent cancer fatalities. This increase represents about an 0.13-percent increase over the 19,000 cancer fatalities that would be likely to occur from all other causes in the same worker population.

After about 100 years, Scenario 2 assumes no effective institutional control of the 77 sites and assumes that the storage facilities would be abandoned. Therefore, there would be no health risk for workers during that period. For the long-term impacts from Scenario 2, the analysis estimated human health impacts to the public on a regional basis (DIRS 104924-Poe 1999, p. 15). The estimated total population dose would increase from 6.6 million person-rem to about 7.3 million person-rem, resulting in an increase in the number of latent cancer fatalities from about 3,300 to almost 3,700 over the 9,900-year analysis period. Appendix K (Sections K.2.4.1 and K.3.1) contains details of the Proposed Action analysis.

7.3.2.8 Accidents

For Scenario 1, both short- and long-term accident consequences for the additional inventory of Module 1 would be bounded by the severe seismic event and could result in slightly higher impacts than those predicted for the Proposed Action inventory. However, this accident scenario would probably produce only minor radiological impacts to persons in the immediate vicinity of the storage facility.

For Scenario 2, the long-term impacts for Module 1 would be the same as those for the Proposed Action (see Section 7.2.2.7) because only a single concrete storage module would be affected, regardless of inventory.

7.3.2.9 Noise

For Scenario 1, noise levels for the Module 1 inventory should not be noticeably greater than those for the Proposed Action. Therefore, the noise would not adversely affect the hearing of facility workers or frighten wildlife from the area.

For the long-term impacts from Scenario 2, as with the Proposed Action, no noise would emanate from the facilities; therefore, no adverse impacts would occur. For about the first 100 years, noise levels would be the same as those for Scenario 1.

7.3.2.10 Aesthetics

As for the Proposed Action, Scenario 1 impacts to aesthetic or scenic resources from storage facilities resulting from the Module 1 inventory would be unlikely. Though the inventory would be larger than that for the Proposed Action, Module 1 would still require only two adjacent locations at each site. Every 100 years, a new facility would be constructed on the idle site, and the storage containers would be transferred. The old facility would be demolished and the site would remain idle for the next 100 years.

For the long-term impacts from Scenario 2, aesthetics would not change until facilities began to degrade, at which time the aesthetic value of the sites would change.

7.3.2.11 Utilities, Energy, and Materials

For Scenario 1, decommissioning and reclamation activities every 100 years associated with the increased number of concrete storage modules required for the Module 1 inventory would consume slightly more diesel fuel, gasoline, and materials than those for the Proposed Action. However, as with the Proposed Action, much equipment and many materials would be salvaged and recycled. DOE would recycle building materials as practicable. Minimal surveillance activities would require some gasoline. Therefore, the increased Module 1 inventory would not adversely affect the utility, energy, or material resources of the region or the country.

For the long-term impacts from Scenario 2, as with the Proposed Action, DOE would not use utilities, energy, or materials after about 100 years and, therefore, impacts to these resources would be unlikely.

7.3.2.12 Waste Management

Under Scenario 1, the construction of new facilities and the demolition of old facilities every 100 years (and the one-time refurbishment of existing facilities after the first 50 years) would generate construction debris and sanitary and industrial solid waste. In addition, routine repairs and maintenance to the facilities and storage containers, routine radiological surveys, and overpacking of failed containers would generate sanitary and industrial solid and low-level radioactive wastes. Because there would not be a dedicated workforce at the storage facilities, only small amounts of sanitary wastes would be generated except during periods of construction. The greatest amount of waste would be generated during the demolition of facilities at the 72 commercial and 5 DOE storage sites every 100 years. The demolition of facilities once every 100 years at all the sites would generate, on average, an estimated 1.4 million cubic meters (1.8 million cubic yards) of nonhazardous demolition debris, recyclable steel, and potentially a small amount of low-level waste if a dry storage canister failed while in storage (DIRS 104596-Orthen 1999, Table 7). The debris and wastes would be disposed of at commercial or DOE disposal facilities across the Nation. The impacts to available capacity would be spread nationwide, thus minimizing impacts to a single disposal facility. The capacities of the disposal facilities would accommodate the wastes generated at the storage facilities.

For Scenario 2, demolition activities would terminate after about 100 years and, therefore, no additional long-term waste management impacts would be likely after this period.

7.3.2.13 Environmental Justice

For Scenario 1, the potential impacts of continued storage of the Module 1 inventory with institutional control would be minimal. Therefore, minority or low-income populations would not be disproportionately or adversely affected.

For the long-term impacts from Scenario 2, the increased number of facilities required to store the Module 1 inventory could adversely affect the nearby public to a degree greater than that for the Proposed Action inventory. As with the Proposed Action inventory, nearby minority or economically disadvantaged communities could experience disproportionately high and adverse human health impacts. In addition, financial considerations could make it more difficult for members of minority or low-income populations to obtain uncontaminated resources or to move away from contaminated soils and water. Because subsistence patterns vary for minority or low-income populations, members of these populations could be exposed to greater than average doses. The result of differing potentials for exposure could result in disproportionately high and adverse impacts to minority or low-income populations.

7.3.2.14 Traffic and Transportation

For Scenario 1, the estimated number of workers commuting to and from work would increase from about 700 to about 800 (DIRS 104596-Orthen 1999, Table 7). The analysis assumed that the number of personnel required for round-the-clock surveillance would not increase but would remain at two individuals per shift per site.

The estimated number of traffic fatalities, which DOE calculated using the assumptions of Section 7.2.1.14, would be approximately 7 for the first 100 years and would increase from about 730 to about 900 for the remaining 9,900 years (DIRS 104596-Orthen 1999, Table 7).

For about the first 100 years, there would be no fatalities from exhaust emissions because there would be no construction or demolition of facilities. For the remaining 9,900 years, trucks would travel over 2.2 billion kilometers (1.4 billion miles), resulting in approximately 31 prompt traffic fatalities (DIRS 103455-Saricks and Tompkins 1999, Table 4, p. 25) and about 0.2 latent fatality from vehicle exhaust emissions.

The long-term impacts from Scenario 2 would be the same as those estimated for the first 100 years under Scenario 1 for Module 1. After the first 100 years, there would be no traffic or transportation-related impacts because all activity would cease.

7.3.2.15 Sabotage

For Scenarios 1 and 2, the risk of intruder access at each of the 77 sites would be essentially the same for Module 1 as for the Proposed Action inventory because the number of sites would remain the same. Therefore, the difficulty of maintaining 77 sites over 100 or 10,000 years also would remain essentially unchanged.

REFERENCES

Note: In an effort to ensure consistency among Yucca Mountain Project documents, DOE has altered the format of the references and some of the citations in the text in this Final EIS from those in the Draft EIS. The following list contains notes where applicable for references cited differently in the Draft EIS.

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8. CUMULATIVE IMPACTS

The Council on Environmental Quality regulations that implement the procedural provisions of the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321 *et seq.*), define a cumulative impact as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions" (40 CFR 1508.7). The term reasonably foreseeable refers to future actions for which there is a reasonable expectation that the action could occur, such as a proposed action under analysis, a project that has already started, or a future action that has obligated funding. Cumulative impacts can result from individually minor but collectively important actions taking place over a period of time. An evaluation of cumulative impacts is necessary to an understanding of the environmental implications of implementing the Proposed Action and is essential to the development of appropriate mitigation measures and the monitoring of their effectiveness.

DOE structured the cumulative impact assessments in this chapter by identifying actions that could have effects that coincided in time and space with the effects from the proposed repository and associated transportation activities. The identification of the relevant actions was based on reviews of resource, policy, development, land-use plans prepared by agencies at all levels of government and from private organizations, other environmental impact statements, environmental assessments, and Native American tribal meeting records. Consistent with Council on Environmental Quality regulations 40 CFR 1502.16(c) and 1506.2, in addition to the assessment of potential cumulative impacts, the analysis considered potential conflicts with plans issued by various governmental entities to the extent practicable and to the extent they provided relevant information.

Not all actions identified in this chapter would have cumulative impacts in all discipline areas. Potential impacts for such actions are discussed for the appropriate discipline areas. In some instances for which an action is reasonably foreseeable, quantitative estimates of impacts are not possible because the action is in its early stages. For those actions, DOE acknowledges the project and states that potential cumulative impacts are unknown at this time.

This chapter evaluates the environmental impacts of repository activities coupled with the impacts of other Federal, non-Federal, and private actions. As part of this process, the chapter includes a detailed analysis of nuclear materials in need of permanent disposal in excess of those evaluated in the Proposed Action. It describes and evaluates these waste quantities, referred to as Inventory Modules 1 and 2, evaluated in terms of their environmental impacts in comparison with those of the Proposed Action impacts. The evaluation of these inventories provides sufficient information for future actions and decisionmaking on inventory selection. This chapter evaluates cumulative short-term impacts from the construction, operation and monitoring, and closure of a geologic repository at Yucca Mountain, and cumulative long-term impacts following repository closure. It also evaluates cumulative transportation impacts from the shipment of spent nuclear fuel and high-level radioactive waste to the repository and of other material to or from the repository. The analysis of cumulative transportation impacts includes the possible construction and operation in Nevada of a branch rail line, or of an intermodal transfer station along with highway improvements for heavy-haul trucks. In addition, the analysis considers cumulative impacts from the manufacturing of repository components.

The cumulative impact analysis in this chapter includes as a reasonably foreseeable future action the disposal in the proposed Yucca Mountain Repository of the total projected inventory of commercial spent nuclear fuel, U.S. Department of Energy (DOE) spent nuclear fuel, and high-level radioactive waste, as well as the disposal of commercial Greater-Than-Class-C waste and DOE Special-Performance-Assessment-Required waste. The total projected inventory of spent nuclear fuel and high-level radioactive waste is more than the 70,000 metric tons of heavy metal (MTHM) considered for the

Proposed Action. Its emplacement at Yucca Mountain would require legislative action by Congress unless a second licensed repository was in operation.

There were several reasons to evaluate the potential for disposing of Greater-Than-Class-C waste and Special-Performance-Assessment-Required waste at Yucca Mountain as reasonably foreseeable actions. First, because both materials exceed Class C limits for specific radionuclide concentrations as defined in 10 CFR Part 61, they are generally unsuitable for near-surface disposal. Second, the U.S. Nuclear Regulatory Commission specifies in 10 CFR 61.55(a)(2)(iv) the disposal of Greater-Than-Class-C waste in a repository unless the Commission approved of disposal elsewhere. Finally, during the scoping process for this environmental impact statement (EIS), several commenters requested that DOE evaluate the disposal of other radioactive waste types that might require isolation in a repository. The disposal of Greater-Than-Class-C and Special-Performance-Assessment-Required wastes at the proposed Yucca Mountain Repository could require a determination by the Nuclear Regulatory Commission that these wastes require permanent isolation. In addition to spent nuclear fuel, high-level radioactive waste, surplus plutonium, Greater-Than-Class-C waste, and Special-Performance-Assessment-Required waste (materials such as depleted uranium), other radioactive wastes could be considered in the future for disposal in the Yucca Mountain Repository.

By analyzing the emplacement of Inventory Module 1 or 2, DOE is not stating that the emplacement of materials beyond those prescribed for the Proposed Action would occur. Rather, the Department is being prudent in analyzing a reasonably foreseeable action that could take place. If a future decision was made to emplace additional material included in the Inventory Modules, the Department would ensure that appropriate National Environmental Policy Act reviews were performed.

In general, the analysis of cumulative impacts in this chapter follows the process recommended in the Council on Environmental Quality's handbook *Considering Cumulative Effects Under the National Environmental Policy Act* (DIRS 103162-CEQ 1997, all). This process includes the identification, through research and consultations, of Federal, non-Federal, and private actions with possible effects that would be coincident with those of the Proposed Action on resources, ecosystems, and human communities. Coincident effects would be possible if the geographic and time boundaries for the effects of the Proposed Action and past, present, and reasonably foreseeable future actions overlapped. Using the methods and criteria described in Chapters 4, 5, and 6 of this EIS and their supporting appendixes, DOE assessed the potential cumulative impacts of coincident effects.

This chapter has six sections. Section 8.1 identifies and analyzes past, present, and reasonably foreseeable future actions with impacts that could combine with impacts of the Proposed Action. Sections 8.2 and 8.3 present the analyses of cumulative short-term (the period before the completion of repository closure) and long-term (the first 10,000 and first 1 million years following closure) impacts, respectively, in the proposed Yucca Mountain Repository region. Section 8.4 describes cumulative transportation impacts, nationally and in Nevada. Section 8.5 addresses cumulative impacts associated with the manufacturing of repository components. Section 8.6 presents an overall summary of potential cumulative impacts by discipline area.

8.1 Past, Present, and Reasonably Foreseeable Future Actions

This section identifies past, present, and reasonably foreseeable future actions with impacts that could combine with impacts of the Proposed Action. It describes these actions and their relationships to the Proposed Action that could result in cumulative impacts (see Table 8-1 for a summary). Sections 8.2 through 8.5 present the cumulative impacts from the past, present, and reasonably foreseeable future actions identified in this section.

Table 8-1. Past, present, and reasonably foreseeable future actions that could result in cumulative impacts (page 1 of 3).

Name and action description	Potential cumulative impact areas			
	Short-term (Section 8.2)	Long-term (Section 8.3)	Transportation (Section 8.4)[a]	Manufacturing (Section 8.5)
Past and present actions[b]				
Nevada Test Site				
Nuclear weapons testing, waste management, etc.	Air quality and public health and safety[b]	Air quality, groundwater, and public health and safety	Occupational and public radiological health and safety	None
Beatty Waste Disposal Area				
Low-level radioactive and hazardous waste disposal	None	Groundwater and public health and safety	Occupational and public radiological health and safety	None
Reasonably foreseeable future actions				
Inventory Module 1[c]				
Disposal of all spent nuclear fuel and high-level radioactive waste in the proposed Yucca Mountain Repository	Same resource areas as the Proposed Action (see Table 8-5)	Same resource areas as the Proposed Action (see Table 8-5)	Same resource areas as the Proposed Action (see Table 8-5)	Same resource areas as the Proposed Action (see Table 8-5)
Inventory Module 2[c]				
Disposal of all spent nuclear fuel and high-level radioactive waste, as well as Greater-Than-Class C waste and Special-Performance-Assessment-Required waste, in the proposed Yucca Mountain Repository	Same resource areas as the Proposed Action (see Table 8-5)	Same resource areas as the Proposed Action (see Table 8-5)	Same resource areas as the Proposed Action (see Table 8-5)	Same resource areas as the Proposed Action (see Table 8-5)
Nellis Air Force Range				
National testing and training for military equipment and personnel	None	None	Land use	None
Nevada Test Site				
Defense (stockpile stewardship and management, material disposition, nuclear emergency response), waste management, environmental restoration, nondefense research and development, work for others	Air quality, groundwater, socioeconomics, public health and safety. (Note: The accident analysis of potential external events in Appendix H addresses the effects of possible future resumption of nuclear weapons tests).	Groundwater and public health and safety	Occupational and public radiological health and safety	None
Nevada Test Site				
Alternative Energy Generation Facility	*Land use, utilities*	None	None	None
DOE Complex-Wide Waste Management Activities Affecting the Nevada Test Site				
Treatment, storage, and disposal of low-level radioactive waste, mixed waste, transuranic waste, high-level radioactive waste, and hazardous waste from past and future nuclear defense and research activities	No additional[d] beyond those analyzed for Nevada Test Site activities	Groundwater and public health and safety	Occupational and public radiological health and safety	None

Table 8-1. Past, present, and reasonably foreseeable future actions that could result in cumulative impacts (page 2 of 3).

Name and action description	Potential cumulative impact areas			
	Short-term (Section 8.2)	Long-term (Section 8.3)	Transportation (Section 8.4)[a]	Manufacturing (Section 8.5)
Reasonably foreseeable future actions (continued)				
Low-Level Waste Intermodal Transfer Station				
Construction and operation of an intermodal transfer station for the shipment of low-level radioactive waste to the Nevada Test Site near Caliente	None	None	Same resource areas as the Proposed Action (see Table 8-5) (Caliente intermodal transfer station and highway route for heavy-haul trucks)	None
Timbisha Shoshone Reservation				
Creation and development of a discontiguous reservation in eastern California and southwestern Nevada	Land use, groundwater	None	Water consumption, land use, public safety, environmental justice	None
Cortez Pipeline Gold Deposit Projects				
Continued operation and potential expansion of a gold mine and processing facility	None	None	Land use and ownership (Carlin rail corridor)	None
Apex Bulk Commodities Intermodal Transfer Station				
Construction and operation of an intermodal transfer station for copper concentrate near Caliente	None	None	Same resource areas as the Proposed Action (see Table 8-5) (Caliente intermodal transfer station and highway route for heavy-haul trucks)	None
Shared use of a DOE branch rail line				
Increase in rail operations and traffic resulting from rail service options for nearby mine operators and communities	None	None	Same resource areas as the Proposed Action (see Table 8-5)	None
Private Fuel Storage				
Temporary storage of spent nuclear fuel at the Goshute Reservation in Utah	None	None	Occupational and public radiological health and safety	None
Owl Creek Energy Project				
Temporary storage of spent nuclear fuel	None	None	Potential occupational and public radiological health and safety	None
Ivanpah Airport				
Construction of an airport on previously undisturbed land	None	None	Land use (Jean transportation corridor)	None
Moapa Paiute Energy Center				
Lease land and water use for construction of a coal-fired powerplant	None	None	Land use	None

Table 8-1. Past, present, and reasonably foreseeable future actions that could result in cumulative impacts (page 3 of 3).

Name and action description	Potential cumulative impact areas			
	Short-term (Section 8.2)	Long-term (Section 8.3)	Transportation (Section 8.4)[a]	Manufacturing (Section 8.5)
Reasonably foreseeable future actions (continued)				
Southern Nevada Public Land Management Act				
Convey approximately 110 square kilometers[e] of Bureau of Land Management lands to commercial and private entities	Land use and ownership	None	Land use and ownership	None
Desert Space Station Science Museum				
Construct an 8,800-square-meter[f] science museum on land acquired from the Bureau of Land Management	Land use	None	None	None

a. In addition to the specific actions identified in Section 8.1 and summarized in this table, the cumulative impacts for national transportation consider the occupational and public radiological health impacts of other past, present, and reasonably foreseeable future shipments of radioactive material.

b. The impacts of most past and present actions are included in the existing environmental baseline described in Chapter 3 and, therefore, are generally encompassed in the analysis of potential impacts of the Proposed Action in Chapters 4, 5, and 6. This includes site characterization activities at Yucca Mountain.

c. As described in Section 8.1.2.1, there would be essentially no difference in the design and operation of the repository for Inventory Module 1 or 2. Therefore, the cumulative impacts from Inventory Module 1 are generally considered the same as those from Inventory Module 2.

d. DOE waste management activities at the Nevada Test Site are included for the continuation of waste management activities at current levels, plus additional wastes that could be received as a result of decisions based on the Waste Management Programmatic EIS (DIRS 101816-DOE 1997, all). This includes cumulative impacts of transportation and disposal.

e. 110 square kilometers = 27,000 acres.

f. 8,800 square meters = 95,000 square feet.

8.1.1 PAST AND PRESENT ACTIONS

The description of existing (baseline) environmental conditions in Chapter 3 includes the impacts of most past and present actions on the environment that the Proposed Action would affect. This includes site characterization activities at Yucca Mountain. The impacts of past and present actions are, therefore, generally encompassed in the Chapter 4, 5, and 6 analyses of potential environmental impacts of the Proposed Action because the baseline for these analyses is the affected environment described in Chapter 3.

Two past actions that are not addressed in the Chapter 3 environmental baseline were identified for inclusion in the cumulative impact analysis in Sections 8.2, 8.3, and 8.4—past DOE activities at the Nevada Test Site (nuclear weapons testing, etc.) and past disposal of low-level radioactive waste at the Beatty Waste Disposal Area. Resources identified where past Nevada Test Site activities could add to impacts from the Proposed Action include air quality, groundwater, public health and safety, and transportation. For the Beatty Waste Disposal Site, the analysis included potential cumulative impacts from past transportation of waste to the Beatty site and from potential groundwater contamination.

Other actions that are presently occurring also have a component that is reasonably foreseeable as a future action. These are discussed in Section 8.1.2.

8.1.2 REASONABLY FORESEEABLE FUTURE ACTIONS

This section describes the reasonably foreseeable future actions that the cumulative impacts analysis considered. The analysis included cumulative impacts from the disposal in the proposed repository of all

projected spent nuclear fuel and high-level radioactive waste as well as Greater-Than-Class-C waste and Special-Performance-Assessment-Required waste as reasonably foreseeable future actions (Inventory Modules 1 and 2; see Section 8.1.2.1). Sections 8.1.2.2 and 8.1.2.3 describe other Federal, non-Federal, and private actions that could result in cumulative impacts. This chapter does not discuss cumulative impacts for the No-Action Alternative. Chapter 7, Section 7.3, describes those impacts. Chapters 2 and 7 contain details on the No-Action Alternative and on continued storage of the material at its current locations or at one or more centralized location(s).

DOE gathered information on Federal, non-Federal, and private actions to identify reasonably foreseeable future actions that could combine with the Proposed Action to produce cumulative impacts. The types of documents reviewed included other EISs, resource management plans, environmental assessments, Notices of Intent, Records of Decision, etc. Consultations with Federal agencies, state and local agencies, and Native American tribes (see Appendix C) also contributed to the information used in the cumulative impact analysis.

8.1.2.1 Inventory Modules 1 and 2

Under the Proposed Action, DOE would emplace in the proposed Yucca Mountain Repository as much as 70,000 MTHM of spent nuclear fuel and high-level radioactive waste. Of the 70,000 MTHM, approximately 63,000 MTHM would be commercial spent nuclear fuel. The remaining 7,000 MTHM would consist of approximately 2,333 MTHM of DOE spent nuclear fuel and approximately 8,315 canisters (4,667 MTHM) containing solidified high-level radioactive waste (commercial and defense-related). To determine the number of canisters of high-level radioactive waste included in the Proposed Action waste inventory, DOE used an equivalence of 2.3 MTHM per canister of commercial high-level radioactive waste and 0.5 MTHM per canister of defense high-level radioactive waste as discussed in Appendix A, Section A.2.3.1. DOE has consistently used the 0.5-MTHM-per-canister equivalence since 1985. Using a different approach would change the number of canisters of high-level radioactive waste analyzed for the Proposed Action. Regardless of the number of canisters, the impacts from the entire inventory of high-level radioactive waste are analyzed in this chapter. In addition, the 70,000 MTHM inventory would include an amount of surplus plutonium as spent mixed-oxide fuel or immobilized plutonium.

Inventory Modules 1 and 2 represent the reasonably foreseeable future actions of disposing of all projected commercial and DOE spent nuclear fuel and all high-level radioactive waste as well as Greater-Than-Class-C waste and Special-Performance-Assessment-Required waste in the proposed repository (see Figure 8-1). Under Inventory Module 1, DOE would emplace all projected commercial spent nuclear fuel (about 105,000 MTHM), all DOE spent nuclear fuel (about 2,500 MTHM), and all high-level radioactive waste (approximately 22,280 canisters). Inventory Module 2 includes the Module 1 inventory plus other radioactive material that could require disposal in a monitored geologic repository (commercial Greater-Than-Class-C waste and DOE Special-Performance-Assessment-Required waste). The estimated quantities of these other wastes are about 2,000 cubic meters (71,000 cubic feet) and about 4,000 cubic meters (140,000 cubic feet), respectively. Appendix A contains further details on these inventories.

The following paragraphs summarize the differences in repository facilities and operations to receive, package, and emplace the additional materials in Inventory Module 1 or 2. The information on Modules 1 and 2 in this section is from CRWMS M&O (DIRS 104508-1999, DIRS 104523-1999, and DIRS 102030-1999) unless otherwise noted. Table 8-2 summarizes the increased number of shipments that would be required to transport the Module 1 or 2 inventory to the repository. As for the Proposed Action, the estimated numbers of shipments were based on the characteristics of the materials, shipping capabilities at the commercial nuclear sites and DOE facilities, the assumption that there would be one shipping cask per truck or railcar (a train would normally use multiple rail cars and ship more than one

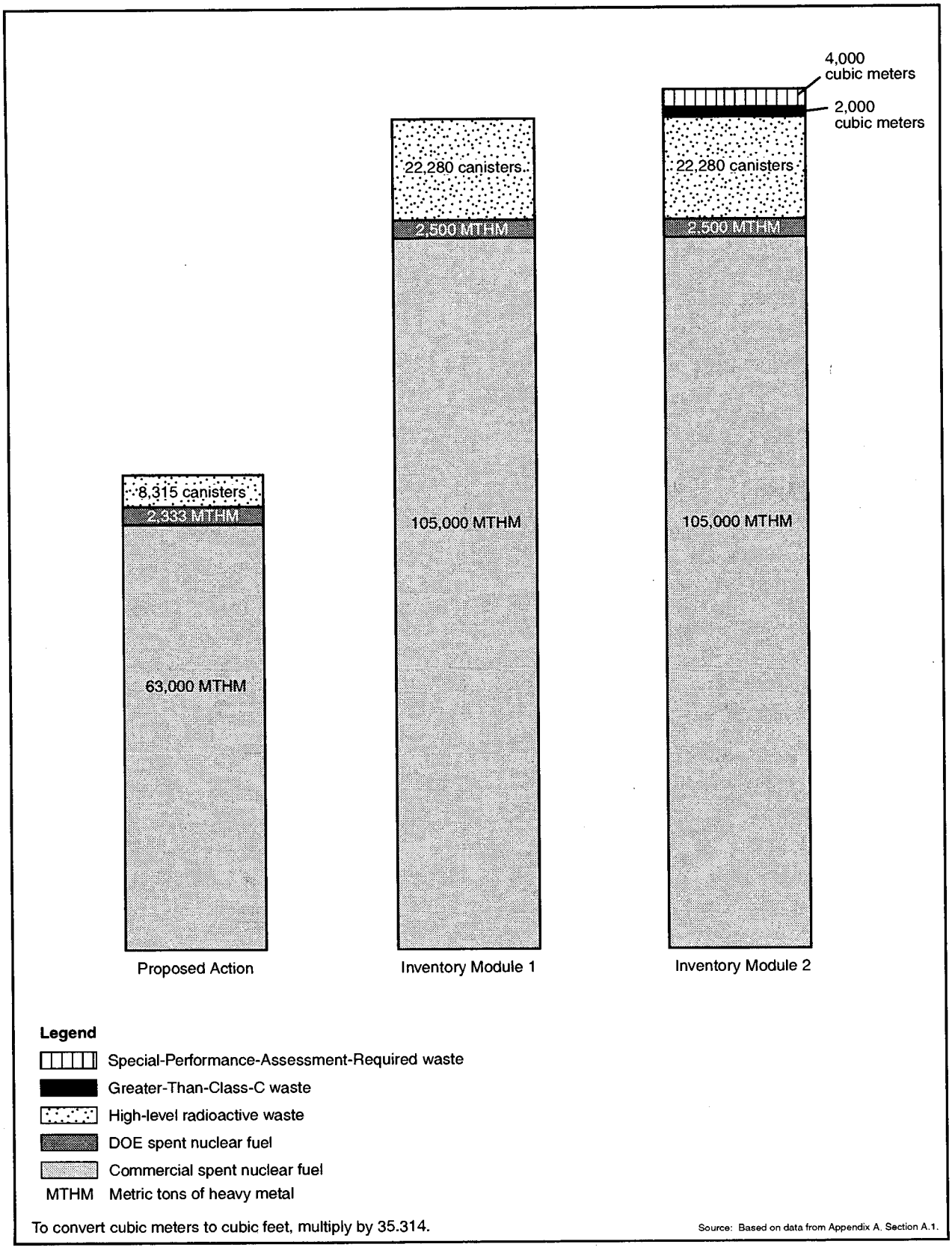

Figure 8-1. Proposed Action, Module 1, and Module 2 inventories evaluated for emplacement in a repository at Yucca Mountain.

Table 8-2. Estimated number of shipments for the Proposed Action and Inventory Modules 1 and 2.[a,b]

	Proposed Action				Module 1				Module 2			
	Mostly legal-weight truck		Mostly rail		Mostly legal-weight truck		Mostly rail		Mostly legal-weight truck		Mostly rail	
Material	Truck	Rail[c]	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Commercial SNF[d]	41,000	0	1,100	7,200	80,000	0	3,100	13,000	80,000	0	3,100	13,000
DOE SNF	3,500	300	0	770	3,700	300	0	800	3,700	300	0	800
HLW[e]	8,300	0	0	1,700	22,000	0	0	4,500	22,000	0	0	4,500
GTCC[f] waste	0	0	0	0	0	0	0	0	1,100	0	0	280
SPAR[g] waste	0	0	0	0	0	0	0	0	1,800	55	0	410
Totals	***53,000***	***300***	***1,100***	***9,700***	***110,000***	***300***	***3,100***	***18,000***	***109,000***	***360***	***3,100***	***19,000***

a. Source: Appendix J, Section J.1.3.1.
b. Totals might differ from sums of values due to rounding.
c. For this EIS, each combination of a shipping cask and railcar is assumed to be a single shipment.
d. SNF = spent nuclear fuel.
e. HLW = high-level radioactive waste.
f. GTCC = Greater-Than-Class-C.
g. SPAR = Special-Performance-Assessment-Required.

cask), various cask designs, and the transportation mode mix (mostly legal-weight truck or mostly rail). Appendix J contains additional details on Inventory Module 1 and 2 transportation requirements.

The following are the major differences between the repository facilities and operations for Inventory Modules 1 and 2 and those for the Proposed Action, which are described in Chapter 2:

- The longer time required to receive, package, and emplace the additional spent nuclear fuel, high-level radioactive waste, Greater-Than-Class-C waste, and Special-Performance-Assessment-Required waste, and to close the repository, for Inventory Module 1 or 2 versus that for the Proposed Action. The periods for the various project phases for Inventory Modules 1 and 2 would be the same.

- The need for more subsurface area to emplace about 17,000 to 26,000 waste packages for the Inventory Modules in comparison to about 11,000 to 17,000 waste packages for the Proposed Action.

Table 8-3 lists the differences in the expected time sequence for the repository construction, operation and monitoring, and closure phases for the Proposed Action and the Inventory Modules. DOE expects the construction phase to last for 5 years. Following this phase, repository development is projected to last for 22 years and emplacement for 24 years for the Proposed Action. During the operation and monitoring phase, development and emplacement is expected to last for 36 and 38 years, respectively, for Module 1 or Module 2. Monitoring activities during this phase would occur concurrently and then would extend beyond the emplacement period for up to 300 years. DOE expects the closure phase to last between 10 and 17 years for the Proposed Action and between 12 and 23 years for the Inventory Modules.

Table 8-3. Expected time sequence (years) of Yucca Mountain Repository phases for the Proposed Action and Inventory Module 1 or 2.

		Operation and monitoring phase			
Inventory	Construction phase	Development	Emplacement[a]	Monitoring	Closure phase
Proposed Action	5	22	24 - 50	76 - 300	10 - 17
Module 1 or 2	5	36	38 - 51	62 - 300	12 - 23

a. Range results from consideration of various operating modes with and without aging.

The amount of land required for surface facilities would increase only slightly for Inventory Module 1 or 2 from that for the Proposed Action (see Table 8-4). The design and operation of the repository surface facilities for Inventory Modules 1 and 2, including a Cask Maintenance Facility if it was at the Yucca Mountain site, would not differ much from those of the Proposed Action. The rate of material receipt,

Table 8-4. Amount of land (in square kilometers) newly disturbed at the proposed Yucca Mountain Repository for the Proposed Action and Inventory Module 1 or 2.[a,b,c]

Area	Proposed Action		Module 1 or 2	
	Higher-temperature	Lower-temperature	Higher-temperature	Lower-temperature
North Portal Operations Area	0.62	0.62	0.62	0.62
South Portal Development Area	0.15	0.15	0.15	0.15
Ventilation Shaft Operations Areas and access roads	0.83 (7 shafts)	1.04 - 1.42 (10 - 17 shafts)	1.13 (11 shafts)	1.38 - 1.89 (16 - 25 shafts)
Excavated rock storage area	0.87	0.87 - 1.51	1.40	1.40 - 2.02
Landfill	0.04	0.04 - 0.06	0.04	0.04 - 0.06
Solar power generating facility	0.22	0.22	0.22	0.22
Concrete batch plant	0.06	0.06	0.06	0.06
Surface aging facility	0	0 - 0.47	0	0 - 0.47
Totals	***2.8***	***3.0 - 4.5***	***3.6***	***3.9 - 5.5***

a. Source: DIRS 152010-CRWMS M&O (2000, Table 6-2, p. 52); DIRS 150941-CRWMS M&O (2000, p. 4-9 and Figure 6-1, p. 6-27); DIRS 155515-Williams (2001, 2.1-m Spacing Option: p. 27 and 29; 6.4-m Spacing Option: p. 24); DIRS 155516-Williams (2001, p. 3); DIRS 153882-Griffith (2001, p. 8).
b. To convert square kilometers to acres, multiply by 247.1.
c. Totals might differ from sums of values due to rounding.

packaging, and emplacement would be approximately the same and would require an extra 14 years beyond the 24-year emplacement period for the Proposed Action. There would be no difference in the duration of the emplacement period between Inventory Modules 1 and 2 because the surface and subsurface facilities could accommodate the small number of additional shipments and waste packages for Module 2.

The repository subsurface facilities for Inventory Module 1 or 2 would require about 60 percent more subsurface excavation than the Proposed Action. About 7.2 square kilometers (1,790 acres) would be required for the higher-temperature repository operating mode for Module 1 or 2, and from 10 to 15.4 square kilometers (2,480 to 3,810 acres) for the lower-temperature mode for Module 1 or 2. This compares to about 4.6 square kilometers (1,150 acres) and from 6.5 to 10.4 square kilometers (1,600 to 2,570 acres) for the higher- and lower-temperature modes, respectively, for the Proposed Action. Additional subsurface area would be needed if maximum spacing was used to achieve the lower-temperature mode. DOE would characterize this additional subsurface area, which would be adjacent to the blocks identified for the Proposed Action, more fully before its use. The subsurface facilities would not differ between Inventory Modules 1 and 2 for the lower-temperature operating mode with maximum-spacing because DOE would place the additional waste packages for Greater-Than-Class C and Special-Performance-Assessment-Required wastes between commercial spent nuclear fuel waste packages. However, total drift length would have to be increased by an estimated 3.7 to 4.9 kilometers (2.3 to 3.0 miles) for the other methods to achieve the lower-temperature operating mode when going from Inventory Module 1 to Module 2. There would be no difference in emplacement operating for Inventory Module 1 or 2 from those described for the Proposed Action in Chapter 2 unless DOE used the lower-temperature mode with surface aging. Because of the extra time involved in receiving and emplacing the Module 1 or 2 waste, there would be no delay in the process with the aging option before movement of the aged waste to the subsurface could begin, and DOE could move it at a faster rate. Monitoring and maintenance activities for Inventory Module 1 or 2 would be comparable to those for the Proposed Action with the exception of their duration in some cases.

Because there would be an increase in the number of waste packages and the increased length of the drifts that would be necessary for Inventory Module 1 or 2, the duration of the closure phase would be longer for Module 1 or 2 (12 to 23 years) compared to 10 to 17 years for the Proposed Action (see Table 8-3).

Inventory Module 1 or 2 closure phase activities would not otherwise differ from those described in Chapter 2 for the Proposed Action.

As discussed in the introduction to this chapter, the Department is not proposing at this time to emplace the additional materials from the Inventory Modules in the repository. If a future proposal was made to emplace these materials, the Department would ensure that appropriate National Environmental Policy Act reviews were performed.

8.1.2.2 Federal Actions

The following paragraphs describe reasonably foreseeable future actions of Federal agencies that could result in cumulative impacts in addition to those from Inventory Module 1 or 2.

Nellis Air Force Range

The Nellis Air Force Range (also referred to as the Nevada Test and Training Range) in south-central Nevada (see Figure 8-2) is a national test and training facility for military equipment and personnel. The *Renewal of the Nellis Air Force Range Land Withdrawal: Legislative Environmental Impact Statement* (DIRS 103472-USAF 1999, all) addresses the potential environmental consequences of the Air Force proposal to continue the Nellis Air Force Range land withdrawal for military use. As part of the actions analyzed in the Legislative EIS, the Air Force would renew its land withdrawal of almost 3 million acres and transfer responsibility to DOE for approximately 127,620 acres of land generally described as Pahute Mesa. Figures 8-2 and 8-3 show Pahute Mesa as part of the Nevada Test Site. The President signed S.1059 in October 1999, making it Public Law 106-65 and authorizing the renewed withdrawals and transfers described in the Legislative EIS.

The Air Force also issued the *Final Environmental Impact Statement F-22 Aircraft Force Development Evaluation and Weapons School Beddown at Nellis Air Force Base* in 1999 (DIRS 155928-Estrada 2001, all) to evaluate the potential impacts of locating F-22 aircraft at the Nellis Air Force Range. The action would entail the construction of some new facilities and other modifications to support the aircraft. The Record of Decision (DIRS 155918-Keck 1999, all) shows that the action "would result in either negligible effects or would not change current environmental conditions at Nellis AFB" for the major discipline areas. Therefore, DOE has not quantified potential cumulative impacts from this action. The descriptions of the affected environment in Chapter 3 and the potential impacts of the Proposed Action in Chapters 4, 5, and 6 include the effects of present activities at the Nellis Air Force Range.

Nevada Test Site

Several actions at the Nevada Test Site would pose a cumulative impact. Figure 8-3 shows a map of the Nevada Test Site to assist in identifying the location of these actions.

The *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DIRS 101811-DOE 1996, all) examines current and future DOE activities in southern Nevada at the Nevada Test Site, Tonopah Test Range, and sites the Department formerly operated in Nevada. The first Record of Decision for that EIS (61 *FR* 65551, December 13, 1996) states that DOE would implement a combination of three alternatives: Expanded Use, No Action (continue operations at current levels) regarding mixed and low-level radioactive waste management, and Alternate Use of Withdrawn Lands regarding public education. On February 18, 2000, the Department issued an Amendment of the Record of Decision (65 *FR* 10061, February 26, 2000). In this Amendment, DOE decided, based on its National Environmental Policy Act reviews for the Nevada Test Site and for the Complex-wide waste management program described in the Programmatic Waste Management EIS (DIRS 101816-DOE 1997, all), to implement the Expanded Use Alternative for waste management activities at the Test Site, including mixed and low-level radioactive waste.

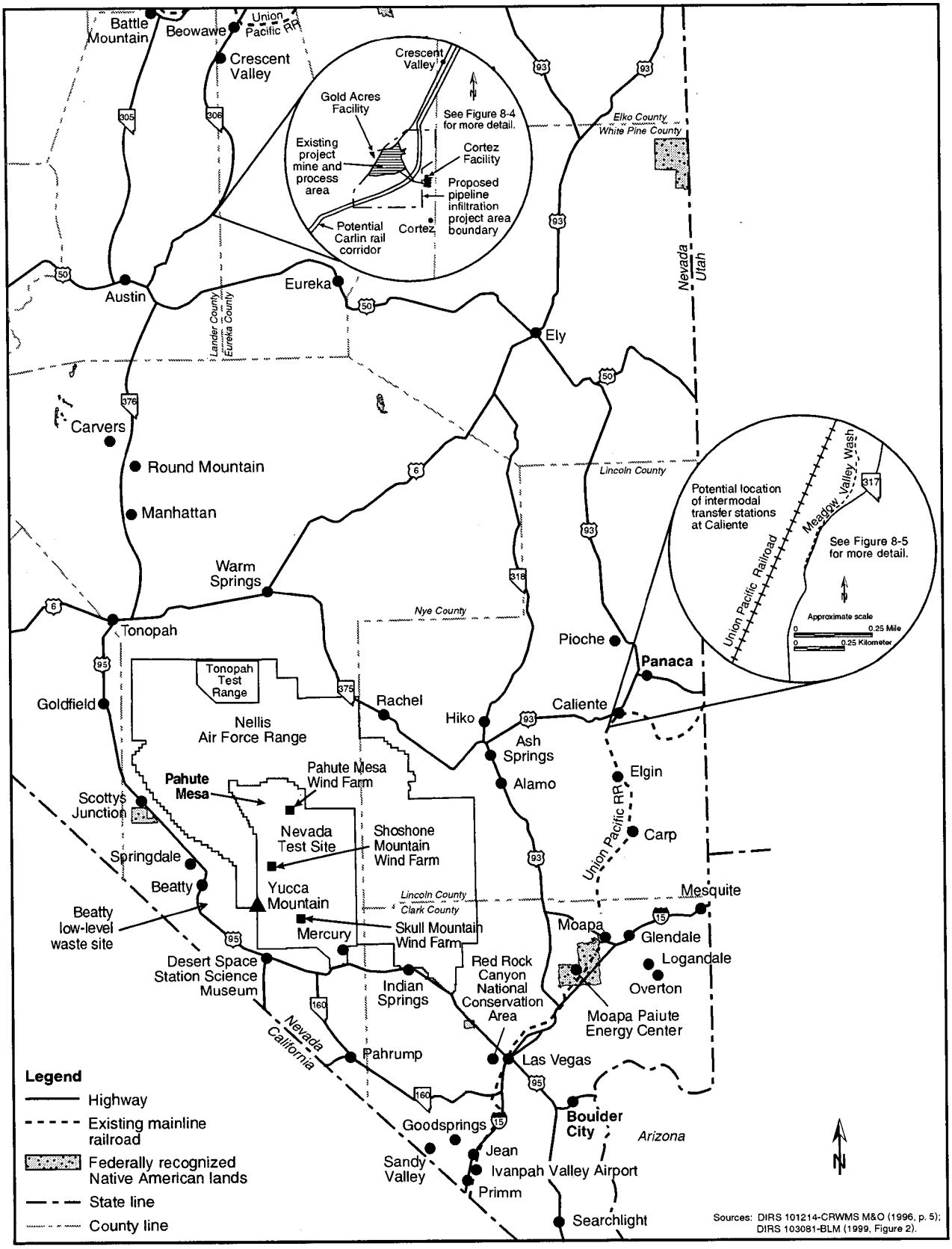

Figure 8-2. Locations of past, present, and reasonably forseeable future actions considered in the cumulative impact analysis.

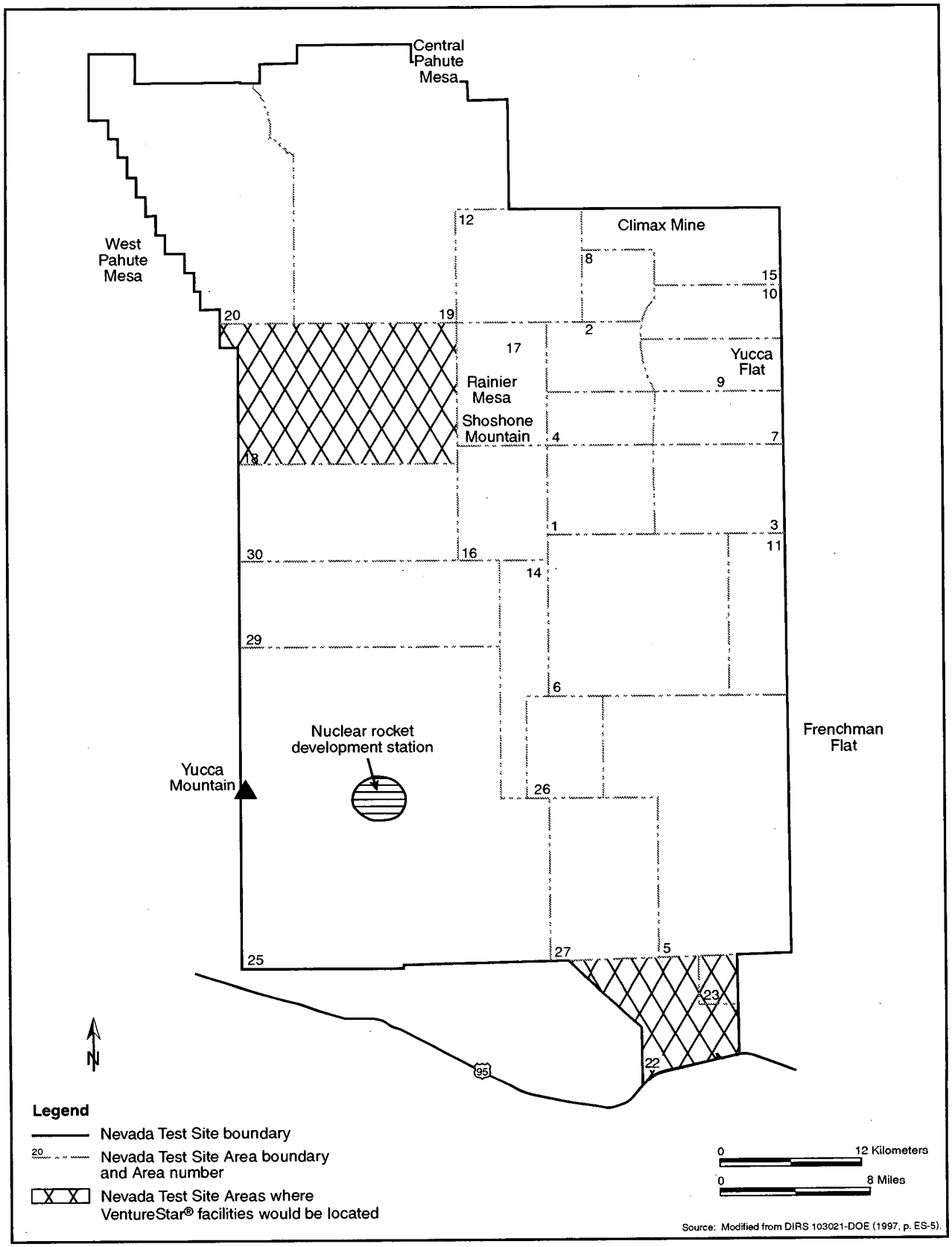

Figure 8-3. Potential locations of proposed cumulative activity associated with VentureStar®/Kistler at the Nevada Test Site.

The Expanded Use Alternative incorporates all the activities and operations from ongoing Nevada Test Site programs and increases some of those programs. Activities of the Office of Defense Programs would expand at both the Nevada Test Site and the Tonopah Test Range, primarily in the areas of stockpile stewardship and management, materials disposition, and nuclear emergency response. As part of the Stockpile Stewardship and Management Program, there are continuing *subcritical* weapons test activities to study aging of weapons components and their reliability after aging. Waste management activities would continue at current levels pending decisions by DOE based on the *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (DIRS 101816-DOE 1997, all). Based on the preferred alternative in the programmatic EIS, this cumulative impact analysis included the additional low-level and mixed waste that could come to the Nevada Test Site. The Environmental Restoration Program would continue, potentially at an accelerated rate, at the Nevada Test Site and all offsite locations. Under the Work for Others Program, military use of the airspace over the Nevada Test Site and the Tonopah Test Range would increase, as would the use of certain lands on the Nevada Test Site by the military for training, research, and development. Public education activities would include the possible construction of a museum that highlights Nevada Test Site testing activities. The Nevada Test Site Development Corporation is considering the VentureStar® program initiative from the Lockheed Martin Corporation for a launch/recovery system that would link with the Kistler Aerospace Satellite launch and recovery project. The VentureStar® program would require two spaceports, a manufacturing and assembly facility, and a payload processing and administrative complex. These activities could occur in Areas 18, 22, and 23, respectively (Figure 8-3). However, the Kistler aerospace activity is currently on hold (DIRS 152582-Davis 2000, all), and there is not enough information at this time to perform a cumulative impacts analysis for this project.

An analysis of the environmental impacts presented in the Nevada Test Site EIS (DIRS 101811-DOE 1996, all) (including impacts from weapons testing and the VentureStar®/Kistler project) identified the following resources for which impacts could overlap in relation to geography and timing with impacts from the proposed repository: air quality, groundwater, socioeconomics, public health and safety, and transportation. The effects on the Yucca Mountain Repository if a decision were made in the future to resume nuclear weapons testing or from a possible vehicle launch or recovery accident at the proposed VentureStar®/Kistler project are considered in the accident analysis of potential external events in Appendix H.

As discussed above in the section on the Nellis Air Force Range, part of the land previously assigned to the Range, specifically the parcel known as Pahute Mesa, has been transferred to the Nevada Test Site. The use of the land has not changed; this was a transfer of jurisdiction to match actual use with ownership.

A moratorium on the explosive testing of nuclear weapons began in October 1992. As discussed in the Nevada Test Site EIS, however, other testing continues at the Test Site, including dynamic, hydrodynamic, and explosive tests (DIRS 101811-DOE 1996, all). These tests are necessary for the continued assurance of the Nation's nuclear arsenal but do not result in nuclear explosions like those that were common during the Cold War. Therefore, environmental contamination from nuclear weapons testing is largely due to past testing and not to current activities at the Test Site. Although there are potential past and present impacts of the explosive testing of nuclear weapons, the long-lived radionuclides that have been deposited far underground could pose future impacts that are evaluated in Section 8.3. As shown in that section, DOE has made conservative assumptions to ensure the identification of any potential cumulative impacts between the Nevada Test Site and the proposed repository.

In March 2000, DOE published the *Nevada Test Site Development Corporation's Desert Rock Sky Park at the Nevada Test Site Environmental Assessment* (DIRS 155529-DOE 2000, all) and the associated

Finding of No Significant Impact. This environmental assessment evaluated the potential impacts of issuing a general use permit to the Nevada Test Site Development Corporation to develop, operate, and maintain a commercial/industrial park at the Test Site. The project would permit development of approximately 2 square kilometers (510 acres) of land already designated as a "private/commercial development zone."

In March 2001, DOE published the *Preapproval Draft Environmental Assessment for a Proposed Alternative Energy Generation Facility at the Nevada Test Site* (DIRS 154545-DOE 2001, all). The NTS Development Corporation (NTSDC) and the M&N Wind Power Inc. and Siemens (MNS) have requested authorization (under an easement between DOE and NTSDC and a subeasement between NTSDC and MNS) for the installation of 260 and 436 megawatts of a commercial wind-turbine-generated power system using as many as 545 wind turbine generators on three areas of the Nevada Test Site. The development of this system would allow for land use diversification of the Test Site by including nondefense and private use. The areas consist of the Shoshone Mountain Area, the Pahute Mesa, and Skull Mountain. DOE used these areas comprising 4.9 square kilometers (1,200 acres) for nuclear and conventional explosive testing facilities. The wind generators would be constructed on the ridges in these areas to maximize the effects of wind currents. They would be constructed in three phases and would not conflict with continued Nevada Test Site operations in the valley areas. On July 25, 2001, DOE announced its intention to prepare an EIS based on its analysis contained in the previous environmental assessment. This EIS would consider alternative locations and examine the impacts of the No-Action Alternative.

DOE Waste Management Activities

The Waste Management Programmatic EIS (DIRS 101816-DOE 1997, all) evaluates the environmental impacts of managing five types of radioactive and hazardous wastes generated by past and future nuclear defense and research activities at a variety of DOE sites in the United States. The five waste types are low-level radioactive waste, mixed low-level waste (referred to in this EIS as simply mixed waste), transuranic waste, high-level radioactive waste, and hazardous waste. The Waste Management Programmatic EIS provides information to assist DOE with decisions on the management of, and facilities for, the treatment, storage, and disposal of these radioactive, hazardous, and mixed wastes.

DOE has issued six Records of Decision or revisions to Records of Decision on the Programmatic Waste Management EIS (DIRS 101816-DOE 1997, all). The discussion of these decisions is presented in this section; however, the impacts of actions from these decisions would be related primarily to transportation of materials; these impacts are part of the analysis in Section 8.4. The first Record of Decision (63 *FR* 3629, January 23, 1998) announced the Department's decision to treat and store transuranic waste at each DOE facility except Sandia National Laboratory, which would transfer its transuranic waste to Los Alamos National Laboratory for preparation and storage. This waste would ultimately be disposed of in the Waste Isolation Pilot Plant in Carlsbad, New Mexico.

The fourth Record of Decision announced the Department's decision to make the Nevada Test Site and the Hanford Site available to all DOE sites for disposal of low-level waste and mixed low-level waste. This decision was accompanied by an amendment to the Record of Decision for the Nevada Test Site EIS (65 *FR* 10061, February 25, 2000) to implement the Expanded Use Alternative from that EIS.

On December 29, 2000, the Department announced a revision (65 *FR* 82985) to its decision regarding transuranic waste. Under this decision, the Department would establish at the Waste Isolation Pilot Plant the capability to prepare transuranic waste for disposal. In addition, the above-ground capacity at the Waste Isolation Pilot Plant would be increased by 25 percent.

On July 25, 2001, the Department issued (66 *FR* 38646) a further revision to its previous decision by announcing its decision to transfer about 300 cubic meters of transuranic waste from the Mound facility

in Miamisburg, Ohio, to the Savannah River Site for storage, characterization, and repackaging prior to sending it to the Waste Isolation Pilot Plant.

The *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement* (DIRS 101814-DOE 1997, Chapter 5) identifies potential cumulative transportation impacts from the shipment of transuranic wastes from DOE sites across the United States, including the Nevada Test Site, to the Waste Isolation Pilot Plant in southeastern New Mexico for disposal.

Low-Level Waste Intermodal Transfer Station

DOE prepared a draft environmental assessment (DIRS 103225-DOE 1998, all) on a proposed action to encourage low-level radioactive waste generators and their contractors to use transportation alternatives that would minimize radiological risk, enhance safety, and reduce the cost of waste shipments to the Nevada Test Site. However, DOE determined that there was no decision for it to make relative to transportation of low-level radioactive waste that would require a National Environmental Policy Act analysis, and therefore no longer plans to issue a National Environmental Policy Act document. DOE has published a technical report that provides its low-level radioactive waste generators with a comparative risk analysis of alternative highway routes and intermodal transportation facilities (DIRS 155779-DOE 1999, all).

Road improvements to accommodate legal-weight trucks and the construction of a rail siding or spur on a 0.02-square-kilometer (5-acre) site 1.2 kilometers (0.75 mile) south of Caliente would be needed for the low-level radioactive waste intermodal transfer station. Lifting equipment (crane or forklift) would transfer containers of low-level radioactive waste from railcars to trucks for transport to the Nevada Test Site. Based on a 10-year average estimate of low-level waste volumes and shipments for the expanded use alternative from the Nevada Test Site EIS (DIRS 101811-DOE 1996, pp. 5-110 to 5-112), DOE expects the traffic through the intermodal transfer station to be less than 3 trains per day and about 14 trucks per day (7 outbound from the station and 7 returning from the Nevada Test Site). Intermodal transfer operations would occur only during daytime working hours, with containers dropped off during the night transported to the Nevada Test Site the following morning. A staff of three would be adequate to conduct operations at the station. Trucks would be inspected and decontaminated, as necessary, at the Nevada Test Site before returning to the station (DIRS 103225-DOE 1998, pp. 2-1 to 2-10 unless otherwise noted).

A high-end estimate for the planned trucking operation to support the low-level radioactive waste intermodal transfer station indicates a terminal on about 0.04 to 0.06 square kilometer (10 to 15 acres), a maintenance building 21 by 23 meters (70 by 75 feet), 9 tractors and 27 trailers, and 11 employees. One proposed location would be south and just outside of Caliente. Trucks would not pass through the Town of Caliente to reach the intermodal transfer station site (DIRS 103225-DOE 1998, p. 5-4).

The projections of low-level radioactive waste shipments from current DOE-approved generators to the Nevada Test Site do not extend to 2010 when shipments of spent nuclear fuel and high-level radioactive waste would begin to the proposed Yucca Mountain Repository. However, because it is reasonable to assume that low-level radioactive waste shipments to the Nevada Test Site could continue and occur coincidentally with shipments to the Yucca Mountain Repository, Section 8.4 analyzes the potential for cumulative impacts from the construction and operation of these two intermodal transfer stations as well as a privately owned intermodal transfer station described in the following section.

Timbisha Shoshone Reservation

The Secretary of the Interior issued a draft report to Congress (DIRS 103470-Timbisha Shoshone and DOI 1999, all) describing a plan to establish a discontiguous reservation for people of the Timbisha Shoshone Tribe in portions of the Mojave Desert in eastern California and southwestern Nevada. On

November 1, 2000, the President signed Bill S.2102 (Public Law 106-423) to provide a permanent land base for the Timbisha Shoshone Tribe within its ancestral homeland.

The National Park Service of the U.S. Department of the Interior prepared a Legislative EIS (DIRS 154121-DOI 2000, all), which describes the environmental impacts of this action. The EIS analyzes the potential transfer of almost 32 square kilometers (7,800 acres) in five noncontiguous parcels in portions of the Mojave Desert in eastern California and southwestern Nevada, as follows:

- Approximately 1.3 square kilometers (314 acres) in Furnace Creek, Death Valley National Park, California
- Approximately 4 square kilometers (1,000 acres) in Death Valley Junction, California
- Approximately 11 square kilometers (2,800 acres) in Scottys Junction, Nevada
- Approximately 2.6 square kilometers (640 acres) in Centennial, California
- Approximately 12 square kilometers (3,000 acres) in Lida, Nevada

Of these five parcels, the first three are in whole or in part within the 80-kilometer (50-mile) radius of the proposed repository. In addition to these five parcels, the Law authorizes the Secretary of the Interior to purchase two additional parcels of land with water rights as follows:

- Approximately 0.49 square kilometer (120 acres) at the Indian Rancheria Site, California
- Approximately 9.5 square kilometers (2,340 acres) at Lida Ranch, Nevada

In addition, Public Law 106-423 prescribes Federal water rights for these parcels of land and describes partnerships between the National Park Service and the Timbisha Shoshone Tribe that will provide economic and cultural opportunities for the Tribe while preserving the resources in the area. As described in the Legislative EIS (DIRS 154121-DOI 2000, all), activities on the parcels of land would not differ greatly from their historic uses. Modern housing with the associated infrastructure could be constructed at the Furnace Creek site, but would be limited by law to conserve and protect resources. Commercial development is permitted at several of the sites, but would have to be consistent with existing designations and uses of the land. The future development could cause potential transportation impacts, but the lack of information on specific plans precludes a detailed analysis at this time.

Because of the proximity of some of the parcels to the proposed repository and to some of the transportation corridors, there are potential cumulative impacts between their use and the proposed repository with regard to land use, regional water use, and transportation impacts. Therefore, DOE considered this action in its analysis of cumulative impacts in this chapter. As discussed in Chapter 6, the parcel near Scottys Junction (shown in Figure 8-1), if inhabited, could be affected if a rail corridor was used in the future.

8.1.2.3 Non-Federal and Private Actions

The following paragraphs describe reasonably foreseeable future actions of non-Federal and private agencies or individuals that could result in cumulative impacts. This EIS considers the Cortez Pipeline Gold Deposit projects described below to be private actions even though they require the approval of the Bureau of Land Management.

Cortez Pipeline Gold Deposit Projects

The Cortez Gold Mine Pipeline Project is near the potential branch rail line in the Carlin Corridor in Nevada (see Chapter 6, Section 6.3.2.2.2). Cortez Gold Mine, Inc., operates the Pipeline Project mine and processing facility; the environmental impacts of the existing mining operation are discussed in the *Cortez Pipeline Gold Deposit: Final Environmental Impact Statement* (DIRS 103078-BLM 1996, all). The Pipeline Infiltration Project (which was approved in March 1999) would expand the Pipeline Project area to add more land for the construction and operation of infiltration ponds to support the existing mine (DIRS 103081-BLM 1999, all). The Bureau of Land Management published the *South Pipeline Project Final Environmental Impact Statement* (DIRS 155530-BLM 2000, all) in which the proposed action was to "develop the South Pipeline ore deposit and construct associated facilities to continue to extract gold from the mined ore within the existing Project Area." Based on an analysis of the general area potentially affected by the Cortez Gold Mine Project, there could be cumulative land-use and ownership impacts with the proposed Carlin rail corridor (see Figure 8-2). The Bureau issued the Record of Decision for the EIS on June 27, 2000 (DIRS 155095-BLM 2000, all). On July 31, 2000, the Western Mining Action Project (representing Great Basin Mine Watch, Western Shoshone Defense Project, and Mineral Policy Center) filed an Appeal and Request for Stay (DIRS 155531-BLM 2001, all); however, the stay request was denied in January 2001.

Apex Bulk Commodities Intermodal Transfer Station

Apex Bulk Commodities is negotiating with BHP Copper of Ely, Nevada, to build an intermodal transfer station at Caliente near the potential intermodal transfer station site for shipping spent nuclear fuel and high-level radioactive waste to the proposed Yucca Mountain Repository. Apex anticipates one diesel truck per hour carrying 40 tons of copper concentrate, 24 hours per day, for 15 years. An improved access road and about 4,200 meters (14,000 feet) of new rail would be constructed. The transfer facility would be housed in a building 90 by 30 meters (300 by 100 feet) designed to retain dust, water, and spills generated during the transfer process. Air emission particulates would be collected in two baghouses. Apex would also need a truck maintenance facility, which would be in a building 30 by 18 meters (100 by 60 feet). An above-ground storage tank for about 45,000 liters (12,000 gallons) of diesel fuel is also planned. Apex estimates 25 new jobs for Caliente and an annual payroll of $800,000 (DIRS 103225-DOE 1998, p. 5-5).

Although a start date for Apex copper concentration intermodal transfer station and truck transportation operations is unknown, Section 8.4 analyzes the potential for cumulative impacts from the construction and operation of that station, assuming these activities would coincide with impacts from the Nevada Test Site low-level radioactive waste intermodal transfer station and the intermodal transfer station for shipments to the proposed Yucca Mountain Repository.

Shared Use of a DOE Branch Rail Line

If DOE built a branch rail line to transport spent nuclear fuel and high-level radioactive waste to the Yucca Mountain Repository, it could share the use of this line with others. A branch rail line in the Carlin corridor could provide transportation service options for mine operators in the central mountain valleys of Nevada and could provide freight service options for southwestern Nevada communities such as Tonopah, Beatty, Goldfield, and Pahrump. A branch rail line in the Caliente corridor could serve those communities plus Warm Springs, along with mine operators in the interior of Nevada. A branch rail line in the Valley Modified or Jean corridors would provide freight service access to farms, industries, and businesses in the Amargosa Valley and Pahrump communities. A Valley Modified branch line would also provide rail service to the Indian Springs community. Any of the potential branch rail lines to the Yucca Mountain site (see Chapter 6, Figure 6-14) would provide rail access to the Nevada Test Site. The shared use of a branch rail line would have positive economic benefits, but could produce cumulative impacts due to increased operations and traffic.

Private Fuel Storage at Skull Valley

In June 2000, the Nuclear Regulatory Commission published the *Draft Environmental Impact Statement for the Construction and Operation of an Independent Spent Fuel Storage Installation on the Reservation of the Skull Valley Band of Goshute Indians and the Related Transportation Facility in Tooele County, Utah* (DIRS 152001-NRC 2000, all). That EIS evaluates the environmental impacts of constructing and operating a facility for the interim storage of commercial spent nuclear fuel.

The storage site would be on the reservation of the Skull Valley Band of Goshute Indians in Skull Valley in Tooele County, Utah. The facility would occupy approximately 3.3 square kilometers (820 acres) and would involve construction of a 52-kilometer (32-mile) rail line on public land administered by the Bureau of Land Management from Skunk Ridge (near Low, Utah) to the reservation.

The facility would be constructed and operated by Private Fuel Storage, LLC, a limited liability company comprised of eight U.S. power utilities.

The storage site would be designed to store up to 40,000 metric tons of heavy metal (MTHM) of commercial spent nuclear fuel, which is sufficient to store all the spent nuclear fuel from the Private Fuel Storage member utilities as well as additional fuel from non-member utilities. The fuel would be stored in above-ground concrete vault structures that would provide structural integrity and radiation shielding. The proposed facility would be licensed by the Nuclear Regulatory Commission to operate for as long as 20 years, at which time the Commission could renew the license.

The facility would be used as an interim storage facility until a geologic repository was available for disposal of the spent nuclear fuel. Therefore, the actions considered in the Nuclear Regulatory Commission EIS could have cumulative impacts with those contemplated in the Yucca Mountain EIS by affecting the transportation routes through which material would arrive at the proposed repository. However, because of the distance of the storage facility from the Yucca Mountain site, DOE does not expect cumulative impacts between the proposed operation of the facility and the Proposed Action for this EIS.

Section 8.4 discusses estimated impacts from transportation of material to the Private Fuel Storage facility.

Owl Creek Energy Project

The Owl Creek Energy Project (DIRS 155595-Stuart and Anderson 1999, all) is a potential interim storage project for commercial spent nuclear fuel that would be developed in the State of Wyoming. The location for the project is near the Town of Shoshoni, Wyoming, and consists of about 11 square kilometers (2,700 acres) of privately owned land with access to rail and nearby roads. A private company is pursuing the project, which would be temporary, with a projected life of 40 years.

The Owl Creek Energy Project would involve the storage of spent nuclear fuel using dry storage techniques in specially designed facilities. However, the project is still in its infancy; no license application has been submitted to the Nuclear Regulatory Commission. Further, the potential impacts of the facility are unknown at present. Therefore, DOE has not attempted to quantify potential impacts at this time, but believes it would be unlikely that the operational impacts would be markedly different from those expected for the Private Fuel Storage Facility in Tooele County, Utah (described above).

Moapa Paiute Energy Center

In March 2001, the Bureau of Indian Affairs issued the *Moapa Paiute Energy Center Draft Environmental Impact Statement* (DIRS 155979-PBS&J 2001, all). Calpine Corporation proposes to construct the Moapa Paiute Energy Center on 0.26 square kilometer (65 acres) of land leased from the Moapa River Paiute Reservation approximately 12 kilometers (45 miles) northeast of Las Vegas. The

plant would consist of a nominal 760-megawatt baseload natural-gas-fired, combined-cycle power unit with peak capacity to approximately 1,100 megawatts. The land disturbance would consist of as much as 0.88 square kilometer (218 acres) of reservation land and as much as 0.33 square kilometer (82 acres) of off-reservation lands. Transmission lines would follow an existing Bureau of Land Management utility corridor that passes through the reservation, requiring no change in land use. The lines would pass approximately 19 kilometers (12 miles) to the southwest to the existing Nevada Power Company Harry Allen Substation. The natural gas supply system to the facility would consist of approximately 1,220 meters (4,000 feet) of pipeline and a pumping station. The natural gas line and the pump station would require approximately 0.004 square kilometer (5.5 acres). The Bureau of Land Management would be responsible for rights-of-way for construction, operation, and termination for the facilities in the utility right-of-way on the reservation.

Because the Energy Center would be some distance from the proposed repository, there is minimal potential for direct cumulative impacts with repository operation. Groundwater management practices would minimize depletion of groundwater resources. Air emissions would be minimized, and there would be essentially no potential for overlap of the plumes from the repository and the Energy Center.

Southern Nevada Public Land Management Act

The Southern Nevada Public Land Management Act (Public Law 105-263) authorizes the Bureau of Land Management to sell some public lands in the Las Vegas Valley to promote responsible and orderly development.

The law specifies that money generated by these land sales will remain in Nevada. This money will provide funding for a variety of land management activities emphasizing recreation sites, such as the following:

- Acquisition of environmentally sensitive land in Nevada, with priority given to lands in Clark County
- Capital improvements at the Lake Mead National Recreation Area, the Desert National Wildlife Refuge, the Red Rock Canyon National Conservation Area, and other areas administered by the Bureau of Land Management in Clark County, and the Spring Mountains National Recreation Area (subject to an annual limitation)
- Development of a multispecies habitat conservation plan in Clark County, Nevada
- Development of parks, trails, and natural areas in Clark County

The Act included approximately 110 square kilometers (27,000 acres) of land for sale (Public Law 105-263). As of April 2001, the Bureau of Land Management had conveyed about 17 square kilometers (4,200 acres) to private and commercial entities. In December 2000, the Bureau published its "Round 2 Preliminary Recommendation" in which it recommended the acquisition of more than 23 square kilometers (5,800 acres) of land throughout Nevada that is privately or commercially owned to be distributed among the Bureau, the National Park Service, and the Forest Service (DIRS 155597-BLM 2000, all).

This action has potential land use cumulative impacts because some of the parcels conveyed or acquired by the Bureau of Land Management could be either within the 80-kilometer (50-mile) radius of the proposed repository or near potential transportation corridors, although DOE cannot predict which parcels might be affected or the timing of such conveyances.

Ivanpah Valley Airport

On October 27, 2000, the President signed the Ivanpah Valley Airport Public Lands Transfer Act (Public Law 106-362) to transfer Federal lands in Ivanpah Valley, Nevada, to Clark County. The land to be transferred, which is part of the Mojave National Preserve, would be used for construction of a general aviation airport at Jean, Nevada.

The passage of the Ivanpah Valley Airport Public Lands Transfer Act does not automatically transfer the lands. Under provisions of the bill, the U.S. Departments of the Interior and Transportation must complete an environmental impact statement before an actual transfer. As described in Chapter 6, the initiation of the Stateline option of the Jean Corridor for a potential branch rail line encroaches upon the land to be transferred. Therefore, this EIS evaluates the potential for cumulative impacts due to the land transfer.

Desert Space Station Science Museum

The Nevada Science and Technology Center is proposing to construct an 8,800-square-meter (95,000-square-foot) museum on 1.8 square kilometers (450 acres) of land in Amargosa Valley at the intersection of U.S. Highway 95 and State Route 373 (DIRS 148148-Williams and Levy 1999, p. 1). The land would be transferred from the Bureau of Land Management to Nye County, which in turn would lease the land to the Nevada Science and Technology Center (DIRS 155478-Dorsey 2001, all). As shown in Figure 8-2, this parcel of land is near the Nevada Test Site and is, thus, within the region of influence for the proposed repository.

Because detailed quantitative impact information is not available, DOE has not included a detailed analysis of this action other than to report the potential land use implications in Section 8.2.1.

8.2 Cumulative Short-Term Impacts in the Proposed Yucca Mountain Repository Region

This section describes short-term cumulative impacts during the construction, operation and monitoring, and closure of the repository in the regions of influence for the resources the repository could affect. DOE has organized the analysis of cumulative impacts by resource area. As necessary, the discussion of each resource area includes cumulative impacts from Inventory Module 1 or 2; from other Federal, non-Federal, and private actions; and from the combination of Inventory Modules 1 and 2 and other Federal, non-Federal, and private actions. Table 8-5 summarizes these impacts. The impacts listed for the Proposed Action in Table 8-5 include the combined effects of the potential repository and transportation activities.

There would be essentially no difference in the design and operation of the repository for Inventory Modules 1 and 2. As described in Appendix A, the radioactive inventory for Greater-Than-Class-C waste and for Special-Performance-Assessment-Required waste is much less than that for spent nuclear fuel and high-level radioactive waste. The subsurface emplacement of the material in Inventory Module 2, in comparison with the inventory for Module 1, would not greatly increase radiological impacts to workers or the public (DIRS 104523-CRWMS M&O 1999, p. 6-44). For the surface facilities, the number of workers and the radiological exposure levels would be the same for Inventory Modules 1 and 2 (DIRS 104508-CRWMS M&O 1999, Tables 6-1, 6-2, 6-4, and 6-5). Therefore, DOE did not perform separate analyses for Modules 1 and 2 to estimate the short-term impacts. This section identifies the short-term impacts as being for Modules 1 and 2, indicating that the impacts for the two modules would not differ greatly.

Table 8-5. Summary of cumulative short-term impacts in the proposed Yucca Mountain Repository region (page 1 of 8).

Resource area	Proposed Action (repository and transportation)	Inventory Module 1 or 2[a]	Other Federal, non-Federal, and private actions	Total cumulative impacts
Land use and ownership	Withdraw about 600 square kilometers (150,000 acres) of land already under Federal control by DOE, U.S. Air Force, and Bureau of Land Management. Public access to about 200 square kilometers (50,000 acres) of BLM public lands would be terminated. About 6.0 square kilometers (1,500 acres) of withdrawn land would be disturbed for the repository under the Proposed Action. As much as 20 square kilometers (4,900 acres) of land would be disturbed along transportation routes in Nevada, a portion of which would be in the Yucca Mountain region and could include the need for rights-of-way agreements or withdrawals.	Land withdrawal impacts would be the same as those for the Proposed Action. As much as 1 square kilometer (250 acres) of additional land would be disturbed, for a total of as much as 7.0 square kilometers (1,730 acres). Land use and ownership impacts from transportation would be the same as for the Proposed Action.	In addition to impacts for the Proposed Action, under current and reasonably foreseeable actions, 10,000 acres of federal land would be transferred for Indian reservations; 65 acres of reservation land would be used for commercial purposes; in excess of 38,000 acres of Federal land would be used for private and commercial purposes. There is the potential for over 5,800 acres of privately owned land to be acquired by the Federal Government. An intermodal transfer station could be constructed for shipping low-level radioactive waste within the Yucca Mountain region.	Withdraw about 600 square kilometers (150,000 acres) of land already under Federal control by DOE, U.S. Air Force, and Bureau of Land Management. Public access to about 200 square kilometers (50,000 acres) of BLM public lands would be terminated. As much as 27 square kilometers (1,100 acres) of withdrawn land would be disturbed for the repository and along transportation route. In addition to impacts for the Proposed Action, under current and reasonably foreseeable actions, 10,000 acres of federal land would be transferred for Indian reservations; 65 acres of reservation land would be used for commercial purposes; in excess of 38,000 acres of Federal land would be used for private and commercial purposes. There is the potential for over 5,800 acres of privately owned land to be acquired by the Federal Government.
Air Quality				
Nonradiological	Criteria pollutant [nitrogen dioxide, sulfur dioxide, carbon monoxide, and particulate matter (PM_{10}, $PM_{2.5}$)] and cristobalite concentrations calculated at the analyzed land withdrawal area boundary would be less than 6 percent of applicable regulatory limits (see Tables 8-6, 8-7, and 8-8). Emissions associated with transportation in the proposed repository region would be low.	Criteria pollutant and cristobalite concentrations calculated at the analyzed land withdrawal area boundary would be less than 7 percent of applicable regulatory limits (see Tables 8-6, 8-7, and 8-8). Emissions associated with transportation in the proposed repository region would be low.	Nevada Test Site: Baseline monitoring shows that criteria pollutants at the Nevada Test Site and in the proposed repository region are well below National Ambient Air Quality Standards and would result in very small cumulative nonradiological air quality impacts. Emissions associated with the transportation of waste, people, and materials for Nevada Test Site activities in the repository region would be low.	Criteria pollutant and cristobalite concentrations calculated at the analyzed land withdrawal area boundary would be small fractions of applicable regulatory limits (generally less than 10 percent). Emissions associated with transportation in the repository region would be low.

Table 8-5. Summary of cumulative short-term impacts in the proposed Yucca Mountain Repository region (page 2 of 8).

Resource area	Proposed Action (repository and transportation)	Inventory Module 1 or 2[a]	Other Federal, non-Federal, and private actions	Total cumulative impacts
Air Quality (continued)				
Radiological[b]	The maximally exposed individual in the public would receive an estimated annual radiation dose of 1.3 millirem or less (see Tables 8-10, 8-11, 8-12, and 8-13), primarily from naturally occurring radon.	The maximally exposed individual in the public would receive an estimated annual dose of 2.2 millirem or less, primarily from naturally occurring radon.	Nevada Test Site: Activity would continue to contribute extremely small increments to the risk to the general population and should not increase injury or mortality rates. As an example, the maximally exposed individual in the public would receive an estimated annual radiation dose of less than 0.15 millirem from past, present and reasonably foreseeable future activities.	The maximally exposed individual in the public would receive an annual radiation dose of 2.5 millirem or less, which is well below the 10 CFR 63.204 limit of 15 millirem from radioactive material releases from the repository and the Nevada Test Site.
Hydrology				
Surface water	Between 2.8 and 4.5 square kilometers (690 and 1,100 acres) of land would be newly disturbed and resulting impacts would likely be small and limited to the site. Impacts from construction and use of transportation capabilities (heavy-haul and rail) in the site vicinity and region would result in small impacts to surface water. Minor changes to runoff and infiltration rates. Floodplain/wetlands assessment concluded impacts would be small. Additional transportation floodplain/wetlands assessments would be performed in the future as necessary.	Would be similar to impacts from the Proposed Action with an increase of as much as 1 square kilometer (250 acres) in new surface disturbance for a total of as much as 5.5 square kilometers (1,360 acres). Impacts from construction and use of transportation capabilities (heavy-haul and rail) would be small. Minor changes to runoff and infiltration rates. Floodplain/wetlands assessment concluded impacts would be small. Transportation floodplain/wetlands assessments would be performed in the future as necessary.	No other actions were identified with potential cumulative surface-water impacts within the region of influence of repository construction, operation and monitoring, and closure. Transportation impacts would be small.	As much as 5.5 square kilometers (1,360 acres) of land would be newly disturbed and resulting impacts would likely be minor and limited to the site. Impacts from construction and use of transportation capabilities (heavy-haul and rail) in the site vicinity and region would result in small impacts to surface water. Minor changes to runoff and infiltration rates. Floodplain/wetlands assessment concluded impacts would be small. Transportation floodplain/wetlands assessments would be performed in the future as necessary.

Table 8-5. Summary of cumulative short-term impacts in the proposed Yucca Mountain Repository region (page 3 of 8).

Resource area	Proposed Action (repository and transportation)	Inventory Module 1 or 2[a]	Other Federal, non-Federal, and private actions	Total cumulative impacts
Hydrology (continued)				
Groundwater	Annual water demand would be between 230 and 290 acre-feet (during emplacement), and below the lowest estimate of perennial yield of the western two-thirds of the Jackass Flats basin (580 acre-feet). Water use for the construction of a rail line could be as much as 710 acre-feet from multiple wells and hydrographic areas over 4 years.	Anticipated annual water demand (below Nevada State Engineer's ruling on perennial yield) could be slightly higher (ranging from 240 to 320 acre-feet) than that of the Proposed Action, and the highest demand, which would also occur when emplacement and development activities occurred together, would extend for an additional 14 years. Water use for transportation would be the same as that for the Proposed Action.	Nevada Test Site: Anticipated annual water demand from Nevada Test Site activities would be about 280 acre-feet, which is less than the estimate of perennial yield of the western two-thirds of the Jackass Flats basin (580 acre-feet).	Combining the highest annual water demand of the repository of 320 acre-feet (during emplacement and development activities for the lower-temperature maximum spacing scenario with Modules 1 or 2) with annual water withdrawals from the Nevada Test Site of 280 acre-feet would result in a total of 600 acre-feet, which would slightly exceed the lowest estimate of perennial yield of the western two-thirds of the Jackass Flats basin (580 acre-feet), but would not approach the highest estimate of perennial yield, which is 4,000 acre-feet. There is a potential for drawdown of the water level in nearby wells from water withdrawal. The combined peak annual water use of a repository under other operation options, even with Modules 1 or 2, with Nevada Test Site annual water use would result in a maximum peak cumulative use of about 560 acre-feet per year, which is below the lowest estimate of perennial yield of the western two-thirds of the Jackass Flats basin (580 acre-feet). In addition, up to 710 acre-feet of water over 2.5 years would be used to construct a rail line in Nevada.

Table 8-5. Summary of cumulative short-term impacts in the proposed Yucca Mountain Repository region (page 4 of 8).

Resource area	Proposed Action (repository and transportation)	Inventory Module 1 or 2[a]	Other Federal, non-Federal, and private actions	Total cumulative impacts
Biological resources and soils	Between 2.8 and 4.5 square kilometers (690 to 1,100 acres) of soil, habitat, and vegetation would be newly disturbed, resulting in lost productivity and animal mortality and displacement. Adverse impacts to the desert tortoise and loss of individuals would occur. Wetland assessment concluded impacts would be small. Impacts from transportation would include the loss of 0 (legal-weight truck) to 20 square kilometers (4,900 acres) (rail) of habitat in Nevada. Impacts to the desert tortoise probably would occur if a rail line were constructed. Additional wetlands assessments would be performed in the future as necessary.	Inclusive of the Proposed Action, a total of as much as 5.5 square kilometers (1,360 acres) of soil, habitat, and vegetation would be disturbed, resulting in lost productivity and animal mortality and displacement. Adverse impacts to the desert tortoise would occur. Wetland assessment concluded impacts would be small. Impacts from transportation would be the same as those under the Proposed Action. Additional wetlands assessments would be performed in the future as necessary.	No other actions were identified with potential cumulative biological resource or soil impacts within the region of influence of repository construction, operation and monitoring, and closure.	As much as 5.5 square kilometers (1,360 acres) of soil, habitat, and vegetation would be newly disturbed, resulting in lost productivity and animal mortality and displacement. Adverse impacts to the desert tortoise and loss of individuals would occur. Impacts to potential jurisdictional wetlands would be very small and minimized. Impacts from transportation would include the loss of 0 (legal-weight truck) to 20 square kilometers (4,900 acres) (rail) of habitat in Nevada, a portion of which would be within the Yucca Mountain vicinity. Impacts to the desert tortoise and wetlands probably would occur if a rail line were constructed. Additional wetlands assessments would be performed in the future as necessary.

Table 8-5. Summary of cumulative short-term impacts in the proposed Yucca Mountain Repository region (page 5 of 8).

Resource area	Proposed Action (repository and transportation)	Inventory Module 1 or 2[a]	Other Federal, non-Federal, and private actions	Total cumulative impacts
Cultural resources	Repository development would disturb about 2.8 to 4.5 square kilometers (690 to 1,100 acres). Direct and indirect impacts (damage to archaeological and historical sites or illicit collection of artifacts) would be mitigated per applicable regulations. In addition, as much as 20 square kilometers (4,900 acres) would be disturbed along transportation routes in Nevada. Native Americans view all impacts to be adverse and immune to mitigation.	Land disturbance for repository development would increase to a total of as much as 5.5 square kilometers (1,360 acres). Transportation impacts would be the same as those under the Proposed Action. Direct and indirect impacts and mitigations would be similar to the Proposed Action. Native Americans view all impacts to be adverse and immune to mitigation.	No other actions were identified with potential cumulative cultural resource impacts within the region of influence of repository construction, operation and monitoring, and closure. Native Americans view all impacts to be adverse and immune to mitigation.	Repository development would disturb as much as 5.5 square kilometers (1,360 acres). As much as 20 square kilometers (4,900 acres) would be disturbed if a rail line was constructed in Nevada. Direct and indirect impacts (damage to archaeological and historical sites or illicit collection of artifacts) would be mitigated per applicable regulations. Native Americans view all impacts to be adverse and immune to mitigation.
Socioeconomics	Estimated peak direct employment of 3,400 occurring in 2006 would result in less than a 1 percent increase in direct and indirect regional employment. Employment increases would range from less than 1 percent to approximately 5 percent (use of intermodal transfer station or rail line in Lincoln County, Nevada) of total employment by county.	Estimated peak direct employment would be the same as for the Proposed Action.	Nevada Test Site: Any employment increases would occur prior to construction of the repository and no cumulative impacts would be expected.	Estimated peak employment increase of about 3,400 occurring in 2006 would result in less than a 1-percent increase in direct and indirect regional employment (with as much as a 5-percent change in Lincoln County, Nevada if intermodal transfer station or rail line were located there).
Occupational and public health and safety[d]				
Nonradiological health impacts	2 to 3 fatalities[e] during construction, operation and monitoring, and closure. Exposures well below regulatory limits. Also, between 14 and 26 fatalities[e] from commuting, and transportation of material (repository and rail line construction material, as well as spent nuclear fuel and high-level radioactive waste).	4 or less fatalities[e] during construction, operation and monitoring, and closure. Exposures well below regulatory limits. Also, between 19 and 33 fatalities[e] from commuting, and transportation of material (repository and rail line construction material, as well as spent nuclear fuel and high-level radioactive waste).	No other actions were identified with potential cumulative industrial hazard impacts to repository workers.	23 to 37 fatalities[e] during construction, operation and monitoring, and closure (including transportation). Exposures well below regulatory limits.

Table 8-5. Summary of cumulative short-term impacts in the proposed Yucca Mountain Repository region (page 6 of 8).

Resource area	Proposed Action (repository and transportation)	Inventory Module 1 or 2[a]	Other Federal, non-Federal, and private actions	Total cumulative impacts
Occupational and public health and safety (continued)[d]				
Radiological health impacts				
Workers	4 to 7 latent cancer fatalities[e] from repository construction, operation and monitoring, and closure. Up to 3 to 12 latent cancer fatalities[e] to workers from mostly rail and mostly truck, respectively.	5 to 8 latent cancer fatalities[e] from repository construction, operation and monitoring, and closure. Up to 7 to 24 latent cancer fatalities[e] to workers from mostly rail and mostly truck, respectively.	No other actions were identified with potential cumulative radiological health impacts to repository workers.	About 12 to 32 latent cancer fatalities[e] from repository construction, operation and monitoring, and closure (including transportation).
Public	Estimated doses would result in less than 1 latent cancer fatality to the public from repository construction, operation and monitoring, and closure. Up to 1 to 3 latent cancer fatalities[e] would result from transport by mostly rail and mostly truck, respectively.	Estimated doses would result in less than one latent cancer fatality to the public from repository construction, operation and monitoring, and closure. Impacts from transportation would be almost twice those from the Proposed Action.	Nevada Test Site: Estimated doses and associated health effects from the Nevada Test Site would be less than one latent cancer fatality.	About 2 to 5 latent cancer fatalities[e] from repository construction, operation and monitoring, and closure (including transportation); and Nevada Test Site activities.
Accidents	No latent cancer fatalities would be likely from the maximum reasonably foreseeable repository accident scenarios. Between 1 and 5 latent cancer fatalities would result from a maximum reasonably foreseeable transportation accident scenario that has less than 3 chances in 10 million of occurring.	The accident risk (probability of occurrence times consequence) is essentially the same as that for the Proposed Action. Impacts of a maximum reasonably foreseeable transportation accident scenario would be the same as those for the Proposed Action.	No other actions were identified with potential cumulative accident risk impacts.	No latent cancer fatalities would be likely from the maximum reasonably foreseeable repository accident scenarios. Between 1 and 5 latent cancer fatalities would result from a maximum reasonably foreseeable transportation accident scenario that has less than 3 chances in 10 million of occurring.

Table 8-5. Summary of cumulative short-term impacts in the proposed Yucca Mountain Repository region (page 7 of 8).

Resource area	Proposed Action (repository and transportation)	Inventory Module 1 or 2[a]	Other Federal, non-Federal, and private actions	Total cumulative impacts
Noise	Impacts from construction, operation and monitoring, and closure of a repository would result in low noise impacts. Noise levels would be transient, less than 90 dBA[c]. New intermittent noise source if a rail line was used in Nevada, including in the Yucca Mountain region.	Same as the Proposed Action.	Future development of the Timbisha Shoshone Homeland parcel near Scottys Junction could result in residents or businesses being exposed to up to 90 dB of noise from the transportation route.	Impacts from construction, operation and monitoring, and closure of a repository would result in low noise impacts. Noise levels would be transient, less than 90 dBA[c]. New intermittent noise source if a rail line was used in Nevada, including in the Yucca Mountain.
Aesthetics	Placement of exhaust stacks on top of Yucca Mountain could possibly impact visual resources, since stacks would be visible for some distance. If the stacks were equipped with beacons, the visual effect would be more noticeable at night. Rail line construction would occur if rail was used in Nevada. Possible conflict with visual resource management goals for Jean rail corridor.	Same as the Proposed Action.	Disturbed areas are likely on former federal lands that are used for commercial and private purposes. Acquisition of private lands by the federal government could result in reduced aesthetics impacts and possible return of land to natural state.	Placement of exhaust stacks on top of Yucca Mountain could possibly impact visual resources, since stacks would be visible for some distance. If the stacks were equipped with beacons, the visual effect would be more noticeable at night. Rail line construction would occur if rail was used in Nevada. Possible conflict with visual resource management goals for Jean rail corridor. Disturbed areas are likely on former federal lands that are used for commercial and private purposes. Acquisition of private lands by the federal government could result in reduced aesthetics impacts and possible return of land to natural state.
Utilities, energy, materials, and site services	Peak electric power demand would require an upgrade to the electrical transmission and distribution system. Adverse impacts on energy and material supplies or to site services would be unlikely, including materials needed for transportation capabilities in the Yucca Mountain vicinity.	Peak electric power demand would require upgrade to the electrical transmission and distribution system. Although requirements for electricity, fossil fuels, concrete, steel, and copper would increase, adverse impacts to energy and material supplies or to site services would be unlikely, including materials needed for transportation capabilities in the Yucca Mountain vicinity.	Construction of other energy supply facilities, such as the Moapa Paiute Energy Center or the Alternative Energy Facility at the Nevada Test Site could provide additional electrical capacity for the region.	Peak electric power demand would require upgrade to the electrical transmission and distribution system. (See Chapter 4, Section 4.1.11.) Adverse impacts on energy and material supplies or to site services would be unlikely, including materials needed for transportation capabilities in the Yucca Mountain vicinity.

Table 8-5. Summary of cumulative short-term impacts in the proposed Yucca Mountain Repository region (page 8 of 8).

Resource area	Proposed Action (repository and transportation)	Inventory Module 1 or 2[a]	Other Federal, non-Federal, and private actions	Total cumulative impacts
Waste management	Disposal of repository-generated low-level waste would require about 4 percent of the reserve capacity of the Nevada Test Site. If nonradioactive, nonhazardous solid waste would be disposed of at the Nevada Test Site, existing landfills would need to be expanded.	Disposal of repository-generated low-level waste would require about 9 percent of the reserve capacity of the Nevada Test Site. If nonradioactive, nonhazardous solid waste would be disposed of at the Nevada Test Site, the larger quantity of this waste would require even further landfill expansion at the Nevada Test Site.	Nevada Test Site: The total low-level radioactive waste disposal capacity of the Nevada Test Site is sufficient and would not be exceeded by the combined actions of repository development and selection of the Nevada Test Site as a regional disposal site for DOE-complex-wide low-level radioactive and mixed wastes.	The Nevada Test Site has sufficient capacity for low-level radioactive waste from all reasonably foreseeable future actions. If nonradioactive, nonhazardous solid waste would be disposed of at the Nevada Test Site, existing landfills would need to be expanded.
Environmental justice	No disproportionately high and adverse impacts to minority or low-income populations would occur for repository or transportation activities. DOE recognizes that Native American people living in the region near Yucca Mountain have concerns about the protection of traditions and the spiritual integrity of the land that extend to the propriety of the Proposed Action, and that implementing the Proposed Action would continue restrictions on access to the proposed site.	No disproportionately high and adverse impacts to minority or low-income populations would occur for repository or transportation activities. DOE recognizes that Native American people living in the region near Yucca Mountain have concerns about the protection of traditions and the spiritual integrity of the land that extend to the propriety of the Proposed Action, and that implementing the Proposed Action would continue restrictions on access to the proposed site.	No other actions were identified with potential cumulative impacts within the region of influence of repository construction, operation and monitoring, and closure that would create environmental justice concerns. DOE recognizes that Native American people living in the region near Yucca Mountain have concerns about the protection of traditions and the spiritual integrity of the land that extend to the propriety of the Proposed Action, and that implementing the Proposed Action would continue restrictions on access to the proposed site.	No disproportionately high and adverse cumulative impacts to minority or low-income populations would occur for repository or transportation activities. DOE recognizes that Native American people living in the region near Yucca Mountain have concerns about the protection of traditions and the spiritual integrity of the land that extend to the propriety of the Proposed Action, and that implementing the Proposed Action would continue restrictions on access to the proposed site.

a. As described in Section 8.1.2.1, there would be essentially no difference in the design and operation of the repository for Inventory Module 1 or 2. Therefore, the analysis considered cumulative impacts from Inventory Module 2 to be the same as those from Inventory Module 1.

b. DOE compared the estimated annual dose to the Preclosure Public Health and Environmental Standard found at 10 CFR 63.204, which is 15 millirem per year to a member of the public.

c. dBA = A-weighted decibels, a common sound measurement. A-weighting accounts for the fact that the human ear responds more effectively to some pitches than to others. Higher pitches receive less weighting than lower ones.

d. Occupational and public health and safety impacts for the Proposed Action and Inventory Module 1 or 2 include both impacts from transportation activities in the repository region of influence as well as impacts estimated to occur nationally from transportation of spent nuclear fuel and high-level radioactive waste.

e. These ranges represent the maximum for each environmental resource area. Because the maximum could occur for different implementing alternatives in the various resource areas, simple addition of these summary level maximums could overstate the impacts due to mixing of incompatible alternatives.

DOE performed quantitative calculations for long-term impacts for both modules (see Section 8.3.1). The conclusion from these quantitative estimates was that the long-term impacts for Modules 1 and 2 would not differ greatly.

In estimating the potential impacts considered in this EIS, DOE consulted various documents, including resource plans, other National Environmental Policy Act documents, and technical documents. If appropriate, DOE has cited these documents in the discussion of each technical discipline.

Based on comments received during scoping and on the Draft EIS, DOE considered the Special Nevada Report from September 1991 (DIRS 153277-SAIC 1991, all) for inclusion as a source of technical information for the EIS. The Special Nevada Report, which was mandated by the Military Lands Withdrawal Act of 1986, contains a description of defense-related activities (as identified in 1991) along with estimates of potential impacts from those activities. However, the cumulative impacts analysis in this chapter considered the agencies that report represents—the Department of the Air Force, Department of the Navy, and Department of the Interior. Evaluations of the cumulative impacts of repository activities and other agency activities included review of a number of documents that are more current than the Special Nevada Report, including National Environmental Policy Act documents prepared by the Federal agencies listed throughout Section 8.1. Therefore, based on these more recent reports, DOE believes this report does not provide additional insight into projections of future impacts and, therefore, did not use it in its analysis of cumulative impacts.

8.2.1 LAND USE AND OWNERSHIP

The ownership, management, and use of the analyzed land withdrawal area described in Chapter 4, Section 4.1.1 for the Proposed Action would not change for Inventory Module 1 or 2. The amount of land required for surface facilities would increase somewhat for Module 1 or 2 because of the larger storage area for excavated rock and additional ventilation shafts for the larger required repository. This would have no substantial cumulative land-use or ownership impact.

To identify and quantify cumulative impacts for land use, DOE used a twofold approach. Actions that occurred within a 50-mile (80-kilometer) radius of the repository were reviewed for potential contributions to land use impacts. Second, actions that could affect transportation corridors were reviewed for their potential land use impacts. This second group of impacts is discussed in Section 8.4.2.1 (see Table 8-4).

Section 8.1 lists several actions that have the potential for land use impacts. DOE reviewed those actions to identify land areas that could be affected and has quantified, where possible, the amount of land that is subject to new uses. DOE identified how the land use would be converted (for example, undisturbed federal land to commercial use) and any restrictions that might affect the length of time the land would be used.

As discussed in Chapter 3, Section 3.1.1.1, the Federal Government manages approximately 240,000 square kilometers of land in Nevada, approximately 190,000 square kilometers of which are managed by BLM and available for public use. The land transfer/usage indicated in Table 8-6 represents approximately 340 square kilometers of additional land that is currently scheduled for removal from public use. In addition approximately 430 square kilometers would require removal from public use as the result of the potential development of a repository and transportation corridor. The total land removed from public use would represent less than 0.5 percent of BLM land and approximately 0.3 percent of the total Federal lands of Nevada. The largest change in land use is associated with the Southern Nevada Public Land Management Act. Although the Bureau of Land Management could convey as much as 110 square kilometers (27,000 acres) to private and commercial use, only about 17 square kilometers (4,200 acres) had been transferred as of April 30, 2001. As stipulated by the Act,

Table 8-6. Potential cumulative land use impacts for activities in or near the region of influence.[a]

Action	Land use conversion[b]	Ownership change	Land use restrictions
Moapa Paiute Energy Center[c]	Powerplant construction/ operation on 0.26 square kilometers of Reservation land.	Moapa Band of Paiute Indians to Calpine Corporation – powerplants footprint. Reservation to BLM for management of new natural gas pipeline	25-year lease with 20-year renewal
Ivanpah Cargo Airport[d]	Recreation and mining to airport and industrial development. Approximately 27 square kilometers, 8.1 square kilometers of which is for airport alone.	BLM to Clark County for public/private development	None
Timbisha Shoshone Reservation[e]	Grazing, recreation, mining, wildlife management to Tribal use (economic development, historic/cultural use, special use). Approximately 40 square kilometers.	NPS, BLM, and private lands to reservation/BIA	None
Cortez Mine[f]	Grazing, recreation, mining to mining 18 square kilometers.	BLM lease to Cortez Gold Mine	10 years
NTS Energy Generation Facility (Wind Farm)[g]	DOE land withdrawn for NTS to commercial use–4.9 square kilometers.	NTS subeasement to MNS through NTSDC	20 year generation period
Southern Nevada Public Land Management Act[h,i]	BLM general use to private/ commercial development and private/commercial land to public land. • Potential of 110 square kilometers to be transferred • 17 square kilometers conveyed as of April 30, 2001 • More than 23 square kilometers recommended by BLM to be acquired	• BLM to private/commercial • Private/commercial to BLM, NFS, NPS	None
Desert Space Station Science Museum[j]	BLM general use to commercial use (1.8 square kilometers).	BLM to Nye County	Land leased from Nye County to Nevada Science and Technology Center
Total land use impacts			
Federal land to Indian Reservations:	40 square kilometers		
Federal land to private and commercial use:	154+ square kilometers		
Private to Federal land:	25+ square kilometers (proposed as of December 2000)		

a. BLM = Bureau of Land Management; NTS = Nevada Test Site; NTSDC = NTS Development Corporation; MNS = M&N Wind Power Inc. and Siemans; NPS = National Park Service; BIA = Bureau of Indian Affairs.
b. To convert square kilometers to acres, multiply by 247.1.
c. Source: DIRS 155979-PBS&J (2001, pp. xi and xiii to xviii).
d. Source: Ivanpah Valley Public Lands Transfer Act (Public Law 106-362, 114 Stat. 1404).
e. Source: DIRS 154121-DOI (2000, Section 2.2).
f. Source: DIRS 155095-BLM (2000, pp. 1 to 13).
g. Source: DIRS 154545-DOE (2001, pp. 3-1 to 3-9).
h. Source: *Southern Nevada Public Land Management Act of 1998* (Public Law 105-263, 112 Stat. 2343).
i. Source: DIRS 155597-BLM (2000, all).
j. Source: DIRS 148148-Williams and Levy (1999, p. 1).

the Bureau has recommended acquiring about 23 square kilometers (5,800 acres) of environmentally sensitive lands throughout the State of Nevada that would be transferred from commercial and private use to general Bureau use.

Several land use conversions could result in commercial or private use of Federal lands. In addition to those lands transferred under the Southern Nevada Public Land Management Act, lands would be leased or transferred for the Ivanpah Cargo Airport, the Moapa Paiute Energy Center, the Cortez Mine, and the Desert Space Station Science Museum. These changes in land use would permit orderly development of public lands.

The projects that would occur on the Nevada Test Site and the Nellis Air Force Range would result in no net change in land use because the lands are already removed from the public use and are designated for development.

Some of the lands that would be transferred to the Timbisha Shoshone Nation could have some associated commercial use; however, this use would be consistent with the designations for the areas, and developments would be restricted to maintain the natural resources of the land.

In addition to the cumulative changes to land use and ownership, DOE considered potential conflicts with plans and policies issued by various government entities in the vicinity of the proposed Yucca Mountain Repository. In particular, DOE reviewed a number of documents issued by or in conjunction with Nye County and communities in Nye County. In general, the local governments have expressed goals that would minimize the conversion of private lands to public use. At this time DOE is not aware of any direct operational conflicts between the proposed repository and Nye County planning efforts because the Department does not foresee a need to expand the withdrawal area or for the conversion of private lands in the vicinity of the repository. Transportation-related issues are discussed in Section 8.4.2.1.

8.2.2 AIR QUALITY

8.2.2.1 Inventory Module 1 or 2 Impacts

This section addresses potential nonradiological and radiological cumulative impacts to air quality from emplacement in a repository at Yucca Mountain of the additional quantities of spent nuclear fuel and high-level radioactive waste above those evaluated for the Proposed Action, Greater-Than-Class-C waste, and Special-Performance-Assessment-Required waste (that is, Inventory Modules 1 and 2). It compares potential nonradiological and radiological cumulative impacts to applicable regulatory limits, including the new U.S. Environmental Protection Agency National Ambient Air Quality Standard for particulate matter with a diameter of less than 2.5 micrometers. Chapter 3, Section 3.1.2.1, discusses the current status of this standard. Sources of nonradiological air pollutants at the proposed repository could include fugitive dust emissions from land disturbances, excavated rock handling, and concrete batch plant operations and emissions from fossil-fuel consumption.

8.2.2.1.1 *Nonradiological Air Quality*

The construction, operation and monitoring, and closure of the proposed Yucca Mountain Repository for Inventory Module 1 or 2 would result in increased releases of criteria pollutants (nitrogen dioxide, sulfur dioxide, carbon monoxide, and particulate matter) and cristobalite as described in the following sections. The types of activities producing these releases would be the same as those described for the Proposed Action (see Chapter 4, Section 4.1.2).

Construction. The repository construction phase for Inventory Module 1 or 2 would produce the same levels of gaseous pollutants and cristobalite but slightly higher air concentrations of particulate matter, as

listed in Table 8-7. The air concentrations would still be small fractions of the applicable regulatory limits.

Table 8-7. Estimated construction phase concentrations of criteria pollutants and cristobalite (micrograms per cubic meter).[a]

Pollutant	Averaging time	Regulatory limit[b]	Proposed Action: Maximum concentration[c,d,e] Higher-temperature	Proposed Action: Maximum concentration[c,d,e] Lower-temperature	Proposed Action: Percent of regulatory limit[e] Higher-temperature	Proposed Action: Percent of regulatory limit[e] Lower-temperature
Nitrogen dioxide	Annual	100	0.40	0.41 - 0.42	0.41	0.41 - 0.42
Sulfur dioxide	Annual	80	0.10	0.10	0.13	0.13
	24-hour	365	1.3	1.3	0.36	0.36
	3-hour	1,300	8.5	8.6 - 8.7	0.66	0.66 - 0.67
Carbon monoxide[f]	8-hour	10,000	4.2	4.3 - 4.4	0.041	0.042 - 0.043
	1-hour	40,000	29	29 - 30	0.072	0.073 - 0.075
PM_{10} ($PM_{2.5}$)[f]	Annual	50 (15)	0.69	0.74 - 0.94	1.4	1.5 - 1.9
	24-hour	150 (65)	6.5	7.0 - 8.4	4.3	4.7 - 5.6
Cristobalite	Annual[g]	10[g]	0.018	0.017 - 0.018	0.18	0.17 - 0.18
			Inventory Module 1 or 2			
Nitrogen dioxide	Annual	100	0.40	0.41 - 0.42	0.40	0.41 - 0.42
Sulfur dioxide	Annual	80	0.10	0.10	0.13	0.13
	24-hour	365	1.3	1.3	0.36	0.36
	3-hour	1,300	8.5	8.6 - 8.7	0.66	0.66 - 0.67
Carbon monoxide	8-hour	10,000	4.2	4.3 - 4.4	0.041	0.043
	1-hour	40,000	29	29 - 30	0.072	0.073 - 0.075
PM_{10} ($PM_{2.5}$)[f]	Annual	50 (15)	0.81	0.85 - 1.1	1.6	1.7 - 2.1
	24-hour	150 (65)	7.1	7.4 - 8.9	4.7	4.9 - 5.8
Cristobalite	Annual[g]	10[g]	0.018	0.017 - 0.018	0.18	0.17-0.18

a. Source: Appendix G, Section G.1.4.
b. Regulatory limits for criteria pollutants from 40 CFR 50.4 through 50.11 and Nevada Administrative Code 445B.391 (see Chapter 3, Table 3-5).
c. Sum of highest concentrations at the accessible land withdrawal boundary, regardless of direction.
d. Source: Chapter 4, Section 4.1.2 and Appendix G, Section G.1.4.
e. Numbers are rounded to two significant figures; therefore, the percent of regulatory limit might not equal the percent calculated from the numbers listed in the table.
f. Data on $PM_{2.5}$ not being collected at time of analysis. However, overall PM_{10} numbers are well below standard for both.
g. There are no regulatory limits for public exposure to cristobalite, a form of crystalline silica. An Environmental Protection Agency health assessment (DIRS 103243-EPA 1996, all) states that the risk of silicosis is less than 1 percent for a cumulative exposure to 1,000 micrograms per cubic meter-year. Using a 70-year lifetime, an approximate annual average concentration of 10 micrograms per cubic meter was established as a benchmark for comparison.

Operation and Monitoring. Table 8-8 lists estimated air quality impacts from criteria pollutants and cristobalite for Inventory Module 1 or 2. The concentrations in this table are for the period of continuing surface and subsurface development and emplacement activities. During the subsequent monitoring and maintenance activities these concentrations would decrease considerably. All concentrations are comparable to those produced under the Proposed Action. All concentrations would be small fractions of the applicable regulatory limits for Module 1 or 2. Because the development of the emplacement drifts for Module 1 or 2 would take additional time compared to the Proposed Action, these releases of criteria pollutants would occur over a longer period than those from the Proposed Action. In general, the values in Table 8-8 for operation and monitoring are smaller than the values in Table 8-7 for construction because there would be more land surface disturbance during construction.

Closure. Continuing the closure of the repository for either Inventory Module 1 or 2 would produce comparable, but slightly lower, concentrations of gaseous pollutants, particulate matter, and cristobalite than those estimated for the Proposed Action. The concentrations would still be small fractions of the applicable regulatory limits (see Table 8-9). With Inventory Module 1 or 2, the amount of backfill required to close the ramps, main tunnels, and ventilation shafts would be larger than that for the Proposed Action, and the size of the excavated rock pile to reclaim would be larger. However, the

Table 8-8. Estimated operation and monitoring phase concentrations of criteria pollutants and cristobalite (micrograms per cubic meter).[a]

Pollutant	Averaging time	Regulatory limit[b]	Proposed Action: Maximum concentration[c,d,e] Higher-temperature	Proposed Action: Maximum concentration[c,d,e] Lower-temperature	Proposed Action: Percent of regulatory limit[e] Higher-temperature	Proposed Action: Percent of regulatory limit[e] Lower-temperature
Nitrogen dioxide	Annual	100	0.28	0.28 - 0.31	0.28	0.29 - 0.32
Sulfur dioxide	Annual	80	0.089	0.089 - 0.092	0.11	0.11 - 0.12
	24-hour	365	1.2	1.2	0.33	0.34
	3-hour	1,300	7.8	7.9 - 8.0	0.60	0.61 - 0.62
Carbon monoxide	8-hour	10,000	2.7	2.7 - 3.0	0.026	0.027 - 0.029
	1-hour	40,000	19	19 - 21	0.048	0.049 - 0.052
PM_{10} ($PM_{2.5}$)[f]	Annual	50 (15)	0.080	0.10 - 0.19	0.16	0.20 - 0.39
	24-hour	150 (65)	0.97	1.3 - 2.3	0.65	0.87 - 1.6
Cristobalite	Annual[g]	10[g]	0.0093	0.009 - 0.017	0.093	0.091 - 0.17
			Inventory Module 1 or 2			
Nitrogen dioxide	Annual	100	0.28	0.29 - 0.32	0.28	0.29 - 0.32
Sulfur dioxide	Annual	80	0.089	0.090 - 0.093	0.11	0.12
	24-hour	365	1.2	1.2 - 1.3	0.34	0.34
	3-hour	1,300	7.9	7.9 - 8.1	0.60	0.61 - 0.62
Carbon monoxide	8-hour	10,000	2.6	2.7 - 2.9	0.026	0.026 - 0.029
	1-hour	40,000	19	19 - 21	0.047	0.048 - 0.052
PM_{10} ($PM_{2.5}$)[f]	Annual	50 (15)	0.18	0.18 - 0.23	0.37	0.37 - 0.46
	24-hour	150 (65)	2.6	2.6 - 3.0	1.7	1.7 - 2.0
Cristobalite	Annual[g]	10[g]	0.011	0.010 - 0.016	0.11	0.10 - 0.16

a. Source: Appendix G, Section G.1.5.
b. Regulatory limits for criteria pollutants from 40 CFR 50.4 through 50.11, and Nevada Administrative Code 445B.391 (see Chapter 3, Table 3-5).
c. Sum of highest concentrations at accessible land withdrawal boundary, regardless of direction.
d. Source: Chapter 4, Section 4.1.2 and Appendix G, Section G.1.5.
e. Numbers are rounded to two significant figures; therefore, the percent of regulatory limit might not equal the percent calculated from the numbers listed in the table.
f. Data on $PM_{2.5}$ not being collected at time of analysis. However, overall PM_{10} numbers are well below standard for both.
g. There are no regulatory limits for public exposure to cristobalite, a form of crystalline silica. An Environmental Protection Agency health assessment (DIRS 103243-EPA 1996, all) states that the risk of silicosis is less than 1 percent for a cumulative exposure to 1,000 micrograms per cubic meter-year. Using a 70-year lifetime, an approximate annual average concentration of 10 micrograms per cubic meter was established as a benchmark for comparison.

duration of the closure period for Inventory Module 1 or 2 would increase over that of the Proposed Action, resulting in minor changes in the air concentrations between the Proposed Action and Inventory Module 1 or 2.

8.2.2.1.2 *Radiological Air Quality*

Inventory Module 1 or 2 would require more subsurface excavation and a longer closure phase leading to increased radon releases compared to the Proposed Action. The increased quantity of spent nuclear fuel that repository facilities would receive and package would also result in additional releases of krypton-85 from failed spent nuclear fuel cladding but, as for the Proposed Action, naturally occurring radon-222 and its radioactive decay products would still be the dominant dose contributors.

The following paragraphs discuss the estimated radiological air quality impacts in terms of the potential radiation dose to members of the public and workers for the construction, operation and monitoring, and closure phases of Inventory Module 1 or 2. For these estimates, workers exposed through the air pathway would be noninvolved workers.

Construction. Table 8-10 lists estimated doses to members of the public and workers for the construction phase. These values resulting from radon releases during the 5-year construction phase

Table 8-9. Estimated closure phase concentrations of criteria pollutants and cristobalite (micrograms per cubic meter).[a]

Pollutant	Averaging time	Regulatory limit[b]	Proposed Action: Maximum concentration[c,d,e] Higher-temperature	Proposed Action: Maximum concentration[c,d,e] Lower-temperature	Proposed Action: Percent of regulatory limit[d] Higher-temperature	Proposed Action: Percent of regulatory limit[d] Lower-temperature
Nitrogen dioxide	Annual	100	0.54	0.54	0.54	0.54 - 0.55
Sulfur dioxide	Annual	80	0.11	0.11	0.15	0.15
	24-hour	365	1.4	1.4	0.38	0.38
	3-hour	1,300	9.3	9.3	0.71	0.71 - 0.72
Carbon monoxide	8-hour	10,000	4.7	4.7	0.045	0.045 - 0.046
	1-hour	40,000	31	31	0.078	0.078
PM_{10} ($PM_{2.5}$)[f]	Annual	50 (15)	0.38	0.34 - 0.37	0.76	0.67 - 0.73
	24-hour	150 (65)	5.5	5.2 - 5.4	3.6	3.4 - 3.6
Cristobalite	Annual[g]	10[g]	0.012	0.0089 - 0.0095	0.12	0.089 - 0.098
			Inventory Module 1 or 2			
Nitrogen dioxide	Annual	100	0.51	0.48 - 0.49	0.52	0.49
Sulfur dioxide	Annual	80	0.11	0.11	0.14	0.14
	24-hour	365	1.4	1.4	0.38	0.37
	3-hour	1,300	9.1	9.0	0.70	0.69
Carbon monoxide	8-hour	10,000	4.4	4.2 - 4.3	0.043	0.041 - 0.042
	1-hour	40,000	30	28 - 29	0.075	0.071 - 0.072
PM_{10} ($PM_{2.5}$)[f]	Annual	50 (15)	0.40	0.32 - 0.35	0.079	0.65 - 0.69
	24-hour	150 (65)	5.6	5.1 - 5.2	3.7	3.4 - 3.5
Cristobalite	Annual[g]	10[g]	0.013	0.010 - 0.013	0.13	0.10 - 0.13

a. Source: Appendix G, Section G.1.6.
b. Regulatory limits for criteria pollutants from 40 CFR 50.4 through 50.11 and Nevada Administrative Code 445B.391 (see Chapter 3, Table 3-5).
c. Sum of highest concentrations at accessible land withdrawal boundary, regardless of direction.
d. Source: Chapter 4, Section 4.1.2 and Appendix G, Section G.1.6.
e. Numbers are rounded to two significant figures; therefore, the percent of regulatory limit might not equal the percent calculated from the numbers listed in the table.
f. Data on $PM_{2.5}$ not being collected at time of analysis. However, overall PM_{10} numbers are well below standard for both.
g. There are no regulatory limits for public exposure to cristobalite, a form of crystalline silica. An Environmental Protection Agency health assessment (DIRS 103243-EPA 1996, all) states that the risk of silicosis is less than 1 percent for a cumulative exposure to 1,000 micrograms per cubic meter-year. Using a 70-year lifetime, an approximate annual average concentration of 10 micrograms per cubic meter was established as a benchmark for comparison.

would be similar to those for the Proposed Action because the subsurface volume excavated would be about the same.

Operation and Monitoring. The doses from krypton-85 from receipt and packaging activities during operation and monitoring would be very low. Dose to the public would be only a fraction (0.00003 or less) of the dose from naturally occurring radon-222 and its radioactive decay products, as discussed below. Similarly, the dose to Yucca Mountain workers from krypton-85 would be a fraction (0.00001 or less) of the dose to those workers from radon-222. The annual dose from krypton-85 would be the same as that for the Proposed Action, but would occur for 38 years of spent nuclear fuel handling activities rather than 24 years.

Table 8-11 and Table 8-12 list doses to individuals and populations for operation and monitoring, respectively. In all cases, naturally occurring radon-222 would be the dominant contributor to the doses, which would increase because of the larger repository required for Inventory Module 1 or 2. Average annual doses would be higher to members of the public and higher to noninvolved workers during the 38 years of development and emplacement activities when the South Portal would be open and used for exhaust ventilation. The analysis estimated collective doses for public and worker populations for the 100 to 338 years for operation and monitoring, including the 38 years of development and emplacement activities and 62 to 300 years of monitoring and maintenance activities. The dose to the maximally exposed member of the public is for 38 years of operations and 32 years of monitoring (that is, a 70-year

Table 8-10. Estimated radiation doses to maximally exposed individuals and populations from subsurface radon-222 releases during initial construction period.[a,b,c]

Impact	Operating mode			
	Higher-temperature		Lower-temperature	
	Total	Maximum annual	Total	Maximum annual
	Proposed Action			
Dose to public				
Offsite MEI[d] (millirem)	1.7	0.43	1.7 - 2.0	0.43 - 0.53
80-kilometer population[e] (person-rem)	33	8.4	33 - 40	8.4 - 10
Dose to noninvolved (surface) workers				
Maximally exposed noninvolved worker[f] (millirem)	7.5	2.0	7.5 - 9.0	1.9 - 2.3
Yucca Mountain noninvolved worker population[g] (person-rem)	0.41	0.10	0.41 - 0.48	0.10 - 0.13
Nevada Test Site noninvolved worker population[h] (person-rem)	0.0013	0.00032	0.0013 - 0.0015	0.00032 - 0.00039
	Inventory Module 1 or 2			
Dose to public				
Offsite MEI (millirem)	1.7	0.43	2.0	0.52 - 0.53
80-kilometer population (person-rem)	33	8.4	39 - 40	10
Dose to noninvolved (surface) workers				
Maximally exposed noninvolved worker (millirem)	7.5	2.0	8.8 - 9.0	2.3
Yucca Mountain noninvolved worker population (person-rem)	0.41	0.10	0.47 - 0.49	0.12 - 0.13
Nevada Test Site noninvolved worker population (person-rem)	0.0013	0.00032	0.0015	0.00038 - 0.00039

a. Source: Appendix G, Section G.2.
b. Numbers are rounded to two significant figures.
c. Annual values are for the maximum year during the construction phase.
d. MEI = maximally exposed individual; public MEI location would be at the southern boundary of the land withdrawal area.
e. The population includes about 76,000 individuals within 80 kilometers (50 miles) of the repository (see Chapter 3, Section 3.1.8).
f. Maximally exposed noninvolved worker would be in the South Portal Development Area.
g. Includes noninvolved workers at the North Portal Operations Area and South Portal Development Area.
h. DOE workers at the Nevada Test Site [about 6,600 workers (DIRS 101811-DOE 1996, p. 5-14) 50 kilometers (30 miles) east-southeast near Mercury, Nevada].

Table 8-11. Estimated radiation doses to maximally exposed individuals and populations during operations activities.[a,b,c,d]

Impact	Operating mode			
	Higher-temperature		Lower-temperature	
	Total	Maximum annual	Total	Maximum annual
	Proposed Action			
Dose to public				
Offsite MEI[e] (millirem)	12	0.73	17 - 43	1.0 - 1.3
80-kilometer population[f] (person-rem)	230	14	320 - 830	20 - 26
Dose to noninvolved (surface) workers				
Maximally exposed noninvolved worker[g] (millirem)	30	2.0	39 - 42	2.8 - 3.0
Yucca Mountain noninvolved worker population[h] (person-rem)	1.2	0.081	1.8 - 1.9	0.12 - 0.13
Nevada Test Site noninvolved worker population[i] (person-rem)	0.011	0.00063	0.015 - 0.043	0.00090 - 0.0012
	Inventory Module 1 or 2			
Dose to public				
Offsite MEI (millirem)	22	0.94	31 - 66	1.3 - 2.2
80-kilometer population (person-rem)	430	18	600 - 1,300	26 - 42
Dose to noninvolved (surface) workers				
Maximally exposed noninvolved worker (millirem)	45	2.0	62 - 95	2.8 - 4.6
Yucca Mountain noninvolved worker population (person-rem)	1.8	0.081	2.5 - 4.1	0.11 - 0.2
Nevada Test Site noninvolved worker population (person-rem)	0.02	0.00085	0.028 - 0.063	0.0012 - 0.002

a. Source: Appendix G, Section G.2.
b. Numbers are rounded to two significant figures.
c. For Inventory Module 1 or 2, the operation and monitoring phase would last 100 years for the higher-temperature operating mode and 163 to 338 years for the lower-temperature operating mode.
d. Maximum annual dose occurs during the last year of development, when repository would be largest and South Portal would still be used for exhaust ventilation.
e. MEI = maximally exposed and individual; at the southern boundary of the land withdrawal area.
f. The population includes about 76,000 individuals within 80 kilometers (50 miles) of the repository (see Chapter 3, Section 3.1.8).
g. Maximally exposed noninvolved worker would be in the South Portal Development Area.
h. Includes noninvolved workers at the North Portal Operations Area and South Portal Development Area.
i. DOE workers at the Nevada Test Site [6,600 workers (DIRS 101811-DOE 1996, p. 5-14) 50 kilometers (30 miles) east-southeast near Mercury, Nevada].

Table 8-12. Estimated radiation doses to maximally exposed individuals and populations during monitoring activities.[a,b,c,d]

Impact	Operating mode			
	Higher-temperature		Lower-temperature	
	Total	Maximum annual	Total	Maximum annual
	Proposed Action			
Dose to public				
Offsite MEI[e] (millirem)	29	0.41	30 - 62	0.59 - 0.89
80-kilometer population[f] (person-rem)	600	8	1,500 - 3,500	11 - 17
Dose to noninvolved (surface) workers				
Maximally exposed noninvolved worker[g] (millirem)	0.096	0.0019	0.16 - 0.33	0.0011 - 0.0067
Yucca Mountain noninvolved worker population[h] (person-rem)	0.0091	0.0013	0.0031 - 0.05	0.000034 - 0.0057
Nevada Test Site noninvolved worker population[i] (person-rem)	0.033	0.00044	0.083 - 0.019	0.00021 - 0.00094
	Inventory Module 1 or 2			
Dose to public				
Offsite MEI (millirem)	39	0.62	20 - 100	0.29 - 1.4
80-kilometer population (person-rem)	740	12	2,200 - 5,400	5.6 - 28
Dose to noninvolved (surface) workers				
Maximally exposed noninvolved worker (millirem)	0.22	0.0043	0.33 - 0.54	0.0022 - 0.011
Yucca Mountain noninvolved worker population (person-rem)	0.025	0.0044	0.067 - 0.1	0.000075 - 0.0091
Nevada Test Site noninvolved worker population (person-rem)	0.041	0.00066	0.12 - 0.3	0.00031 - 0.0015

a. Source: Appendix G, Section G.2.
b. Numbers are rounded to two significant figures.
c. For Inventory Module 1 or 2, the operation and monitoring phase would last 100 years for the higher-temperature operating mode and 163 to 338 years for the lower-temperature operating mode.
d. Maximum annual dose occurs during the last year of development, when repository would be largest and South Portal would still be used for exhaust ventilation.
e. MEI = maximally exposed individual; at the southern boundary of the land withdrawal area.
f. The population includes about 76,000 individuals within 80 kilometers (50 miles) of the repository (see Chapter 3, Section 3.1.8).
g. Maximally exposed noninvolved worker would be in the South Portal Development Area.
h. Includes noninvolved workers at the North Portal Operations Area and South Portal Development Area.
i. DOE workers at the Nevada Test Site [6,600 workers (DIRS 101811-DOE 1996, p. 5-14) 50 kilometers (30 miles) east-southeast near Mercury, Nevada].

lifetime). The dose to the maximally exposed noninvolved worker is for 50 years at the South Portal during development, emplacement, and monitoring activities.

Closure. Table 8-13 lists estimated doses to populations and maximally exposed individuals during the closure phase. Radiation doses would increase over those for the Proposed Action not only because of the larger excavated volume but also the longer time required for closure (12 to 23 years) in comparison to 10 to 17 years.

Summary. Based on the analysis of radiological air quality impacts from repository construction, operation and monitoring, and closure for Inventory Module 1 or 2, the estimated maximum annual dose to the maximally exposed individual member of the public would be 0.99 millirem for the lower-temperature operating mode during development and emplacement activities in the operation and monitoring phase. DOE compared the estimated annual dose to the Preclosure Public Health and Environmental Standard found at 10 CFR 63.204, which is 15 millirem per year to a member of the public. The dose would be about 6.6 percent of this standard. The radiation dose is 0.3 percent of the annual 340-millirem natural background dose to individuals in Amargosa Valley. Section 8.2.7 discusses human health impacts to the public that could result from radiation exposures during construction, operation and monitoring, and closure for Inventory Module 1 or 2.

8.2.2.2 Cumulative Impacts from Inventory Module 1 or 2 and Other Federal, Non-Federal, and Private Actions

This section addresses potential nonradiological and radiological cumulative impacts to air quality from activities at the repository for the Proposed Action or Inventory Module 1 or 2 and other Federal,

Table 8-13. Estimated radiation doses to maximally exposed individuals and populations from radon-222 releases during closure phase.[a,b,c]

Impact	Operating mode			
	Higher-temperature		Lower-temperature	
	Total	Maximum annual	Total	Maximum annual
	Proposed Action			
Dose to public				
MEI[d] (millirem)	3.0	0.39	4.3 - 9.4	0.57 - 0.87
80-kilometer population[e] (person-rem)	57	7.4	83 - 180	10 - 16
Dose to noninvolved (surface) workers				
Maximally exposed noninvolved (surface) worker[f] (millirem)	0.014	0.0018	0.024 - 0.070	0.0030 - 0.0063
Yucca Mountain noninvolved (surface) worker population[g] (person-rem)	0.0040	0.00052	0.0070 - 0.015	0.00088 - 0.0014
Nevada Test Site noninvolved worker population[h] (person-rem)	0.0031	0.00041	0.0046 - 0.0099	0.00058 - 0.00089
	Inventory Module 1 or 2			
Dose to public				
MEI (millirem)	4.9	0.60	8.5 - 19	0.86 - 1.4
80-kilometer population (person-rem)	95	11	160 - 360	16 - 26
Dose to noninvolved (surface) workers				
Maximally exposed noninvolved (surface) worker (millirem)	0.034	0.0040	0.063 - 0.14	0 - 0.010
Yucca Mountain noninvolved (surface) worker population (person-rem)	0.012	0.0013	0.015 - 0.026	0.0014 - 0.0019
Nevada Test Site noninvolved worker population (person-rem)	0.0052	0.00061	0.0090 - 0.020	0.00088 - 0.00015

a. Source: Appendix G, Section G-2.
b. Numbers are rounded to two significant figures.
c. The closure phase would last 10 to 7 years for the Proposed Action and 12 to 23 years for Inventory Module 1 or 2.
d. MEI = maximally exposed individual; at the southern boundary of the land withdrawal area.
e. The population includes about 76,000 individuals within 80 kilometers (50 miles) of the repository (see Chapter 3, Section 3.1.8).
f. Maximally exposed noninvolved worker would be in the South Portal Development Area.
g. Includes noninvolved workers at the North Portal Operations Area and South Portal Development Area.
h. DOE workers at the Nevada Test Site [6,600 workers (DIRS 101811-DOE 1996, p. 5-14) 50 kilometers (30 miles) east-southeast near Mercury, Nevada].

non-Federal, and private actions that would coincide with repository operations and potentially affect the air quality within the geographic boundaries of repository air quality impacts.

To identify and quantify potential cumulative impacts on air resources from other actions, the Department used a 50-mile (80-kilometer) radius around the proposed repository as the region of influence. However, because of the distances involved and the dispersion afforded by distance and different wind directions, the potential for overlap of plumes from multiple actions would be greatest for those actions that are in close proximity to each other (that is, a few miles). Beyond that, the degree of plume overlap is less certain and indeed may not exist.

8.2.2.2.1 *Nonradiological Air Quality*

Construction, operation and monitoring, and closure of the proposed Yucca Mountain Repository would have very small impacts on regional air quality for the Proposed Action or for Inventory Module 1 or 2. Annual average concentrations of criteria pollutants at the land withdrawal boundary would be 1 percent or less of applicable regulatory limits except for PM_{10}, which the analysis estimated would be as much as 6.5 percent of the regulatory limit at the land withdrawal boundary. This estimate does not consider standard dust suppression activities (such as wetting), so actual concentrations probably would be much lower.

DOE has monitored particulate matter concentrations in the Yucca Mountain region since 1989; gaseous criteria pollutants were monitored from October 1991 through September 1995. Concentrations were well below applicable National Ambient Air Quality Standards (see Chapter 3, Section 3.1.2.1). In 1990, DOE also measured ambient air quality in several Nevada Test Site areas for short-term concentrations of sulfur dioxide, carbon monoxide, and PM_{10} (DIRS 101811-DOE 1996, Volume I, pp. 4-146 and 4-148).

The measurements were all lower than the applicable short-term (1-hour, 3-hour, 8-hour, and 24-hour) limits.

Pollutant concentrations related to Nevada Test Site activities would be well below ambient air quality standards and would not increase ambient pollutant concentrations above standards in Nye County (DIRS 101811-DOE 1996, Volume I, p. 4-146). Therefore, DOE expects the cumulative impacts from proposed repository and Nevada Test Site operations to be very small.

Other actions discussed in Section 8.1 would be unlikely to have cumulative impacts with the repository because they are sufficiently far away that plumes would have limited potential for overlap. Further, the responsible agencies would take measures for each action to minimize regional air impacts.

Repository activities would have no effect on air quality in the Las Vegas Valley air basin, which is a nonattainment area for carbon monoxide and PM_{10}, because the Las Vegas Valley air basin lies approximately 120 kilometers (75 miles) southeast of the proposed repository site.

8.2.2.2.2 *Radiological Air Quality*

Past activities at the Nevada Test Site are responsible for the seepage of radioactive gases from underground testing areas and slightly increased krypton-85 levels on Pahute Mesa in the northwest corner of the Nevada Test Site (see Figure 8-2). Some radioactivity on the site is attributable to the resuspension of soils contaminated from past aboveground nuclear weapons testing (DIRS 101811-DOE 1996, Volume I, p. 4-149). Current Nevada Test Site defense program activities have not resulted in detectable offsite levels of radioactivity. As discussed in Chapter 3, Section 3.1.8.2, estimated radiation doses to the public during 1999 were 0.12 millirem to the maximally exposed individual [a hypothetical resident of Springdale, Nevada, which is about 14 kilometers (19 miles) north of Beatty (see Figure 8-2)] and 0.38 person-rem to the population within 80 kilometers (50 miles) of Nevada Test Site airborne emission sources (DIRS 146592-Black and Townsend 1998, p. 7-1). The radiation dose estimates from repository construction, operation and monitoring, and closure (see Tables 8-10, 8-11, 8-12, and 8-13) would add to these estimates assuming the exposed individuals and population were the same (they are not). Conservatively adding the 1999 maximally exposed individual dose from the Nevada Test Site to the highest estimated average annual dose to the maximally exposed individual from repository operations (hypothetical individual located at the southern border of the land withdrawal area) (2.2 millirem) resulted in a cumulative dose of 2.3 millirem. DOE compared the estimated annual dose to the Preclosure Public Health and Environmental Standard found at 10 CFR 63.204, which is 15 millirem per year to a member of the public. The dose would be about 15 percent of this standard. This dose would also represent 0.68 percent of the annual 340-millirem natural background radiation dose to individuals in Amargosa Valley. Conservatively adding the 1999 Nevada Test Site and highest estimated annual repository population dose (42 person-rem) results in a cumulative dose of 42 person-rem. No latent cancer fatalities to the population would be expected from this cumulative exposure (see Section 8.2.7).

Chapter 3 discusses potential radiological doses from past weapons testing at the Nevada Test Site. Residents who were present during the periods when such testing (in particular, atmospheric weapons testing from the 1950s to the early 1960s) occurred could have received as much as 5 rem to the thyroid gland from iodine-131 releases. Using a tissue weighting factor of 0.03 as specified in International Commission on Radiological Protection Publication 26 (DIRS 101075-ICRP 1977, all) this equates to an effective dose equivalent of about 150 millirem. Because of the length of time since atmospheric weapons testing ended, essentially all of this dose has already occurred. This dose would apply only to those residents who lived in the region of influence during the period of atmospheric weapons testing. DOE has not added this dose to the maximally exposed individual dose, but has included this information here so long-term residents in the region of influence can evaluate their potential for impacts from past

nuclear weapons testing. (DOE has also included this information in the air quality portion of Table 8-60.)

The only other activity identified in the 80-kilometer (50-mile)-radius region of influence that could affect radiological air quality is a low-level radioactive disposal site near Beatty, Nevada, which was officially closed on January 1, 1993. The physical work of a State-approved Stabilization and Closure Plan ended in July 1994. Custodianship of the site has been transferred to the State of Nevada. Monitoring is continuing at the site to ensure that any radioactive material releases to the air continue to be low (DIRS 102171-NSHD 1999, Section on the Bureau of Health Protection Services).

8.2.3 HYDROLOGY

8.2.3.1 Surface Water

Potential impacts to surface waters from the Proposed Action would be relatively minor and limited to the immediate vicinity of land disturbances associated with the action (see Chapter 4, Section 4.1.3.2, and the floodplain/wetlands assessment in Appendix L). Surface-water impacts of primary concern would include the following:

- Introduction and movement of contaminants
- Changes to runoff or infiltration rates
- Alterations of natural drainage

This section addresses these impact areas in a discussion of possible increases or other changes that could occur as a result of the emplacement of Inventory Module 1 or 2. To be cumulative, other Federal, non-Federal, or private action effects would have to occur in the immediate area because of the transient nature of the surface water from the repository (that is, stormwater runoff). No currently identified actions have met this criterion.

Introduction and Movement of Contaminants

For Inventory Module 1 or 2, there would be essentially no change in the potential for soil contamination during the construction, operation and monitoring, and closure phases. There would be no change in the types of contaminants present nor would there be changes in operations that would make spills or releases more likely. Similarly, there would be no change in the threat of flooding to cause contaminant releases beyond that described for the Proposed Action.

Changes to Runoff or Infiltration Rates

Compared to the estimated area of land disturbed under the Proposed Action, Inventory Module 1 or 2 would require the disturbance of additional land for the corresponding repository operating mode (see Table 8-4). A maximum of about 5.5 square kilometers (1,400 acres) of land would be newly disturbed for Module 1 or 2 for the lower-temperature mode if surface aging was included. This increase in disturbed land would still be a relatively small portion of the natural drainage areas and would make little difference in the amount of water that soaked into the ground or reached the intermittently flowing drainage channels. Disturbed areas not covered by structures would slowly return to conditions more similar to those of the surrounding undisturbed ground.

Alterations of Natural Drainage

No additional actions or land disturbances associated with Inventory Module 1 or 2 would involve a potential to alter noteworthy natural drainage channels in the area. The excavated rock pile and its increased size for Module 1 or 2 would be in an area that would obstruct a very small portion of overland drainage. Potential impacts to floodplains would be the same as those described for the Proposed Action (see Chapter 4, Section 4.1.3.3). The construction, operation, and maintenance of a rail line, roadways,

and bridges in the Yucca Mountain vicinity could affect the 100- and 500-year floodplains of Fortymile Wash, Busted Butte Wash, Drill Hole Wash, and Midway Valley Wash at Yucca Mountain. The floodplains affected and the extent of activities in the floodplains would depend on which routes DOE selected. Appendix L contains a floodplain/wetlands assessment that describes the actions DOE could take to construct, operate, and maintain a branch rail line or highway route in the Yucca Mountain vicinity.

8.2.3.2 Groundwater

8.2.3.2.1 *Inventory Module 1 or 2 Impacts*

Potential groundwater impacts would be related to the following:

- The potential for a change in infiltration rates that could increase the amount of water in the unsaturated zone and adversely affect the performance of waste containment in the repository, or decrease the amount of recharge to the aquifer
- The potential for contaminants to migrate to the unsaturated or saturated groundwater zones during the active life of the repository
- The potential for water demands associated with the repository to deplete groundwater resources to an extent that could affect downgradient groundwater use or users

Changes to Infiltration and Aquifer Recharge. If DOE emplaced Inventory Module 1 or 2, changes related to infiltration and recharge rates would be limited to three areas: a possible increase in the size of the excavated rock pile, an increase in the number of ventilation shaft operations areas, and an extended scope for subsurface activities. The following paragraphs discuss these items.

Additional land disturbance anticipated during the operation and monitoring phase would be the continued growth of the excavated rock pile. Depending on the repository operating mode, this could involve as much as about 0.5 square kilometer (120 acres) of additional land over that required for the Proposed Action (see Table 8-4). Although the excavated rock pile could have different infiltration rates than undisturbed ground, it probably would not be a recharge location because of the extended depth of unconsolidated material, nor would it be likely to cause a large change in the amount of water that would otherwise reach recharge areas such as drainage channels.

Increased land disturbance would result from the additional ventilation shaft operation areas and the access roads that would be required as the repository footprint size increased to accommodate the Module 1 or 2 inventory. Depending on the repository operating mode, this could involve an additional 0.3 to 0.47 square kilometer (74 to 120 acres) of land disturbance over that required for these elements of the Proposed Action (see Table 8-4). These areas of disturbance would be primarily on steeper terrain, uphill from the portal areas, where unconsolidated material is likely thin and where disturbances could expose fractured bedrock. Infiltration rates could be increased notably in such areas as a result. However, much of the disturbed area would be capped with road material or equipment pads, and the amount of disturbed land would still be small in comparison to the surrounding undisturbed area.

Underground activities and their associated potential to contribute to the deep infiltration of water would be basically the same as those described for the Proposed Action, except emplacement drift construction would take an estimated 36 years to complete with either Inventory Module 1 or 2, compared to 22 years for the Proposed Action (see Table 8-3). As described for the Proposed Action, the quantities of water in the subsurface not removed to the surface by ventilation or pumping and thus available for infiltration

would be small and primarily limited to the duration of drift development when the largest quantities of water would be used in the subsurface for dust control.

Potential for Contaminant Migration to Groundwater Zones. Neither Inventory Module 1 nor 2 would involve additional actions likely to increase the potential for contaminant releases to the environment. The only possible exception to this could be the extended period of subsurface excavation activities to accommodate the additional inventory. However, this exception would be an extension of activities with minimal potential to involve substantial contaminant releases.

Potential to Deplete Groundwater Resources. Anticipated annual water demand for Inventory Module 1 or 2 would be the same or very similar to that projected for the Proposed Action. Table 8-14 summarizes estimated annual water demands for both the Proposed Action and Inventory Module 1 or 2. The table indicates no notable change in water demand during construction.

Table 8-14. Estimated annual water demand (acre-feet)[a] for the Proposed Action and Inventory Module 1 or 2.

Phase	Duration (years)	Water demand (acre-feet/year)[a] Operating mode: Higher-temperature	Lower-temperature
		Proposed Action	
Construction	5	160	190 to 210
Operation and monitoring (by activity)			
Emplacement and development activities			
Combined emplacement and development	22	230	250 to 290
Subsequent emplacement or aging only[b]	2 or 28	180	90 to 190
Monitoring activities			
Initial decontamination	3	220	200 to 230
Subsequent monitoring/caretaking	73 to 297	6	3 to 6
Closure	10 to 17	81	70 to 84
		Inventory Module 1 or 2	
Construction	5	160	190 to 210
Operation and monitoring (by activity)			
Emplacement and development activities			
Combined emplacement and development	36	250	240 to 320
Subsequent emplacement only[b]	2 or 15	180	90 to 190
Monitoring activities			
Initial decontamination	3	220	200 to 230
Subsequent monitoring/caretaking	59 to 297	6	4 to 6
Closure	12 to 23	83	73 to 91

a. To convert acre-feet to cubic meters, multiply by 1,233.49.
b. Unless surface aging is involved, the period during which development was complete and only emplacement being conducted would last 2 years. This higher duration listed is applicable only to the lower-temperature repository operating mode that includes surface aging.

Projected annual water demand during emplacement and development activities of the operation and monitoring phase (as listed in Table 8-14) would be very similar, but generally a little higher under Inventory Module 1 or 2. However, the difference in total water demand would be greater when the change in the duration of the annual demand is taken into consideration. That is, this phase of repository activities, which would have the highest annual water demand, is extended from 22 to 36 years with the Module 1 or 2 inventory. On an annual basis, water demand would increase no more than 4 to 10 percent over that for the Proposed Action but, during the entire 36-year period, Inventory Module 1 or 2 would result in an increased water demand by as much as about 80 percent, depending on the repository operating mode.

Projected annual water demand during monitoring activities of the operation and monitoring phase would be basically the same under either the Proposed Action or Inventory Module 1 or 2. In either case, the relatively high demands listed in Table 8-14 would last only about 3 years during surface facility decontamination, after which the annual demand would drop drastically for the remainder of this long-duration activity. The closure phase for Module 1 or 2 shows there would be only a slight increase in projected annual water demand in comparison to the Proposed Action. The fact that the duration of the closure phase would be longer under Module 1 or 2 would increase the difference on a total-phase basis, but the increases would still be minor.

Potential impacts to water resources under Inventory Module 1 or 2 would be very similar to those under the Proposed Action because the annual water demand would change little, and the best understanding of the groundwater resource is that it is replenished on an annual basis as gauged by the perennial yield of the groundwater basin. Under Module 1 or 2, the repository's annual water demand from the western two-thirds of the Jackass Flats basin would remain below the lowest estimated value for its perennial yield of [720,000 cubic meters (580 acre-feet)] (see Chapter 3, Table 3-11). See Chapter 4, Section 4.1.3.3 for more information on regional groundwater usage and demand.

8.2.3.2.2 *Cumulative Impacts from Inventory Module 1 or 2 and Other Federal, Non-Federal, and Private Actions*

Potential impacts to groundwater, as described in Chapter 4, Section 4.1.3.3, and in Section 8.2.3.2.1, for the Proposed Action and Inventory Module 1 or 2 would be small and limited to the immediate vicinity of land disturbances associated with the action. The exceptions to this would be the potential impact from water demands on groundwater resources and potential impacts from contaminants in groundwater. With these exceptions, other Federal, non-Federal, or private action effects would have to occur in the same region of influence to be cumulative with those resulting from the Proposed Action or Inventory Module 1 or 2, and no currently identified actions meet this criterion.

The remainder of this discussion addresses potential impacts to groundwater resources from water demand. Section 8.3 addresses long-term impacts of contaminants in groundwater.

The discussion of impacts to groundwater resources in Chapter 4, Section 4.1.3.3, includes ongoing water demands from Area 25 of the Nevada Test Site. Area 25 is the proposed location of the primary repository surface facilities. It is also the location of wells J-12 and J-13, which would provide water for the Proposed Action and for ongoing Nevada Test Site activities in this area. The estimated water demand for these ongoing activities is 340,000 cubic meters (280 acre-feet) a year (DIRS 103226-DOE 1998, Table 11-2, p. 11-6).

Water demand during emplacement and development activities of the operation and monitoring phase under Inventory Module 1 or 2 combined with the baseline demands from Nevada Test Site activities would exceed the lowest perennial yield estimate under the lower-temperature repository operating modes if certain features were enacted. The highest annual water demand attributed to the lower-temperature operating mode with maximum package spacing, in combination with ongoing Nevada Test Site water demands, would exceed the lowest estimate of perennial yield, but only marginally. The worst-case scenario for repository water demand (maximum spacing and surface aging under the lower-temperature operating mode) added to the Nevada Test Site demand would total about 240,000 cubic meters (600 acre-feet) per year compared to 720,000 cubic meters (580 acre-feet), the lowest estimate of perennial yield for the western two-thirds of Jackass Flats. Besides these exceptions, the combined water demands would be below the lowest estimate of perennial yield. None of the water demand estimates would approach the high estimate of perennial yield for the entire Jackass Flats hydrographic basin, which is 4.9 million cubic meters (4,000 acre-feet) (see Chapter 3, Table 3-11). Potential impacts to groundwater resources from this combined demand would be no different than those described in Chapter 4,

Section 4.1.3.3. That is, some decline in the water level would be likely near the production wells, and water elevation decreases at the town of Amargosa Valley would probably be no more than 0.4 to 1.1 meter (1.2 to 3.6 feet) (see Section 4.1.3.3). The reduction in underflow from the Jackass Flats hydrographic area to the Amargosa Desert hydrographic area would be less than the quantity of water actually withdrawn from the upgradient area because there would probably be minor changes in groundwater flow patterns as the water level adjusted to the withdrawals. Groundwater flow models predict the reduction in underflow to the Amargosa Desert would be no higher than 160,000 to 180,000 cubic meters (130 to 150 acre-feet) per year (see Section 4.1.3.3).

The Nevada Test Site EIS (DIRS 101811-DOE 1996, pp. 3-18, 3-19, and 3-34) indicates that the potential construction and operation of a Solar Enterprise Zone facility would represent the only action that would cause water withdrawals on the Test Site to exceed past levels. That EIS estimates that this demand would be greater than the highest estimates of the basin's perennial yield. Therefore, cumulative impacts from the Solar Enterprise Zone facility are likely. DOE is considering several locations for the Solar Enterprise Zone facility, one of which is Area 25. If DOE built this facility in Area 25, it would obtain water from the Jackass Flats hydrologic area, and possibly from other hydrologic areas.

Cumulative demands on the Jackass Flats hydrographic area could have long-term impacts on water availability in the downgradient aquifers beneath the Amargosa Desert. The groundwaters in these areas are hydraulically linked, but the exact nature and extent of that link is still a matter of study and some speculation. However, the amount of water already being withdrawn in the Amargosa Desert [averaging about 17 million cubic meters (14,000 acre-feet) of water per year from 1995 through 1997 (see Chapter 3, Table 3-11)] is much greater than the quantities being considered for withdrawal from Jackass Flats. If water pumpage from Jackass Flats affected water levels in the Amargosa Desert, the impacts would be small in comparison to those caused by local pumping in that area.

A report from the Nye County Nuclear Waste Repository Office (DIRS 103099-Buqo 1999, pp. 39 to 53) provides a perspective of potential cumulative impacts with that County as the center of interest. The Nye County report evaluates impacts to all water resources potentially available in the entire county, whereas this EIS focuses principally on impacts to the Jackass Flats groundwater basin (the source of water that DOE would use for the repository) and the groundwater system that could become contaminated thousands of years in the future. Nye County reports that the potential cumulative impacts would include additive contamination as radionuclides ultimately reached the groundwater, constraints on development of groundwater due to land withdrawal, and reduction of water available for Nye County development because of use by Federal agencies (DIRS 103099-Buqo 1999, pp. 49 to 51).

8.2.4 BIOLOGICAL RESOURCES

Impacts to biological resources from Inventory Module 1 or 2 would be similar to impacts that would occur as a result of the Proposed Action evaluated in Chapter 4, Section 4.1.4. Those impacts would occur primarily as a result of site clearing, placement of material in the excavated rock pile, habitat loss, and the loss of individuals of some animal species during site clearing and from vehicle traffic.

Inventory Module 1 or 2 would require disturbing biological resources in a larger area under each thermal load scenario than would be disturbed under the Proposed Action, primarily because the excavated rock pile would be larger (Table 8-15).

Repository construction and the excavated rock pile to support Inventory Module 1 or 2 would disturb up to 5.5 square kilometers of previously undisturbed land. Disturbances would occur in areas dominated by Mojave mixed scrub and salt desert scrub land cover types. These cover types are widespread in the withdrawal area and in Nevada. This disturbed area is larger than that for the Proposed Action and would

Table 8-15. Area of land cover types in analyzed withdrawal area disturbed by construction and the excavated rock pile (square kilometers).[a,b,c]

Land cover type	Area in Nevada	Area in analyzed withdrawal area[d]	Operating mode	
			Higher-temperature	Lower- temperature
		Proposed Action		
Blackbrush	9,900	140	0.0	0 - 0.2
Creosote-bursage	15,000	300	0.6	0.6 - 0.7
Mojave mixed scrub	5,700	120	2.2	2.4 - 3.6
Sagebrush	67,000	16	0.0	0
Salt desert scrub	58,000	20	0.0	0
Previously disturbed[e]	NA[f]	4	1.5	1.5
Totals	***NA***	***600***	***4.3***	***4.5 - 6***
		Inventory Module 1 or 2		
Blackbrush	9,900	140	0.0	0 - 0.2
Creosote-bursage	15,000	300	0.6	0.6 - 0.7
Mojave mixed scrub	5,700	120	3.0	3.2 - 4.6
Sagebrush	67,000	16	0.0	0
Salt desert scrub	58,000	20	0.0	0
Previously disturbed[e]	NA	4	1.5	1.5
Totals	***NA***	***600***	***5.1***	***5.4 - 7***

a. Source: Facility diagrams from DIRS 104523-CRWMS M&O (1999, Figures 6.1.7-1, 6.1.7-2, 6.2.7-1, and 6.2.7-2; pp. 6-42, 6-43, 6-84, and 6-85) overlain on the land cover types map; DIRS 104589-CRWMS M&O (1998, p. 9 as adapted) using a Geographic Information System.
b. To convert square kilometers to acres, multiply by 247.1.
c. Totals might differ from sums of values due to rounding.
d. A small area [0.016 square kilometer (4 acres)] of the pinyon-juniper-2 land cover type occurs in the analyzed land withdrawal area, but would not be affected.
e. Estimate of land previously disturbed in support of the proposed repository.
f. NA = not applicable.

affect vegetation on approximately 1 percent of the previously undisturbed land within the land withdrawal area.

Releases of radioactive materials would not adversely affect biological resources. Routine releases would consist of noble gases, primarily krypton-85 and radon-222. These gases would not accumulate in the environment around Yucca Mountain and would result in low doses to plants or animals.

Overall impacts to biological resources from Inventory Module 1 or 2 would be very small. Species at the repository site are generally widespread throughout the Mojave or Great Basin Deserts and repository activities would affect a very small percentage of the available habitat in the region. Changes in the regional population of any species would be undetectable and no species would be threatened with extinction. The removal of vegetation from the small area required for Module 1 or 2 or the local loss of small numbers of individuals of some species due to site clearing and vehicle traffic would not affect regional biodiversity and ecosystem function. The loss of desert tortoise habitat and small numbers of tortoises under Module 1 or 2 would have no impact on recovery efforts for this threatened species.

Activities associated with other Federal, non-Federal, and private actions in the region should not add measurable impacts to the overall impact on biological resources. However, as stated in the Nevada Test Site EIS (DIRS 101811-DOE 1996, p. 6-16), cumulative impacts to the desert tortoises would occur throughout the region, although the intensity of the impacts would vary from location to location. The largest impact to the habitat probably would occur in the Las Vegas Valley region. The Clark County Desert Conservation Plan authorizes the taking of all tortoises on 445 square kilometers (110,000 acres) of non-Federal land in the County, and on 12 square kilometers (3,000 acres) disturbed by Nevada

Department of Transportation activities in Clark and adjacent counties. The plan also authorizes several recovery units designed to optimize the survival and recovery of this threatened species. Potential land disturbance activities at the Nevada Test Site under the expanded use alternative represent a small amount of available desert tortoise habitat and will not add measurably to the loss of this species (DIRS 101811-DOE 1996, p. 6-16). As discussed in Chapter 4, Section 4.1.4, repository construction activities would involve the loss of an amount of desert tortoise habitat that would be small in comparison to its range. Yucca Mountain is at the northern end of the range of this species. DOE anticipates that small numbers of tortoises would be killed inadvertently by vehicle traffic during the repository construction, operation and monitoring, and closure phases.

8.2.5 CULTURAL RESOURCES

The only identified actions that could result in cumulative cultural resource impact in the Yucca Mountain site vicinity are Inventory Module 1 or 2. The emplacement of either module would require small additional disturbances to land in areas already surveyed during site characterization activities (see Table 8-4). Because repository construction, operation and monitoring, and closure would be Federal actions, DOE would identify and evaluate cultural resources, as required by Section 106 of the National Historic Preservation Act, and would take appropriate measures to avoid or mitigate adverse impacts to such resources. As a consequence, archaeological information gathered from artifact retrieval during land disturbance would contribute additional cultural resources information to the regional data base for understanding past human occupation and use of the land. However, there would be a potential for illicit or incidental vandalism of archaeological or historic sites and artifacts as a result of increased activities in the repository area, which would be extended for Module 1 or 2 (see Table 8-3), and this could contribute to an overall loss of regional cultural resources information.

The Native American view of resource management and preservation is holistic in its definition of cultural resources, incorporating all elements of the natural and physical environment in an interrelated context (DIRS 102043-AIWS 1998, all). The Native American perspective on cultural resources is further discussed in Chapter 3, Section 3.1.6. Potential impacts resulting from the Proposed Action described in Chapter 4, Section 4.1.5, would also apply to Inventory Module 1 or 2.

8.2.6 SOCIOECONOMICS

8.2.6.1 Inventory Modules 1 and 2 Impacts

This section addresses potential socioeconomic impacts associated with Inventory Module 1 or 2 and concludes that impacts for Inventory Module 1 or 2 would be essential the same during construction phase as the Proposed Action, slightly greater during the development and emplacement phases than the Proposed Action, the same during the monitoring phase, and slightly greater than impacts for the Proposed Action during the closure phase. The impacts in all phases for Module 1 or 2 would be small, as are impacts estimated for the Proposed Action (see Chapter 4, Section 4.1.6). DOE analyzed both the higher-temperature operating mode and the lower-temperature operating mode. Table 8-16 summarizes the peak direct employment levels during all phases for the Proposed Action and for the Inventory Modules.

Construction

DOE expects the construction phase to last for 5 years. The construction phase for Inventory Module 1 or 2 would require approximately 1,800 workers in the peak year, the same as the Proposed Action (see Table 8-16). The impacts for Module 1 or 2 would therefore be the same as those for the Proposed Action.

Table 8-16. Estimated peak direct employment level impacts from repository phases.[a,b]

Phase	Proposed Action		Inventory Module 1 or 2	
	Higher-temperature	Lower-temperature	Higher-temperature	Lower-temperature
Construction	1,800	1,800	1,800	1,800
Operation and Monitoring				
Development, emplacement	1,700	1,800 - 1,900	1,700	1,700 - 2,600
Monitoring[c]	120	40 - 120	140	130 - 140
Closure	960	960	970	1,100 - 1,200

a. Includes approximately 220 currently employed workers.
b. Numbers rounded to two significant places.
c. Excludes approximately 1,100 workers required for decontamination (monitoring period). Number of required workers is approximately the same for both operating modes for Inventory Module 1 or 2.

Operation and Monitoring

For the Proposed Action, DOE expects the repository development to last for 22 years and emplacement to last for 24 years. With Modules 1 or 2, development would last 36 years and emplacement 38 years. If a design with an aging facility were selected, emplacement activities would last 50 years for the Proposed Action or 51 years for Module 1 or 2. Monitoring activities occur concurrently and then extend beyond the emplacement period for up to 300 years. Employment levels for Module 1 or 2 during this phase could require approximately 700 more workers than the estimated worker requirement for the Proposed Action (see Table 8-16). Although the overall duration of the operation phase, including the development, emplacement, and monitoring activities, varies in length depending on the final scenario of the flexible design, the primary difference between Inventory Module 1 or 2 and the Proposed Action is the increased duration of development and emplacement activities (by 14 years).

The annualized impacts during development and emplacement activities for Inventory Module 1 or 2 would be similar to those for the Proposed Action, but these impacts would continue for an additional 14 years. As with the Proposed Action, direct and indirect increases in regional employment, population, Gross Regional Product, real disposal income, and government expenditures would be small, 3 percent or less of the baselines, for affected counties. No substantial socioeconomic impacts would be likely during the operations phase.

Closure

DOE expects the closure phase to last between 12 and 23 years. Although the required staffing level for Inventory Module 1 or 2 would be slightly greater, but similar in impact, to that of the Proposed Action, Inventory Module 1 or 2 would require more time. Closure would last up to 23 years for Inventory Module 1 or 2. However, as with the Proposed Action, because work force demands would be less than the peak year employment demands during the operations or construction phase, impacts to regional employment, population, Gross Regional Product, real disposal income, and government expenditures would be very small. No substantial impact would likely occur during the closure for Inventory Module 1 or 2.

8.2.6.2 Cumulative Impacts from Inventory Module 1 or 2 and Other Federal, Non-Federal, and Private Actions

Reasonably foreseeable future actions at the Nevada Test Site could affect the socioeconomic region of influence (Nye, Clark, and Lincoln Counties). Sections 8.1.1 and 8.1.2 discuss other activities in the region that could have a socioeconomic impact. However, most of these activities have either already occurred or would occur prior to peak employment associated with the proposed repository. Because of the minimal amount of overlap that would occur in the activities, the affected communities would have more time to assimilate any new residents that might relocate to the region. Thus, no substantial impacts would be likely to occur from these activities.

8.2.7 OCCUPATIONAL AND PUBLIC HEALTH AND SAFETY

This section discusses the short-term health and safety impacts to workers and to members of the public (radiological only) associated with construction, operation and monitoring, and closure activities at the Yucca Mountain site for Inventory Module 1 or 2 (Sections 8.2.7.1 through 8.2.7.3). Section 8.2.7.4 provides a summary of these impacts. Appendix F contains the approach and methods used to estimate the health and safety impacts and additional detailed results for Module 1 or 2 health and safety impacts to workers.

With one exception, no other Federal, non-Federal, or private actions were identified with spatially or temporally coincident short-term impacts in the region of influence that would result in cumulative health and safety impacts with those of the proposed Yucca Mountain Repository. Chapter 3 discusses the potential radiological doses from past weapons testing at the Nevada Test Site. While all of the current population was not present at the time of the testing, residents who were present during the time periods when weapons testing (in particular, atmospheric weapons testing from the 1950s to the early 1960s) occurred could have received as much as 5 rem to the thyroid gland from iodine-131 releases. Using a tissue-weighting factor of 0.03 as specified in International Commission on Radiological Protection Publication 26 (DIRS 101075-ICRP 1977, all), this would equate to an effective dose equivalent of about 150 millirem. Because of the length of time since atmospheric weapons testing ceased, essentially all of this dose has already occurred. This dose would apply only to those residents who lived in the region of influence during the time period of atmospheric weapons testing. DOE has not added this dose to the maximally exposed individual dose, but DOE has included this information so that long-term residents in the region of influence can evaluate their potential for impacts from past nuclear weapons testing. (The dose is included in the risk estimates in Table 8-60 for the summary of public health and safety.)

With the increased number of persons living and working in the region, the number of injuries and fatalities from nonrepository-related activities would increase. However, injury and mortality incidence should remain unchanged or decrease, assuming the continued enforcement of occupational and public health and safety regulations.

Regarding the health and safety impact analysis for Inventory Module 1 or 2, the radiological characteristics of the spent nuclear fuel and high-level radioactive waste would be the same as those for the Proposed Action; there just would be more material to emplace. As described in Appendix A, the radioactive inventory (and radiological properties) of the Greater-Than-Class-C waste and Special-Performance-Assessment-Required waste is much less than that for spent nuclear fuel and high-level radioactive waste. Therefore, the subsurface emplacement of the material in Inventory Module 2 would not greatly increase radiological impacts to workers over those estimated for Module 1. For the surface facility evaluation, the number of workers would be the same for Inventory Module 1 or 2 (DIRS 104508-CRWMS M&O 1999, Section 3.3, third paragraph). Therefore, DOE did not perform separate impact analyses for Modules 1 and 2.

The primary changes in the parameters that would affect the magnitude of the worker health and safety impacts between the Proposed Action and Inventory Module 1 or 2 would be the periods required to perform the work and the numbers of workers for the different phases. Appendix F, Table F-43 p. 2 contains a detailed breakdown of the estimates for the involved and noninvolved workforce for the repository phases for Inventory Module 1 or 2 in terms of full-time equivalent worker-years.

For the public, the principal changes in parameters that would affect the magnitude of the health impact estimates would be the length of the various phases and the rate at which air would be exhausted from the repository. The exhaust rate of the subsurface ventilation system would affect both the radon-222 concentrations to which subsurface workers would be exposed and the quantity of radon-222 released to

the environment. Appendix G, Section G.2.3.1, discusses radon-222 concentrations in the subsurface environment and release rates to the environment from the various project phases.

8.2.7.1 Construction

This section presents estimates of health and safety impacts to repository workers and members of the public for the construction phase. The values are similar to those for the Proposed Action because the length of the construction phase would be the same and activities would be similar.

Industrial Hazards

Table 8-17 lists health and safety hazards to workers common to the workplace. They are based on the health and safety loss statistics listed in Appendix F, Tables F-4 and F-5. For Inventory Module 1 or 2 these impacts would be independent of the operating mode because the number of workers would be the same for both operating modes.

Table 8-17. Summary of industrial hazard health and safety impacts to facility workers during the construction phase.[a]

Worker group	Operating mode	
	Higher-temperature	Lower-temperature
	Proposed Action	
Involved worker		
Total recordable cases of injury and illness	340	340 - 370
Lost workday cases	160	160 - 180
Fatalities	0.16	0.16 - 0.18
Noninvolved worker		
Total recordable cases of injury and illness	55	55 - 61
Lost workday cases	27	27 - 30
Fatalities	0.048	0.048 - 0.054
All workers		
Total recordable cases of injury and illness	400	400 - 430
Lost workday cases	190	190 - 210
Fatalities	0.21	0.21 - 0.23
	Inventory Module 1 or 2	
Involved worker		
Total recordable cases of injury and illness	340	340 - 370
Lost workday cases	160	160 - 180
Fatalities	0.16	0.16 - 0.18
Noninvolved worker		
Total recordable cases of injury and illness	55	55 - 61
Lost workday cases	27	27 - 30
Fatalities	0.048	0.048 - 0.054
All workers		
Total recordable cases of injury and illness	400	400 - 430
Lost workday cases	190	190 - 210
Fatalities	0.21	0.21 - 0.23

a. Source: Appendix F, Table F-12.

Radiological Health Impacts

This analysis presents radiological health impacts in terms of doses and resultant latent cancer fatalities. Estimated doses were converted to estimates of latent cancer fatality using a dose-to-risk conversion factor of 0.0004 and 0.0005 latent cancer fatality per person-rem for workers and the public, respectively (see Appendix F, Section F.1.1.5).

Workers. Spent nuclear fuel and high-level radioactive waste would not be present during the construction phase. Potential radiological impacts to surface workers during this phase would be limited to those from releases of naturally occurring radon-222 and its decay products with the subsurface ventilation exhaust (these impacts are presented in Section 8.2, Table 8-10). Subsurface workers would incur exposure from radiation resulting from radionuclides in the walls of the drifts and from inhalation of radon-222 in the subsurface atmosphere. Surface worker exposure would be very small compared to those for subsurface workers. The radiological doses and health impacts for Inventory Module 1 or 2 are listed in Table 8-18. The Module 1 or 2 impacts would be independent of the operating mode because the subsurface workforce would not change.

Table 8-18. Summary of radiological health impacts to workers from all activities during construction phase.[a]

Worker group	Operating mode	
	Higher-temperature	Lower-temperature
	Proposed Action	
Involved worker		
Dose to maximally exposed worker (millirem)	1,300	1,300
Probability of latent cancer fatality	0.00052	0.00052
Collective dose (person-rem)	680	680
Number of latent cancer fatalities	0.27	0.27
Noninvolved worker		
Dose to maximally exposed worker (millirem)	330	330
Probability of latent cancer fatality	0.00013	0.00013
Collective dose (person-rem)	37	37
Number of latent cancer fatalities	0.015	0.015
All workers		
Collective dose (person-rem)	720	720
Number of latent cancer fatalities	0.29	0.29
	Inventory Module 1 or 2	
Involved worker		
Dose to maximally exposed worker (millirem)	1,300	1,300
Probability of latent cancer fatality	0.00052	0.00052
Collective dose (person-rem)	680	680
Number of latent cancer fatalities	0.27	0.27
Noninvolved worker		
Dose to maximally exposed worker (millirem)	330	330
Probability of latent cancer fatality	0.00013	0.00013
Collective dose (person-rem)	37	37
Number of latent cancer fatalities	0.015	0.015
All workers		
Collective dose (person-rem)	720	720
Number of latent cancer fatalities	0.29	0.29

a. Source: Appendix F, Table F-11.

Public. Potential radiological impacts to the public during the construction phase would be limited to those from the release of naturally occurring radon-222 with the exhaust from subsurface ventilation. Table 8-19 presents radiological health impacts for the public surrounding the proposed repository.

8.2.7.2 Operations

This section presents estimates of health and safety impacts to workers and members of the public during the operations period. The primary differences between Inventory Module 1 or 2 and the Proposed Action would be the longer durations for development and emplacement activities. Under Module 1 or 2,

Table 8-19. Radiological health impacts to the public from the construction phase.[a]

Impact	Operating mode			
	Higher-temperature		Lower-temperature	
	Total	Maximum annual	Total	Annual
	Proposed Action			
Dose to public				
Offsite MEI[b] (millirem)	1.7	0.43	1.7 - 2	0.43 - 0.53
80-kilometer population (person-rem)	33	8.4	33 - 40	8.4 - 10
Offsite MEI probability of latent cancer fatality	8.5×10^{-7}	2.1×10^{-7}	8.5×10^{-7} - 0.000001	2.1×10^{-7} - 2.6×10^{-7}
80-kilometer population number of latent cancer fatalities	0.017	0.0042	0.017 - 0.02	0.0042 - 0.0052
	Inventory Module 1 or 2			
Dose to public				
Offsite MEI (millirem)	1.7	0.43	2	0.52 - 0.53
80-kilometer population (person-rem)	33	8.4	39 - 40	10
Offsite MEI probability of latent cancer fatality	8.5×10^{-7}	2.1×10^{-7}	9.9×10^{-7} - 0.000001	2.6×10^{-7} - 2.6×10^{-7}
80-kilometer population number of latent cancer fatalities	0.017	0.0042	0.019 - 0.02	0.0051 - 0.0052

a. Sources: Chapter 4, Table 4-23; Appendix G, Section G.2.
b. MEI = maximally exposed individual.

it would take DOE 14 more years to complete drift development (36 years total) than for the Proposed Action and 14 more years to complete emplacement (38 years total) than for the Proposed Action.

Industrial Hazards

Table 8-20 lists health and safety impacts to workers from industrial hazards common to the workplace. These impacts would be about 50 to 60 percent greater than those calculated for the Proposed Action.

Radiological Impacts

Workers. Table 8-21 lists radiological doses and health impacts to workers during the operations period for Inventory Module 1 or 2. Appendix F contains additional detail and presents the radiological impacts for surface workers, subsurface workers, and monitoring activities. Radiological impacts to workers for Module 1 or 2 would be about 50 to 60 percent greater than those for the Proposed Action.

Public. Potential radiological impacts to the public from the operations period would result from the release of naturally occurring radon-222 and its decay products with the subsurface exhaust ventilation air and from radioactive gases, principally krypton-85, that could be released from the Waste Handling Building during spent nuclear fuel handling operations.

Table 8-22 lists the total radiological doses and radiological health impacts to the public from releases to the atmosphere of krypton-85 and radon-222 during the operations period. Radon-222 and its decay products would be the dominant dose contributors (greater than 99 percent).

8.2.7.3 Monitoring

This section contains estimates of the health and safety impacts to workers and members of the public for the monitoring period. The length of this period would depend on the operating mode; however, the monitoring phase for Inventory Module 1 or 2 would generally be shorter than the corresponding monitoring phase for the Proposed Action as shown in Table 8-3.

Industrial Hazards

Table 8-23 lists health and safety impacts to workers from hazards common to the workplace. As discussed above, the duration of the monitoring period for the Inventory Modules is shorter than that for the Proposed Action; therefore, the industrial safety impacts would be less for the Inventory Modules than for the Proposed Action.

Table 8-20. Summary of industrial hazard health and safety impacts to facility workers during operations period.

Worker group	Operating mode: Higher-temperature	Operating mode: Lower-temperature
	Proposed Action	
Involved worker		
Total recordable cases of injury and illness	1,200	1,200 - 1,700
Lost workday cases	590	620 - 840
Fatalities	0.9	0.91 - 1.4
Noninvolved worker		
Total recordable cases of injury and illness	300	310 - 470
Lost workday cases	150	150 - 230
Fatalities	0.31	0.31 - 0.45
All workers		
Total recordable cases of injury and illness	1,500	1,500 - 2,200
Lost workday cases	740	770 - 1,100
Fatalities	1.2	1.2 - 1.9
	Inventory Module 1 or 2	
Involved worker		
Total recordable cases of injury and illness	1,900	1,900 - 2,200
Lost workday cases	970	970 - 1,100
Fatalities	1.4	1.4 - 1.7
Noninvolved worker		
Total recordable cases of injury and illness	470	470 - 560
Lost workday cases	230	230 - 270
Fatalities	0.46	0.46 - 0.54
All workers		
Total recordable cases of injury and illness	2,400	2,400 - 2,800
Lost workday cases	1,200	1,200 - 1,400
Fatalities	1.9	1.9 - 2.2

a. Source: Appendix F, Tables F-22 and F-52.

Radiological Impacts

Workers. Table 8-24 lists radiological doses and health impacts from activities during the monitoring period. During this period the primary source of collective dose to the involved subsurface worker population would be the inhalation dose from radon-222 while the primary source of collective dose to the involved surface worker population would be direct exposure to the waste packages.

Public. Table 8-25 lists the radiological doses and health impacts to the public from activities during the monitoring period. The primary source of these impacts is the release of radon-222 via subsurface ventilation flow.

8.2.7.4 Closure

This section contains estimates of health and safety impacts to workers and members of the public for the closure phase.

Industrial Hazards

Table 8-26 lists health and safety impacts to workers from hazards common to the workplace. The impacts for Inventory Module 1 or 2 would be slightly greater than those for the Proposed Action.

Radiological Impacts

Workers. Table 8-27 lists radiological doses and health impacts to workers during the closure phase. Subsurface workers would be exposed to radon-222 from inhalation of air in the drifts, to external

Table 8-21. Summary of radiological health impacts to workers from all activities during operations period.[a]

Worker group	Operating mode: Higher-temperature	Operating mode: Lower-temperature
	Proposed Action	
Involved worker		
Dose to maximally exposed worker (millirem)	15,000	15,000 - 30,000
Probability of latent cancer fatality	0.006	0.006 - 0.012
Collective dose (person-rem)	7,500	7,600 - 12,000
Number of latent cancer fatalities	3.0	3.0 - 4.8
Noninvolved worker		
Dose to maximally exposed worker (millirem)	1,500	1,500 - 1,800
Probability of latent cancer fatality	0.0006	0.0006 - 0.00072
Collective dose (person-rem)	150	160 - 170
Number of latent cancer fatalities	0.06	0.064 - 0.068
All workers		
Collective dose (person-rem)	7,700	7,800 - 12,000
Number of latent cancer fatalities	3.1	3.1 - 4.8
	Inventory Module 1 or 2	
Involved worker		
Dose to maximally exposed worker (millirem)	24,000	24,000 - 33,000
Probability of latent cancer fatality	0.0096	0.0096 - 0.013
Collective dose (person-rem)	12,000	12,000 - 15,000
Number of latent cancer fatalities	4.8	4.8 - 6
Noninvolved worker		
Dose to maximally exposed worker (millirem)	2,400	2,400
Probability of latent cancer fatality	0.00096	0.00096
Collective dose (person-rem)	180	180 - 190
Number of latent cancer fatalities	0.072	0.072 - 0.076
All workers		
Collective dose (person-rem)	12,000	12,000 - 15,000
Number of latent cancer fatalities	4.8	4.8 - 6

a. Source: Appendix F, Tables F-23 and F-53.

Table 8-22. Radiological health impacts to the public from the operations period.

Impact	Operating mode: Higher-temperature: Total	Higher-temperature: Maximum annual	Lower-temperature: Total	Lower-temperature: Annual
	Proposed Action			
Dose to public				
Offsite MEI[a] (millirem)	12	0.73	17 - 43	1 - 1.3
80-kilometer population (person-rem)	230	14	320 - 830	20 - 26
Offsite MEI probability of latent cancer fatality	0.000006	3.7×10^{-7}	8.3×10^{-6} - 0.000022	5.2×10^{-7} - 6.7×10^{-7}
80-kilometer population number of latent cancer fatalities	0.12	0.0071	0.16 - 0.42	0.01 - 0.013
	Inventory Module 1 or 2			
Dose to public				
Offsite MEI (millirem)	22	0.94	31 - 66	1.3 - 2.2
80-kilometer population (person-rem)	430	18	600 - 1,300	26 - 42
Offsite MEI probability of latent cancer fatality	0.000011	4.7×10^{-7}	0.000016 - 0.000033	6.7×10^{-7} - 1.1×10^{-6}
80-kilometer population number of latent cancer fatalities	0.22	0.0091	0.3 - 0.64	0.013 - 0.021

a. MEI = maximally exposed individual.

Table 8-23. Summary of industrial hazard health and safety impacts to facility workers during monitoring period.[a]

Worker group	Operating mode	
	Higher-temperature	Lower-temperature
	Proposed Action	
Involved worker		
Total recordable cases of injury and illness	320	400 - 1,000
Lost workday cases	130	160 - 410
Fatalities	0.31	0.38 - 1
Noninvolved worker		
Total recordable cases of injury and illness	55	65 - 150
Lost workday cases	27	32 - 73
Fatalities	0.049	0.057 - 0.13
All workers		
Total recordable cases of injury and illness	380	470 - 1,200
Lost workday cases	160	190 - 480
Fatalities	0.36	0.44 - 1.1
	Inventory Module 1 or 2	
Involved worker		
Total recordable cases of injury and illness	290	450 - 1,100
Lost workday cases	120	180 - 440
Fatalities	0.28	0.43 - 1.1
Noninvolved worker		
Total recordable cases of injury and illness	51	74 - 160
Lost workday cases	25	36 - 78
Fatalities	0.045	0.065 - 0.14
All workers		
Total recordable cases of injury and illness	340	520 - 1,300
Lost workday cases	150	220 - 520
Fatalities	0.33	0.50 - 1.2

a. Source: Appendix F, Tables F-31 and F-59.

radiation from radionuclides in the rock in the drift walls, and to external radiation emanating from the waste packages.

Public. Potential radiation-related health impacts to the public from closure activities would result from releases of radon-222 in the subsurface ventilation flow. Section 8.2.2.1.2 describes radiation doses to the public for this phase. Table 8-28 lists radiological dose and health impacts for the closure phase. Radiological health impacts to the public for the inventory modules would be greater than those for the Proposed Action largely because of the longer time period for closure activities (see Table 8-3).

8.2.7.5 Summary

This section contains three summary tables:

- A summary of health impacts to workers from industrial hazards common to the workplace for all phases (Table 8-29)
- A summary of radiological doses and health impacts to workers for all phases (Table 8-30)
- A summary of radiological doses and health impacts to the public for all phases (Table 8-31)

Table 8-24. Summary of radiological health impacts to workers from all activities during monitoring period.[a]

Worker group	Operating mode: Higher-temperature	Operating mode: Lower-temperature
	Proposed Action	
Involved workers		
Dose to maximally exposed worker (millirem)	18,000	18,000
Probability of latent cancer fatality	0.0072	0.0072
Collective dose (person-rem)	1,100	1,500 - 4,300
Number of latent cancer fatalities	0.44	0.6 - 1.7
Noninvolved workers		
Dose to maximally exposed worker (millirem)	1,800	1,800
Probability of latent cancer fatality	0.00072	0.00072
Collective dose (person-rem)	36	46 - 140
Number of latent cancer fatalities	0.014	0.018 - 0.056
All workers		
Collective dose (person-rem)	1,100	1,500 - 4,400
Number of latent cancer fatalities	0.44	0.6 - 1.8
	Inventory Module 1 or 2	
Involved workers		
Dose to maximally exposed worker (millirem)	18,000	18,000
Probability of latent cancer fatality	0.0072	0.0072
Collective dose (person-rem)	990	1,700 - 4,500
Number of latent cancer fatalities	0.4	0.68 - 1.8
Noninvolved workers		
Dose to maximally exposed worker (millirem)	1,800	1,800
Probability of latent cancer fatality	0.00072	0.00072
Collective dose (person-rem)	31	56 - 150
Number of latent cancer fatalities	0.012	0.022 - 0.06
All workers		
Collective dose (person-rem)	1,000	1,800 - 4,700
Number of latent cancer fatalities	0.4	0.72 - 1.9

a. Source: Appendix F, Table F-32 and F-60.

Table 8-25. Radiological health impacts to the public from the monitoring period.

Impact	Operating mode: Higher-temperature Total	Higher-temperature Maximum annual	Lower-temperature Total	Lower-temperature Annual
	Proposed Action			
Dose to public				
Offsite MEI[a] (millirem)	29	0.41	30 - 62	0.59 - 0.89
80-kilometer population (person-rem)	600	8	1,500 - 3,500	11 - 17
Offsite MEI probability of latent cancer fatality	0.000015	2.1×10^{-7}	0.000015 - 0.000031	3×10^{-7} - 4.4×10^{-7}
80-kilometer population number of latent cancer fatalities	0.3	0.004	0.75 - 1.7	0.0057 - 0.0085
	Inventory Module 1 or 2			
Dose to public				
Offsite MEI (millirem)	39	0.62	20 - 100	0.29 - 1.4
80-kilometer population (person-rem)	740	12	2,200 - 5,400	5.6 - 28
Offsite MEI probability of latent cancer fatality	0.000019	3.1×10^{-7}	0.00001 - 0.00005	1.5×10^{-7} - 7.2×10^{-7}
80-kilometer population number of latent cancer fatalities	0.37	0.006	1.1 - 2.7	0.0028 - 0.014

a. MEI = maximally exposed individual.

Table 8-26. Summary of industrial hazard health and safety impacts to facility workers during closure phase.[a]

Worker group	Operating mode	
	Higher-temperature	Lower-temperature
	Proposed Action	
Involved worker		
Total recordable cases of injury and illness	320	340 - 420
Lost workday cases	150	160 - 200
Fatalities	0.15	0.16 - 0.2
Noninvolved worker		
Total recordable cases of injury and illness	51	53 - 62
Lost workday cases	25	26 - 30
Fatalities	0.045	0.047 - 0.054
All workers		
Total recordable cases of injury and illness	370	390 - 480
Lost workday cases	180	190 - 230
Fatalities	0.2	0.21 - 0.25
	Inventory Module 1 or 2	
Involved worker		
Total recordable cases of injury and illness	350	400 - 600
Lost workday cases	170	190 - 280
Fatalities	0.17	0.19 - 0.28
Noninvolved worker		
Total recordable cases of injury and illness	54	59 - 82
Lost workday cases	26	29 - 40
Fatalities	0.048	0.052 - 0.072
All workers		
Total recordable cases of injury and illness	400	460 - 680
Lost workday cases	200	220 - 320
Fatalities	0.22	0.24 - 0.35

a. Source: Appendix F, Tables F-38 and F-66.

Industrial Hazards to Workers

Table 8-29 summarizes health and safety impacts to workers from industrial hazards common to the workplace for all phases. The calculated health impacts from industrial hazards common to the workplace would be in the range of 2 to 3 fatalities for Inventory Module 1 or 2. Most of the impacts would come from the operations period. Industrial safety impacts for Module 1 or 2 are about 30 to 40 percent greater than those for the Proposed Action.

Radiological Health

Workers. Table 8-30 summarizes radiological doses and health impacts to workers for the Proposed Action and Inventory Module 1 or 2. It lists these impacts as the likelihood of a latent cancer fatality for the maximally exposed individual worker over a 50-year working career, and as the number of latent cancer fatalities that could occur in the population. The calculated values for latent cancer fatalities for repository workers during the construction, operation and monitoring, and closure phases for Module 1 or 2 are in the range of 6 to 8 fatalities for Module 1 or 2. These are higher than those for the Proposed Action (4 to 7 fatalities) and would be about double those from normal workplace industrial hazards (see Table 8-29).

Most of the total worker radiation dose would be from the receipt and handling of spent nuclear fuel during the operation period. Radiation exposure from inhalation of radon-222 and its decay products by exposure to radiation emanating from the subsurface would also be contributors to the total dose. No other activities in the area were identified that could cause cumulative impacts to repository workers.

Table 8-27. Summary of radiological health impacts to workers from all activities during closure phase.[a]

Worker group	Operating mode: Higher-temperature	Operating mode: Lower-temperature
	Proposed Action	
Involved worker		
Total recordable cases of injury and illness	320	340 - 420
Lost workday cases	150	160 - 200
Fatalities	0.15	0.16 - 0.2
Noninvolved worker		
Total recordable cases of injury and illness	51	53 - 62
Lost workday cases	25	26 - 30
Fatalities	0.045	0.047 - 0.054
All workers		
Total recordable cases of injury and illness	370	390 - 480
Lost workday cases	180	190 - 230
Fatalities	0.2	0.21 - 0.25
	Inventory Module 1 or 2	
Involved worker		
Total recordable cases of injury and illness	350	400 - 600
Lost workday cases	170	190 - 280
Fatalities	0.17	0.19 - 0.28
Noninvolved worker		
Total recordable cases of injury and illness	54	59 - 82
Lost workday cases	26	29 - 40
Fatalities	0.048	0.052 - 0.072
All workers		
Total recordable cases of injury and illness	400	460 - 680
Lost workday cases	200	220 - 320
Fatalities	0.22	0.24 - 0.35

a. Source: Appendix F, Tables F-39 and F-67.

Table 8-28. Radiological health impacts to the public from the closure phase.

Impact	Higher-temperature: Total	Higher-temperature: Maximum annual	Lower-temperature: Total	Lower-temperature: Annual
	Proposed Action			
Dose to public				
Offsite MEI[a] (millirem)	3	0.39	4.3 - 9.4	0.55 - 0.85
80-kilometer population (person-rem)	57	7.4	83 - 180	10 - 16
Offsite MEI probability of latent cancer fatality	1.5×10^{-6}	1.9×10^{-7}	2.2×10^{-6} - 4.7×10^{-6}	2.7×10^{-7} - 4.2×10^{-7}
80-kilometer population number of latent cancer fatalities	0.028	0.0037	0.041 - 0.09	0.0052 - 0.0081
	Inventory Module 1 or 2			
Dose to public				
Offsite MEI (millirem)	4.9	0.57	8.5 - 19	0.83 - 1.4
80-kilometer population (person-rem)	95	11	160 - 360	16 - 26
Offsite MEI probability of latent cancer fatality	2.5×10^{-6}	2.9×10^{-7}	$4.2 \times 10\text{-}6$ - 9.5×10^{-6}	4.2×10^{-7} - 6.9×10^{-7}
80-kilometer population number of latent cancer fatalities	0.047	0.0055	0.081 - 0.18	0.008 - 0.013

a. MEI = maximally exposed individual.

Public. Table 8-31 summarizes radiological doses and health impacts to the public during all phases for the Proposed Action and Inventory Module 1 or 2. The radiological doses and health impacts would result from exposure of the public to naturally occurring radon-222 and decay products released from the subsurface facilities in ventilation exhaust air. The calculated likelihood for Module 1 or 2 that the maximally exposed individual would experience a latent cancer fatality is less than 0.00005. The

Table 8-29. Summary of industrial hazard health and safety impacts to facility workers during all phases.[a]

Worker group	Operating mode	
	Higher-temperature	Lower-temperature[b]
	Proposed Action	
Involved worker		
Total recordable cases of injury and illness	2,200	2,500 - 3,300
Lost workday cases	1,000	1,200 - 1,500
Fatalities	1.5	1.8 - 2.6
Noninvolved worker		
Total recordable cases of injury and illness	470	500 - 720
Lost workday cases	230	250 - 350
Fatalities	0.45	0.48 - 0.68
All workers		
Total recordable cases of injury and illness	2,700	3,000 - 4,000
Lost workday cases	1,200	1,500 - 1,900
Fatalities	2	2.3 - 3.3
	Inventory Module 1 or 2	
Involved worker		
Total recordable cases of injury and illness	2,900	3,400 - 4,000
Lost workday cases	1,400	1,600 - 1,900
Fatalities	2.1	2.4 - 3.1
Noninvolved worker		
Total recordable cases of injury and illness	640	690 - 830
Lost workday cases	310	340 - 410
Fatalities	0.61	0.65 - 0.78
All workers		
Total recordable cases of injury and illness	3,500	4,100 - 4,800
Lost workday cases	1,700	1,900 - 2,300
Fatalities	2.7	3.1 - 3.9

a. Source: Appendix F, Tables F-40 and F-68.
b. These ranges might differ from simple addition of the minimum and maximum values listed for the constituent phases because the values might not correspond between different phases. For example, a scenario that maximizes impacts during construction could result in minimal impacts during operations.

estimated increase in the number of latent cancer fatalities is less than 2 for the exposed population within about 80 kilometers (50 miles) over the period of more than 100 years of repository activities.

For purposes of comparison, the number of latent cancer fatalities calculated from the public for the Yucca Mountain construction, operation and monitoring, and closure phases for Inventory Module 1 or 2 would be less than 0.75. Statistics published by the Centers for Disease Control indicate that during 1998, 24 percent of all deaths in the State of Nevada were attributable to cancer of some type and cause (adapted from DIRS 153066-Murphy 2000, p. 83). Assuming this rate would remain unchanged for the estimated population in 2035 of about 76,000 within 80 kilometers (50 miles) of the Yucca Mountain site, about 18,000 members of this population would be likely to die from cancer-related causes.

As discussed in Section 8.2.2.2.2, the current operations at the Nevada Test Site resulted in a dose to the maximally exposed individual in 1999 of 0.12 millirem. During that same year, the population dose from Nevada Test Site activities was 0.38 person-rem. Conservatively adding the doses from repository activities to Nevada Test Site activities would result in a dose of 2.3 millirem to the maximally exposed individual and 42 person-rem to the population.

As discussed in the introduction to Section 8.2.7, potential radiological doses from past weapons testing at the Nevada Test Site could result in additional impacts to those residents who were present during that

Table 8-30. Summary of radiological health impacts to workers from all activities during all phases.[a]

Worker group	Operating mode: Higher-temperature	Operating mode: Lower-temperature[b]
	Proposed Action	
Involved worker		
Dose to maximally exposed worker (millirem)	18,000	18,000 - 30,000
Probability of latent cancer fatality	0.0072	0.0072 - 0.012
Collective dose (person-rem)	9,800	11,000 - 17,000
Number of latent cancer fatalities	3.9	4.4 - 6.8
Noninvolved worker		
Dose to maximally exposed worker (millirem)	1,800	1,800
Probability of latent cancer fatality	0.00072	0.00072
Collective dose (person-rem)	230	280 - 360
Number of latent cancer fatalities	0.092	0.11 - 0.14
All workers		
Collective dose (person-rem)	10,000	11,000 - 17,000
Number of latent cancer fatalities	4	4.4 - 6.8
	Inventory Module 1 or 2	
Involved worker		
Dose to maximally exposed worker (millirem)	24,000	24,000 - 33,000
Probability of latent cancer fatality	0.0096	0.0096 - 0.013
Collective dose (person-rem)	14,000	16,000 - 20,000
Number of latent cancer fatalities	5.6	6.4 - 8
Noninvolved worker		
Dose to maximally exposed worker (millirem)	2,400	2,400
Probability of latent cancer fatality	0.00096	0.00096
Collective dose (person-rem)	270	330 - 410
Number of latent cancer fatalities	0.11	0.13 - 0.16
All workers		
Collective dose (person-rem)	14,000	16,000 - 20,000
Number of latent cancer fatalities	5.6	6.4 - 8

a. Source: Appendix F, Tables F-41 and F-69.
b. These ranges might differ from simple addition of the minimum and maximum values listed for the constituent phases because the values might not correspond between different phases. For example, a scenario that maximizes impacts during construction could result in minimal impacts during operations.

Table 8-31. Summary of radiological health impacts to the public from all project phases.

Impact	Operating mode: Higher-temperature Total	Higher-temperature Maximum annual	Lower-temperature[a] Total	Lower-temperature[a] Annual
	Proposed Action			
Dose to public				
Offsite MEI[b] (millirem)	31	0.73	44 - 62	1 - 1.3
80-kilometer population (person-rem)	930	14	1,900 - 3,900	20 - 26
Offsite MEI probability of latent cancer fatality	0.000016	3.7×10^{-7}	0.000022 - 0.000031	5.2×10^{-7} - 6.7×10^{-7}
80-kilometer population number of latent cancer fatalities	0.46	0.0071	0.97 - 2	0.010 - 0.013
	Inventory Module 1 or 2			
Dose to public				
Offsite MEI (millirem)	51	0.94	60 - 110	1.3 - 2.2
80-kilometer population (person-rem)	1,300		3,100 - 6,200	5.6 - 42
Offsite MEI probability of latent cancer fatality	0.000026	4.7×10^{-7}	0.00003 - 0.000057	6.7×10^{-7} - 1.1×10^{-6}
80-kilometer population number of latent cancer fatalities	0.65	0.0091	1.5 - 3.1	0.0028 - 0.021

a. These ranges might differ from simple addition of the minimum and maximum values listed for the constituent phases because the values might not correspond between different phases. For example, a scenario that maximizes impacts during construction could result in minimal impacts during operations.
b. MEI = maximally exposed individual.

timeframe. If the maximally exposed individual is assumed to have also been present during the entire time period in which weapons testing occurred, the maximally exposed individual dose listed in Table 8-31 could be increased by as much as 150 millirem. (These doses have been included in Table 8-60.)

8.2.8 ACCIDENTS

Disposal in the proposed repository of the additional spent nuclear fuel and high-level radioactive waste along with the Greater-Than-Class-C waste and Special-Performance-Assessment-Required waste in Inventory Module 1 or 2 would result in a very small increase in the estimated risk from accidents described in Chapter 4, Section 4.1.8, for the Proposed Action. The potential hazards and postulated accident scenarios identified and evaluated in Chapter 4, Section 4.1.8, would be the same as those for Module 1 or 2 because there would be no change to the basic repository design or operation. The time required for receipt, packaging, and emplacement of the additional waste would extend from 24 to 38 years, but the probability of an accident scenario (likelihood per year) would be essentially unaffected. The accident scenario consequences evaluated for the Proposed Action would bound those that could occur for Inventory Module 1 or 2 because the spent nuclear fuel and high-level radioactive waste, except the Greater-Than-Class-C waste and the Special-Performance-Assessment-Required waste, would be the same. DOE has not determined the final disposition method for Greater-Than-Class-C and Special-Performance-Assessment-Required waste but, based on the characteristics and expected packaging of these wastes (type and quantity of radionuclides; see Appendix A), the accident scenario consequences calculated in Chapter 4, Section 4.1.8 for spent nuclear fuel and high-level radioactive waste would be bounding. Therefore, substantial cumulative accident impacts would be unlikely for Inventory Module 1 or 2.

The analysis of potential external events in Appendix H considered the potential effects on the Yucca Mountain Repository if there was a decision in the future to resume nuclear weapons testing or from a possible vehicle launch or recovery accident at the proposed VentureStar®/Kistler project. An earlier environmental assessment (DIRS 100136-DOE 1986, all) states that DOE could temporarily suspend underground repository activities during a nuclear weapons test to ensure worker safety. The Department has not decided that such a suspension of work activities at the repository would be necessary at the present time; however, as it finalized the design of the proposed repository, the Department could find it necessary to enact worker safety requirements at the repository site if there was a resumption of nuclear weapons testing. As discussed in Section 8.1.2.2, the Kistler aerospace activity is currently on hold.

In addition, the analysis identified no other Federal, non-Federal, or private action that could affect either the occurrence probability or consequences of the accident scenarios evaluated for the Proposed Action or Inventory Modules.

8.2.9 NOISE

The emplacement of Inventory Module 1 or 2 would have noise levels associated with the construction and operation of the repository similar to those for the Proposed Action. An increase in potential noise impacts from Module 1 or 2 would result only from the increased number of shipments to the site. The expected rate of receipt would be about the same as that for the Proposed Action; therefore, the impact would be an extended period (approximately 14 years) that shipping would continue beyond the Proposed Action.

DOE does not expect other Federal, non-Federal, or private actions in the region to add measurable noise impacts to those of the Proposed Action or Inventory Module 1 or 2 because the other activities are some distance from the proposed repository, and it is unlikely that overall increased noise would result.

8.2.10 AESTHETICS

There would be no impacts for Inventory Module 1 or 2 beyond those described in Chapter 4, Section 4.1.10, because the profile of the repository facility would not be different as a result of implementation of Modules 1 or 2. One action that could add to cumulative aesthetics impacts of the region would be the construction and operation of a proposed wind farm (DIRS 154545-DOE 2001, all) on the Nevada Test Site. The locations being considered for the proposed wind farm are located within the areas of Pahute Mesa and the Shoshone Mountains. The areas under consideration are higher in elevation than the surrounding environs. With the addition of the wind turbine to maximum heights of approximately 430 feet above-ground surface these wind turbines may be visible from the west (especially from mountain ranges west of the Nevada Test Site).

8.2.11 UTILITIES, ENERGY, MATERIALS, AND SITE SERVICES

This section discusses potential impacts to utilities, energy, materials, and site services from the construction, operation and monitoring, and closure of the repository for Inventory Module 1 or 2. The scope of the analysis includes electricity use, fossil-fuel and oil and lubricant consumption, and consumption of construction materials. Chapter 4, Section 4.1.11, evaluates special services such as emergency medical support, fire protection, and security and law enforcement, which would not change for Inventory Module 1 or 2. The material in this section parallels Section 4.1.11, which addresses impacts from the Proposed Action. DOE has considered the other actions described in Section 8.1 to evaluate the potential for cumulative impacts on utilities, energy, materials, and site services. Most of the actions have limited information on their potential cumulative impacts, or the available information indicates that there could be no cumulative impacts. However, one action that would potentially have a cumulative impact is the Alternative Energy Generation Facility (Wind Farm) on the Nevada Test Site, which would increase electrical generating capacity for the region by approximately 600 megawatts, which represents less than 15 percent of the peak power (4,300 megawatts) distributed by Nevada Power in 2000, as described in Chapter 3, Section 3.1.11.2.

To determine the potential impacts of Inventory Module 1 or 2, DOE evaluated the projected uses of electricity, fuel, oils and lubricants and construction materials for each repository phase and compared them to those for the Proposed Action. The following paragraphs describe these evaluations.

Construction

As in the Proposed Action, the major impact during the construction phase for Inventory Module 1 or 2 would be the estimated demand for electric power. The peak demand for electricity for the Proposed Action would be 25 megawatts during construction (Table 8-32). During the construction required for Module 1 or 2, the peak demand for electricity would be about the same (25 megawatts). The tunnel boring machines would account for more than half of the demand for electricity during the 5-year construction phase, but power would also be required to operate ventilation equipment and to support the construction of surface facilities. As for the Proposed Action, the existing electric transmission and distribution system at the Nevada Test Site could not support this increased demand. DOE is evaluating modifications to the site electrical system, as discussed in Chapter 4, Section 4.1.11.

The use of electricity for the higher-temperature operating mode for Inventory Module 1 or 2 would be about 150,000 megawatt-hours during the construction phase, which is about the same as for the Proposed Action (see Table 8-33). For the lower-temperature operating mode the electricity usage ranges from 190,000 to 210,000 megawatt-hours, which is the same as for the Proposed Action. The similarity in numbers between the Proposed Action and the Inventory Modules is due to the similar length of time for construction activities.

Table 8-32. Peak electric power demand (megawatts).

Phase	Operating mode	
	Higher-temperature	Lower-temperature
Proposed Action		
Construction	25	25
Operation and monitoring		
Operation	47	40 - 54
Monitoring	8	7.8 - 15
Closure	10	10 - 18
Maximum	47	40 - 54
Inventory Module 1 or 2		
Construction	25	25
Operation and monitoring		
Operation	53	44 - 54
Monitoring	11	11 - 15
Closure	14	10 - 18
Maximum	53	44 - 54

Table 8-33. Electricity use (1,000 megawatt-hours).

Phase	Operating mode	
	Higher-temperature	Lower-temperature
Proposed Action		
Construction	150	190 - 210
Operation and monitoring		
Operation	5,200	5,300 - 9,200
Monitoring	4,800	9,700 - 29,000
Closure	720	790 - 1,300
Totals	***11,000***	***16,000 - 36,000***
Inventory Module 1 or 2		
Construction	150	190 - 200
Operation and monitoring		
Operation	8,200	7,700 - 9,700
Monitoring	6,000	11,000 - 39,000
Closure	1,100	1,300 - 1,600
Totals	***15,000***	***21,000 - 50,000***

The use of liquid fossil fuel during the construction phase would include diesel fuel and fuel oil. The estimated liquid fuel use would be 5.5 to 6 million liters (1.5 to 1.6 million gallons) which would be about the same as for the Proposed Action (see Table 8-34). About 2.6 to 3.5 million liters of oils (primarily hydraulic oil) and lubricants would also be used to support construction as shown in Table 8-35. The usage rate should be well within the regional supply capacity and, therefore, would not result in substantial impacts.

The primary materials needed to support construction would be concrete, steel, and copper. Concrete would be used for liners in the main drifts and ventilation shafts. Concrete also would be used in the construction of the surface facilities. The quantity of concrete required for the surface facilities and initial emplacement drift construction would be about 420,000 to 500,000 cubic meters (550,000 to 650,000 cubic yards). Cement (see Table 8-36) would come from regional suppliers. Sand and gravel needs would be met from materials excavated from the repository or hauled to the repository by local/ regional suppliers. As much as 120,000 metric tons (132,000 tons) of steel for a variety of uses including rebar, piping, vent ducts, and track, and 230 metric tons (250 tons) of copper for electrical cable also would be required. These quantities would not be likely to affect the regional supply capacity.

Table 8-34. Fossil-fuel use (million liters).

Phase	Operating mode	
	Higher-temperature	Lower-temperature
Proposed Action		
Construction	5.5	5.5 - 6.0
Operation and monitoring		
Operation	360	360 - 500
Monitoring	2.3	2.6 - 13
Closure	5.2	5.1 - 6.6
Totals	***370***	***380 - 510***
Inventory Module 1 or 2		
Construction	5.4	5.5 - 6.1
Operation and monitoring		
Operation	550	550 - 600
Monitoring	2.1	7 - 22
Closure	7.4	6.1 - 6.9
Totals	***560***	***570 - 620***

Table 8-35. Oils and lubricants (million liters).

Phase	Operating mode	
	Higher-temperature	Lower-temperature
Proposed Action		
Construction	2.6	3.1 - 3.5
Operation and monitoring		
Operation	8.5	9.8 - 18
Monitoring	9	13 - 53
Closure	1.7	1.8 - 3
Totals	***22***	***33 - 71***
Inventory Module 1 or 2		
Construction	2.6	3.1 - 3.5
Operation and monitoring		
Operation	13	16 - 27
Monitoring	9.9	23 - 110
Closure	3.8	2.9 - 3.2
Totals	***30***	***56 - 140***

Table 8-36. Cement use (1,000 metric tons).

Phase	Operating mode	
	Higher-temperature	Lower-temperature
Proposed Action		
Construction	160	190
Operation and monitoring		
Operation	100	150 - 340
Monitoring	0	0
Closure	1.2	1.2 - 1.9
Totals	***250***	***310 - 530***
Inventory Module 1 or 2		
Construction	160	160 - 190
Operation and monitoring		
Operation	260	290 - 890
Monitoring	0	0
Closure	1.9	1.9 - 2.0
Totals	***420***	***480 - 1,100***

Operation and Monitoring

The event that would indicate the start of the operation and monitoring phase would be the beginning of emplacement of spent nuclear fuel and high-level radioactive waste. During this phase the construction of emplacement drifts would continue in parallel with emplacement activities at about the same rate as during the construction phase. As a result, the peak electric power demand would increase to between about 44 and 54 megawatts. The maximum value of 54 megawatts would be about the same as that for the Proposed Action. As was the case for the Proposed Action, DOE would have to upgrade or revise the transmission and distribution system on the Nevada Test Site to meet this demand. However, the upgrade or revision for the Proposed Action would accommodate the similar increase for Inventory Module 1 or 2.

The demand for electricity for Inventory Module 1 or 2 would be well within the regional capacity for power generation. Nevada Power Company, for example, plans to maintain a reserve capacity of about 12 percent. For the beginning of the operation and monitoring phase in 2010, Nevada Power projects a net peak load of about 6,000 megawatts and plans a reserve of about 710 megawatts (DIRS 103413-NPC 1997, Figure 4, p. 9). The repository peak demand of 54 megawatts would be less than 1 percent of the Nevada Power Company planned capacity and about 8 percent of planned reserves. The repository would not affect the regional availability of electric power to any extent.

Fossil-fuel use during the operation and monitoring phase would be for onsite vehicles and for heating. It should range between 360 and 500 million liters (100 and 130 million gallons) during repository operations. The corresponding use of oils and lubricants would be between 23 and 130 million liters (6 and 34 million gallons). The annual usage rates for fuels would be highest during the first half of the operation and monitoring phase (emplacement and continued construction of drifts) and would decrease substantially during the monitoring period (see Table 8-34). The projected annual usage rates of liquid petroleum products would be higher than those for the Proposed Action but would still be within the regional supply capacity.

Additional construction materials would be required to support the continued construction of subsurface facilities for Inventory Module 1 or 2. About 660,000 cubic meters (860,000 cubic yards) of concrete would be required for the flexible design, higher-temperature repository operating mode, and 730,000 to 2,300,000 cubic meters (950,000 to 3,000,000 cubic yards) would be required for the lower-temperature repository operating mode (see Table 8-37). Corresponding amounts of cement that would be obtained regionally are shown in Table 8-36.

Table 8-37. Concrete use (1,000 cubic meters).

Phase	Operating mode	
	Higher-temperature	Lower-temperature
Proposed Action		
Construction	420	490 - 500
Operation and monitoring		
Operation	240	350 - 880
Monitoring	0	0
Closure	3	3 - 5
Totals	***670***	***850 - 1,400***
Inventory Module 1 or 2		
Construction	420	430 - 490
Operation and monitoring		
Operation	660	730 - 2,300
Monitoring	0	0
Closure	5	4 - 5
Totals	***1,100***	***1,200 - 2,800***

The requirement for steel would be between 120,000 and 360,000 metric tons (130,000 and 390,000 tons), and for copper it would be about 200 and 1,100 metric tons (220 and 1,200 tons) (see Tables 8-38 and 8-39). These quantities, while above the Proposed Action, would be unlikely to affect the regional supply capacity because the annual usage rate would be only slightly higher than that for the Proposed Action.

Table 8-38. Steel use (1,000 metric tons).

Phase	Operating mode	
	Higher-temperature	Lower-temperature
Proposed Action		
Construction	100	120
Operation and monitoring		
Operation	62	150 - 180
Monitoring	0	0
Closure	0.03	0.04
Totals	***160***	***270 - 300***
Inventory Module 1 or 2		
Construction	100	100 - 120
Operation and monitoring		
Operation	120	190 - 360
Monitoring	0	0
Closure	0.04	0.04 - 0.07
Totals	***230***	***290 - 480***

Table 8-39. Copper use (1,000 metric tons).

Phase	Operating mode	
	Higher-temperature	Lower-temperature
Proposed Action		
Construction	0.20	0.23
Operation and monitoring		
Operation	0.08	0.24 - 0.6
Monitoring	0	0
Closure	0	0
Totals	***0.30***	***0.50 - 0.86***
Inventory Module 1 or 2		
Construction	0.20	0.16 - 0.23
Operation and monitoring		
Operation	0.20	0.3 - 1.1
Monitoring	0	0
Closure	0	0
Totals	***0.4***	***0.46 - 1.3***

Closure

The peak electric power required during the closure phase for Inventory Module 1 or 2 would be only slightly higher than that for the Proposed Action and would be less than 20 megawatts for all operating modes. This would be much less than the peak levels predicted for the earlier phases, so impacts would be small.

Fossil-fuel use would be between 6.1 million and 7.4 million liters (1.6 million and 2.0 million gallons). A small amount of concrete and steel would be used for closure. An estimated maximum of 5,000 cubic meters (6,500 cubic yards) of concrete would be required for any operating mode. Similarly, an estimated maximum 70 metric tons (77 tons) of steel would be required for closure. The fossil-fuel and material quantities required for closure would not be large and would not result in substantial impacts.

8.2.12 MANAGEMENT OF REPOSITORY-GENERATED WASTE AND HAZARDOUS MATERIALS

8.2.12.1 Inventory Module 1 or 2 Impacts

Activities for the emplacement of Inventory Module 1 or 2 would generate waste totals beyond the quantities estimated for the Proposed Action (see Chapter 4, Section 4.1.12). The generated waste types and the treatment and disposal of each waste type would be the same as those described for the Proposed Action. The quantities of generated waste are primarily affected by the increase in the amount of spent nuclear fuel and waste emplaced and the subsequent longer operations and monitoring and closure phases. (Table 8-3 lists the difference in time sequences.) Table 4-40 presents the waste types and quantities generated from activities during the construction phase. This table applies to both the Proposed Action and the Inventory Modules because the timeframe and actions are the same during this phase. Table 8-40 lists the waste quantities generated for Inventory Modules 1 and 2 for the operation and monitoring phase. Table 8-41 lists the waste quantities generated for Inventory Modules 1 and 2 for the closure phase.

Table 8-40. Estimated operation and monitoring phase waste quantities.[a]

Waste type	Operating mode	
	Higher-temperature	Lower-temperature
	Inventory Module 1	
Low-level radioactive (cubic meters)a	110,000	110,000 - 230,000
Hazardous (cubic meters)	10,000	9,200 - 16,000
	Inventory Module 2	
Low-level radioactive (cubic meters)	130,000	130,000 - 270,000
Hazardous (cubic meters)	12,000	11,000 - 20,000
	Inventory Module 1 or 2	
Sanitary and industrial solid (cubic meters)	110,000	120,000 - 170,000
Sanitary sewage[b] (million liters)	2,500	3,000 - 3,900
Industrial wastewater (million liters)	1,400	1,400 - 2,200

a. To convert cubic meters to cubic feet, multiply by 35.314.
b. To convert liters to gallons, multiply by 0.26418.

Table 8-41. Estimated closure phase waste quantities.[a]

Waste type	Inventory Module 1 or 2	
	Higher-temperature	Lower-temperature
Low-level radioactive (cubic meters)[b]	3,500	3,200 - 7,100
Hazardous (cubic meters)	1,200	1,100 - 1,800
Sanitary and industrial solid (cubic meters)	10,000	14,000 - 18,000
Sanitary sewage (million liters)[c]	180	240 - 410
Industrial wastewater (million liters)	84	110 - 160
Demolition debris (cubic meters)	220,000	220,000 - 440,000

a. To convert cubic meters to cubic feet, multiply by 35.314.
b. Module 1 is 7,000 cubic meters.
c. To convert liters to gallons, multiply by 0.26418.

Sanitary and industrial solid waste, sanitary sewage, and industrial wastewater would be disposed of in facilities at the repository site. These facilities would be designed to accommodate the additional waste from Inventory Module 1 or 2. However, DOE could use existing Nevada Test Site landfills to dispose of nonrecyclable construction and demolition debris and sanitary and industrial solid waste. If Nevada Test Site landfills were used, about 360,000 cubic meters (13 million cubic feet) for the higher-temperature operating mode and 640,000 cubic meters (23 million cubic feet) under the lower-temperature operating mode would be disposed of from construction through closure. Disposal of the Proposed Action waste

quantities would require the Nevada Test Site landfills to operate past their projected operating lives and to expand as needed (Chapter 4, Section 4.1.12.2). Disposal of the larger waste quantities under Inventory Module 1 or 2 would require the availability of additional disposal capacity in future landfill expansions.

Impacts from the treatment and disposal of hazardous waste off the site would be the same for the Proposed Action and Inventory Module 1 or 2. At present, commercial facilities are available for hazardous waste treatment and disposal, and DOE expects similar facilities to be available until the closure of the repository. The National Capacity Assessment Report (DIRS 103245-EPA 1996, pp. 32, 33, 36, 46, 47, and 50) indicates that the estimated 20-year (1993 to 2013) available capacity for incineration of solids and liquids at permitted treatment facilities in the western states is about 7 times more than the demand for these services. Moreover, the report indicates that the estimated landfill capacity for hazardous waste disposal is about 50 times the demand. Given the current outlook for the capacity versus demand for hazardous waste treatment and disposal, the treatment and disposal of repository-generated hazardous waste would not present a large cumulative impact.

The Nevada Test Site has an estimated total disposal capacity of 3.7 million cubic meters (130 million cubic feet). The DOE analysis of demand for low-level radioactive waste disposal at the Nevada Test Site through 2070 projects a need for about 1.1 million cubic meters (39 million cubic feet or 30 percent) of the total disposal capacity (DIRS 155856-DOE 2000, Table 4-1). The reserve capacity at the Nevada Test Site is about 2.6 million cubic meters (92 million cubic feet). The disposal of repository-generated waste would require about 5 percent of the reserve capacity for the higher-temperature operating mode and about 5 percent to 9 percent for the lower-temperature operating mode.

Even under the Final Waste Management Programmatic Environmental Impact Statement's (DIRS 101816-DOE 1997, pp. 7-23 and I-39) regional disposal concept, the disposal of repository-generated low-level radioactive waste under the Proposed Action and Inventory Module 1 or 2, cumulatively with other DOE waste generators, would use less than 20 percent of the Nevada Test Site's reserve disposal capacity.

The emplacement of Inventory Module 1 or 2 would require the same types and annual quantities of hazardous materials as the Proposed Action, as described in Chapter 4, Section 4.1.12.3. These materials would be used for the additional years associated with the emplacement of the module inventory. As with the Proposed Action, no cumulative impact would be likely from the procurement and use of hazardous materials at the repository.

8.2.12.2 Cumulative Impacts from Inventory Module 1 or 2 and Other Federal, Non-Federal, and Private Actions

Waste operations at the Nevada Test Site (disposing of Nevada Test Site-generated waste and accepting waste from other sites in accordance with decisions from the Waste Management Programmatic EIS) could present a cumulative impact. Section 8.2.12.1 discusses the impact on Test Site facilities from disposal of repository waste and waste that is already projected to be disposed of at the Test Site.

If Nevada Test Site landfills are used to dispose of nonrecyclable construction and demolition debris and sanitary and industrial waste, the landfills would be required to operate past their projected operating lives and to expand as needed (the degree of expansion would depend on how much waste was disposed of at the repository facilities).

Low-level waste capacity at the Nevada Test Site is sufficient to accommodate the repository-generated waste and the projected volume of 1.1 million cubic meters of waste from the Test Site, although the facility might have to use some of its reserve capacity to meet the combined need.

8.2.13 ENVIRONMENTAL JUSTICE

As discussed in Chapter 4, Section 4.1.13, the environmental justice analysis brings together the results of all resource and feature analyses to determine (1) if an activity would have substantial environmental impacts and (2) if those substantial impacts would have disproportionately high and adverse human health or environmental effects on minority or low-income populations. DOE determined that cumulative impacts from Inventory Module 1 or 2 along with those expected from other Federal, non-Federal, and private actions would not produce cumulative adverse impacts to any surrounding populations, which would include minority and low-income populations. Evaluation of subsistence lifestyles and cultural values has confirmed that these factors would not change the conclusion that the absence of high and adverse impacts for the general population means there would be no disproportionately high and adverse impacts on minority or low-income communities. No substantial impacts were identified; therefore, cumulative impacts from Inventory Module 1 or 2 and other Federal, non-Federal, and private actions would not cause environmental justice concerns.

DOE recognizes that Native American people living in areas near Yucca Mountain have concerns about the protection of traditions and the spiritual integrity of the land that extend to the propriety of the Proposed Action, and that the implementation of the Proposed Action would continue restrictions on access to the site. Chapter 4, Section 4.1.3.4, discusses these views and beliefs.

8.3 Cumulative Long-Term Impacts in the Proposed Yucca Mountain Repository Vicinity

This section describes results from the long-term cumulative impact analysis that DOE conducted for Inventory Modules 1 and 2 (Section 8.3.1) and for past, present, and reasonably foreseeable future actions at the Nevada Test Site, and past actions at the Beatty low-level radioactive waste site (Section 8.3.2).

8.3.1 INVENTORY MODULE 1 OR 2 IMPACTS

The analysis of long-term performance for Inventory Modules 1 and 2 used the same methodology described in Chapter 5 and Appendix I for the Proposed Action to estimate potential human health impacts from radioactive and chemically toxic material releases through waterborne and airborne pathways. Section 8.3.1.1 presents the radioactive and chemically toxic material source terms for Inventory Modules 1 and 2, and Sections 8.3.1.2 and 8.3.1.3 present the results of the analysis for Inventory Modules 1 and 2, respectively.

In addition to long-term human health impacts from radioactive and chemically toxic material releases, the other potential long-term impact identified following repository closure involve biological resources. Though the surface area affected by heat rise would be larger for Inventory Module 1 or 2, the amount of heat per unit area would be constant for a given repository operating mode (lower- or higher-temperature), and, therefore, the small ground surface temperature increase would be the same. Thus, long-term biological effects of Module 1 or 2 from heat generated by waste packages that would potentially raise ground surface temperatures would be the same as those described in Chapter 5, Section 5.9 for the Proposed Action.

8.3.1.1 Radioactive and Chemically Toxic Material Source Terms for Inventory Modules 1 and 2

For calculations of long-term performance impacts, the radioactive material inventory of individual waste packages for commercial spent nuclear fuel, high-level radioactive waste, and DOE spent nuclear fuel under Inventory Modules 1 and 2 would be identical to the radioactive material inventory under the

Proposed Action for the same waste categories. Inventory Module 2 includes an additional waste category for Greater-Than-Class-C and Special-Performance-Assessment-Required wastes. This category includes a different category of waste package with its own radioactive material inventory. This waste was simulated with 601 idealized waste packages. The inventory used for each modeled waste package is an averaged radioactive material inventory of each waste category (commercial spent nuclear fuel, DOE spent nuclear fuel, high-level radioactive waste, and Greater-Than-Class-C and Special-Performance-Assessment-Required wastes). More waste packages would be used for Inventory Modules 1 and 2 than for the Proposed Action to accommodate the expanded inventories. Table 8-42 lists the number of waste packages used in the analysis of long-term performance calculations for the Proposed Action and Modules 1 and 2.

Table 8-42. Number of idealized waste packages used in analysis of long-term performance calculations.[a]

Modeled inventory	Commercial SNF[b]	Codisposal (DOE SNF and HLW[c])	GTCC and SPAR[d]	Total
Proposed Action	7,860	3,910	0	11,770
Inventory Module 1	11,754	4,877	0	16,631
Inventory Module 2	11,754	4,877	601	17,232

a. The idealized waste packages in the simulation (model) are based on the inventory abstraction in Appendix I, Section I.3. While the total inventory is represented by the material in the idealized waste packages, the actual number of waste packages emplaced in the proposed repository would be different.
b. SNF = spent nuclear fuel.
c. HLW = high-level radioactive waste.
d. GTCC = Greater-Than-Class-C; SPAR = Special-Performance-Assessment-Required.

IDEALIZED WASTE PACKAGES

The number of waste packages used in the performance assessment simulations do not exactly match the number of actual waste packages specified in DIRS 150558-CRWMS M&O (2000, Section 6.2).

The TSPA model uses two types of *idealized waste packages* (commercial spent nuclear fuel package and codisposal package), representing the averaged inventory of all the actual waste packages used for a particular waste category.

While the number of idealized waste packages varies from the number of actual waste packages in DIRS 150558-CRWMS M&O (2000, Section 6.2), the total radionuclide inventory represented by all of the idealized waste packages collectively is representative of the total inventory, for the radionuclides analyzed, given in Appendix A of this EIS for the purposes of analysis and long-term performance. *The abstracted inventory is designed to be representative for purposes of analysis of long-term performance and cannot necessarily be used for any other analysis, nor can it be directly compared to any other abstracted inventory used for other analyses in this EIS.*

As listed in Table 8-42, Inventory Module 2 differs from Inventory Module 1 only by the addition of 601 Greater-than-Class-C and Special-Performance-Assessment-Required idealized waste packages. Table 8-43 lists the inventory of the Greater-than-Class-C and Special-Performance-Assessment-Required waste packages under Inventory Module 2.

A screening analysis documented in Appendix I, Section I.6.1, showed that the only chemical materials of concern for the 10,000-year analysis period were those that would be released as the external waste package Alloy-22 layer and the waste package support pallet materials corroded. This is because most waste packages would be intact for more than 10,000 years after closure (the results of the analysis of

Table 8-43. Abstracted inventory (grams) of radionuclides passing the screening analysis in each idealized waste package for Greater-Than-Class-C and Special-Performance-Assessment-Required wastes under Inventory Module 2.[a]

Isotope	Inventory
Actinium-227	0
Americium-241	40
Americium-243	0.00151
Carbon-14	28.9
Cesium-137	771
Iodine-129	0.000705
Nickel-63	0
Neptunium-237	0
Protactinium-231	0
Lead-210	0
Plutnium-238	1.56
Plutonium-239	2,860
Plutonium-240	0.0123
Plutonium-241	0.0207
Plutonium-242	0.00614
Radium-226	0.0504
Radium-228	0
Strontium-90	0.82
Technetium-99	568
Thorium-229	0
Thorium-230	0
Thorium-231	0
Uranium-232	0.00000287
Uranium-233	0.00419
Uranium-234	0
Uranium-235	0
Uranium-236	0

a. The idealized waste packages in the simulation (model) are based on the inventory abstraction in Appendix I, Section I.3. While the total inventory is represented by the material in idealized waste packages, the actual number of waste packages emplaced in the proposed repository would be different.

long-term performance for radionuclides described in Appendix I, Section I.5, show that, at most, only three waste packages would be breached before 10,000 years, due to improper heat treatment, under the Proposed Action). Therefore, accounting for the quantities of materials in the engineered barrier system, but not in the waste packages, and accounting for toxicity to humans, the only chemical materials of concern would be chromium, nickel, molybdenum, and vanadium. The inventories of these chemical materials in the engineered barrier system for the Proposed Action and Inventory Modules 1 and 2 are listed in Table 8-44. These are essentially the only inventories available for mobilization and transport within 10,000 years after closure; the inventories of chemical materials in the waste packages would not begin to degrade until waste package failure. Further information on the inventory of chemical materials of concern is provided in Appendix I, Section I.3.

The only radionuclide that would have a relatively large inventory and a potential for gas transport is carbon-14. Iodine-129 can exist in a gas phase, but it is highly soluble and, therefore, would be likely to dissolve in groundwater rather than migrate as a gas. Radon-222 is a gas, but would decay to a solid isotope before escaping from the repository region (see Appendix I, Section I.7.3). After the carbon-14 escaped from the waste package, it could flow through the fractured and porous rock in the form of carbon dioxide. About 2 percent of the carbon-14 in commercial spent nuclear fuel is in gas in the space (or gap) between the fuel and the cladding around the fuel (DIRS 103446-Oversby 1987, p. 92). There are 1.37 grams of carbon-14 in an abstracted commercial spent nuclear fuel waste package (see Appendix I, Table I-5). This represents 6.11 curies per waste package. Since 2 percent of the total is gaseous, the gaseous inventory consists of 0.122 curie of carbon-14 per commercial spent nuclear fuel waste package. There would be additional carbon-14 activity associated with Inventory Module 2, in relation to Module 1, resulting from neutron irradiation of the core shroud metal. The carbon-14 would be unlikely to be present as gaseous carbon dioxide that could be released to the environment and is therefore not included in Table 8-45.

Table 8-44. Total quantities of waterborne chemicals of concern in the engineered barrier system under the Proposed Action and Inventory Modules 1 and 2 (kilograms).[a,b]

Modeled inventory	Chromium	Molybdenum	Nickel	Vanadium
Proposed Action	23,735,000	17,307,000	60,797,000	377,600
Inventory Module 1	34,695,000	25,301,000	88,879,000	552,000
Inventory Module 2	34,951,000	25,490,000	89,545,000	556,000

a. To convert kilograms to pounds, multiply by 2.2046.
b. See screening analysis in Appendix I, Section I.3.2.

Table 8-45. Total **gaseous** carbon-14 in the repository from commercial spent nuclear fuel for the Proposed Action and Inventory Modules 1 and 2 (curies).

Modeled inventory	Quantity[a]
Proposed Action	959
Inventory Module 1	1,430
Inventory Module 2	1,430

a. Based on 0.122 curies of carbon-14 per commercial spent nuclear fuel waste package.

8.3.1.2 Impacts for Inventory Module 1

The human-health impacts from Inventory Module 1 for radioactive materials and chemically toxic materials are discussed in this section.

8.3.1.2.1 *Waterborne Radioactive Material Impacts*

The DOE used the modeling methods described for the Proposed Action in Chapter 5 (and in greater detail in Appendix I) to calculate the impacts both for an individual and the local population resulting from groundwater releases of radioactive material for 10,000 years and 1 million years following repository closure for Inventory Module 1.

8.3.1.2.1.1 Higher-Temperature Operating Mode. Table 8-46 lists the estimated impacts for an individual for the higher-temperature operating mode under the Proposed Action and Inventory Module 1. The peak annual individual dose for the first 10,000 years shows slightly higher values for the mean and 95th percentile of the Proposed Action than for Module 1. Because Module 1 has a higher inventory, this would seem like an incorrect trend. However, note that in the first 10,000 years releases are dominated by at most about 3 waste package failures due to a manufacturing defect (improper heat treatment). Thus, the release is essentially insensitive to inventory and the differences in Table 8-46 between the Proposed Action and Module 1 are merely the result of slightly different statistical outcomes in the 300 simulations.

Table 8-46. Impacts for an individual from groundwater releases of radionuclides during 10,000 years after repository closure for the higher-temperature repository operating mode under the Proposed Action and Inventory Module 1.

		Mean			95th-percentile		
Modeled inventory	Individual	Peak annual individual dose (millirem)	Time of peak (years)	Probability of a LCF[a]	Peak annual individual dose (millirem)	Time of peak (years)	Probability of a LCF[a]
Proposed Action	At RMEI location[b]	0.00002[c]	4,900	6×10^{-10}	0.0001[d]	4,900	4×10^{-9}
	At 30 kilometers[e]	~0[f]	NC[g]	~0	~0[f]	NC[g]	~0
	At discharge location[h]	~0[f]	NC[g]	~0	~0[f]	NC[g]	~0
Inventory Module 1	At RMEI location[b]	0.00003[c]	4,900	1×10^{-9}	0.002[d]	4,100	6×10^{-9}
	At 30 kilometers[d]	~0[f]	NC[g]	~0	~0[f]	NC[g]	~0
	At discharge location[h]	~0[f]	NC[g]	~0	~0[f]	NC[g]	~0

a. LCF = latent cancer fatality; incremental lifetime (70 years) risk of contracting a fatal cancer, assuming a risk of 0.0005 latent cancer fatality per rem for members of the public (DIRS 101856-NCRP 1993, p. 31).
b. The RMEI location, defined in 40 CFR Part 197, is where the predominant groundwater flow path crosses the boundary of the controlled area and is approximately 18 kilometers (11 miles) downgradient from the repository. The maximum allowable peak of the mean annual individual dose for 10,000 years at this distance is 15 millirem.
c. Based on 300 simulations of total system performance, using random samples of uncertain parameters.
d. Represents a value for which 285 out of the 300 simulations yielded a smaller value.
e. To convert kilometers to miles, multiply by 0.62137.
f. Values would be lower than the small values computed for the RMEI location.
g. NC = not calculated (peak time would be greater than time given for the RMEI location).
h. 60 kilometers (37 miles) at Franklin Lake Playa.

Table 8-47 lists the impacts to the population during the first 10,000 years after repository closure for both the Proposed Action and Inventory Module 1 for the higher-temperature operating mode. These impacts were calculated on the same population basis used for the Proposed Action calculations presented in Chapter 5, that is a population size was based on the projected population numbers for 2035 in Figure 3-25 in Chapter 3. For these calculations, the analysis assumed that no contaminated groundwater

Table 8-47. Population impacts from groundwater releases of radionuclides during 10,000 years after repository closure for the higher-temperature repository operating mode under the Proposed Action and Inventory Module 1.[a]

Modeled inventory	Case	Mean		95th-percentile	
		Population dose (person-rem)	Population LCFs[b]	Population dose (person-rem)	Population LCFs[b]
Proposed Action	Peak 70-year lifetime	0.006	0.000003	0.04	0.00002
	Integrated over 10,000 years	0.5	0.0002	0.6	0.0003
Inventory Module 1	Peak 70-year lifetime	0.01	0.000005	0.06	0.00003
	Integrated over 10,000 years	0.7	0.0003	0.8	0.0004

a. Based on 300 simulations of total system performance for each location, using random samples of uncertain parameters.
b. LCF = latent cancer fatality; expected number of cancer fatalities for populations, assuming a risk of 0.0005 latent cancer fatality per rem for members of the public (DIRS 101856-NCRP 1993, p. 31).

would reach populations in any regions to the north of Yucca Mountain. Therefore, populations in the sectors north of the due east and due west sectors were not considered to be exposed.

- 47 people would be exposed at the Reasonably Maximally Exposed Individual (RMEI) location [approximately 18 kilometers (11 miles)] downgradient from the repository [includes sectors from 12 to 28 kilometers (7 to 27 miles)].

- 4,200 people would be exposed at about 30 kilometers (19 miles) downgradient from the potential repository [includes sectors from 28 to 44 kilometers (17 to 27 miles)].

- 69,500 people would be exposed at the discharge location, about 60 kilometers (37 miles) downgradient of the potential repository [includes sectors from 44 to 80 kilometers (27 to 50 miles)].

Thus, approximately 74,000 people would be exposed to contaminated groundwater. This stylized population dose analysis assumed that people would continue to live in the locations being used at present. This assumption is consistent with the recommendation made by the National Academy of Sciences (DIRS 100018-National Research Council 1995, all) because it is impossible to make accurate predictions of future lifestyles and residence locations far into the future.

The population impacts would be greater than the impacts for the Proposed Action under the higher-temperature operating mode. For example, the population dose in the 70-year period of maximum impacts would be about 25 percent greater for Module 1 than for the Proposed Action at the mean level and the same 70-year period.

The values in Table 8-47 include a scaling factor for water use. The performance assessment transport model calculated the annual individual dose assuming the radionuclides dissolved in water that flowed through the unsaturated zone of Yucca Mountain would mix in an average of 2.4 million cubic meters (1,940 acre-feet) (DIRS 155950-BSC 2001, p. 13-42) per year in the saturated zone aquifer. This compares to an annual water use in the Amargosa Valley of about 17.1 million cubic meters (13,900 acre-feet) (DIRS 155950-BSC 2001, p. 13-42). The analysis diluted the concentration of the nuclides in the 2.4 million cubic meters of water throughout the 17.1 million cubic meters of water prior to calculating the population dose.

Table 8-48 lists the peak annual individual dose and time of peak for 1 million years after repository closure for both Inventory Module 1 and the Proposed Action for the higher-temperature operating mode. The impacts would follow the same pattern as those for the first 10,000 years after repository closure listed in Table 8-47, with the impacts for Module 1 about 60 percent greater than those for the Proposed Action.

Table 8-48. Impacts to an individual from groundwater releases of radionuclides for 1 million years after repository closure for the higher-temperature repository operating mode under the Proposed Action and Inventory Module 1.

		Mean		95th-Percentile	
Modeled inventory	Individual	Peak annual individual dose (millirem)	Time of peak (years)	Peak annual individual dose (millirem)	Time of peak (years)
Proposed Action	At RMEI location[a]	150[b]	480,000	620[c]	410,000
	At 30 kilometers[d]	100[e]	NC[f]	420[e]	NC[f]
	At discharge location[g]	59[e]	NC[f]	240[e]	NC[f]
Inventory Module 1	At RMEI location[a]	240[b]	480,000	980[c]	480,000
	At 30 kilometers[d]	160[e]	NC[f]	660[e]	NC[f]
	At discharge location[g]	90[e]	NC[f]	450[e]	NC[f]

a. The RMEI location, defined in 40 CFR Part 197, is where the predominant groundwater flow path crosses the boundary of the controlled area and is approximately 18 kilometers (11 miles) downgradient from the repository.
b. Based on 300 simulations of total system performance for each location, using random samples of uncertain parameters.
c. Represents a value for which 285 out of the 300 simulations yielded a smaller value.
d. To convert kilometers to miles, multiply by 0.62137.
e. Estimated using scale factors as described in Chapter 5, Section 5.4.1.
f. NC = not calculated (peak time would be greater than time given for the RMEI location).
g. 60 kilometers (37 miles) at Franklin Lake Playa.

WHY ARE THE MEAN IMPACTS SOMETIMES HIGHER THAN THE 95TH-PERCENTILE IMPACTS?

The *mean* impact is the arithmetic average of the 300 impact results from simulations of total-system performance. The mean is not the same as the 50th-percentile value (the 50th-percentile value is called the *median*) if the distribution is *skewed*.

The performance results reported in this EIS come from highly skewed distributions. In this context, *skewed* indicates that there are a few impact estimates that are much larger than the rest of the impacts. When a large value is added to a group of small values, the large value dominates the calculation of the mean. The simulations reported in this EIS have mean impacts that are occasionally above the 90th-percentile and occasionally above the 95th percentile.

With respect to groundwater protection standards set forth in 40 CFR Part 197.30, both the mean and the 95th percentile estimated levels during the 10,000-year regulatory period are hundreds of thousands of times less than the regulatory limits (see Table 8-49) for both the Proposed Action and Inventory Module 1.

8.3.1.2.1.2 Lower-Temperature Operating Mode. Impacts were not calculated for the lower-temperature operating mode under Inventory Module 1 or 2 because of the lack of differentiation between higher-temperature and lower-temperature operating modes under the Proposed Action (see Chapter 5). Comparison of the mean individual dose history at the RMEI location for the lower- and higher-temperature operating modes is shown in Figure 8-4. For the Proposed Action, the individual dose for the lower-temperature operating mode at a given location would be about the same as that for the higher-temperature operating mode, with the long-term peak slightly greater for the higher-temperature operating mode. Calculations for Inventory Module 1 produce a similar response. Given the similarity of impacts, and that the lower-temperature operating mode impacts are generally bounded by the higher-temperature operating mode impacts, it was deemed unnecessary to perform detailed simulations for the lower-temperature operating mode under Inventory Module 1. The results would be similar to, but less than, those for the higher-temperature operating mode under Inventory Module 1, as reported in Section 8.3.1.2.1.1.

Table 8-49. Comparison of nominal scenario long-term consequences at the RMEI location[a] to groundwater protection standards during 10,000 years following repository closure for the higher-temperature repository operating mode under the Proposed Action and Inventory Module 1.

Modeled inventory	Radionuclide or type of radiation emitted	EPA Limit[b]	Mean peak[c]	95th-percentile peak[d]
Proposed Action	Combined radium-226 and radium-228,[e] picocuries per year	5	1.0 (1×10^{-11})[f]	1.0 (2×10^{-11})
	Gross alpha activity (including radium-226 but excluding radon and uranium),[e] picocuries per year	15	0.4 (2×10^{-8})	0.4 (1×10^{-8})
	Combined beta and photon emitting radionuclides,[g] millirem per year to the whole body or any organ, based on drinking 2 liters of water per day from the representative volume	4	2×10^{-5}	1×10^{-4}
Inventory Module 1	Combined radium-226 and radium-228,[e] picocuries per year	5	1.0 (3×10^{-10})	1.0 (3×10^{-11})
	Gross alpha activity (including radium-226 but excluding radon and uranium),[e] picocuries per year	15	0.4 (3×10^{-8})	0.4 (4×10^{-8})
	Combined beta and photon emitting radionuclides,[g] millirem per year to the whole body or any organ, based on drinking 2 liters of water per day from the representative volume	4	3×10^{-5}	2×10^{-4}

a. The RMEI location, defined in 40 CFR Part 197, is where the predominant groundwater flow path crosses the boundary of the controlled area and is located approximately 18 kilometers (11 miles) downgradient from the repository.
b. Environmental Protection Agency limits set forth in 40 CFR Part 197.30.
c. Based on 300 simulations of total system performance, each using random samples of uncertain parameters.
d. Represents a value for which 285 out of the 300 simulations yielded a smaller value.
e. Includes natural background radiation.
f. Value in parentheses is the incremental increase over background radiation that would be attributable to the potential repository.
g. This represents a bounding (overestimate) of the maximum dose to any organ because the different radionuclides would affect different organs preferentially.

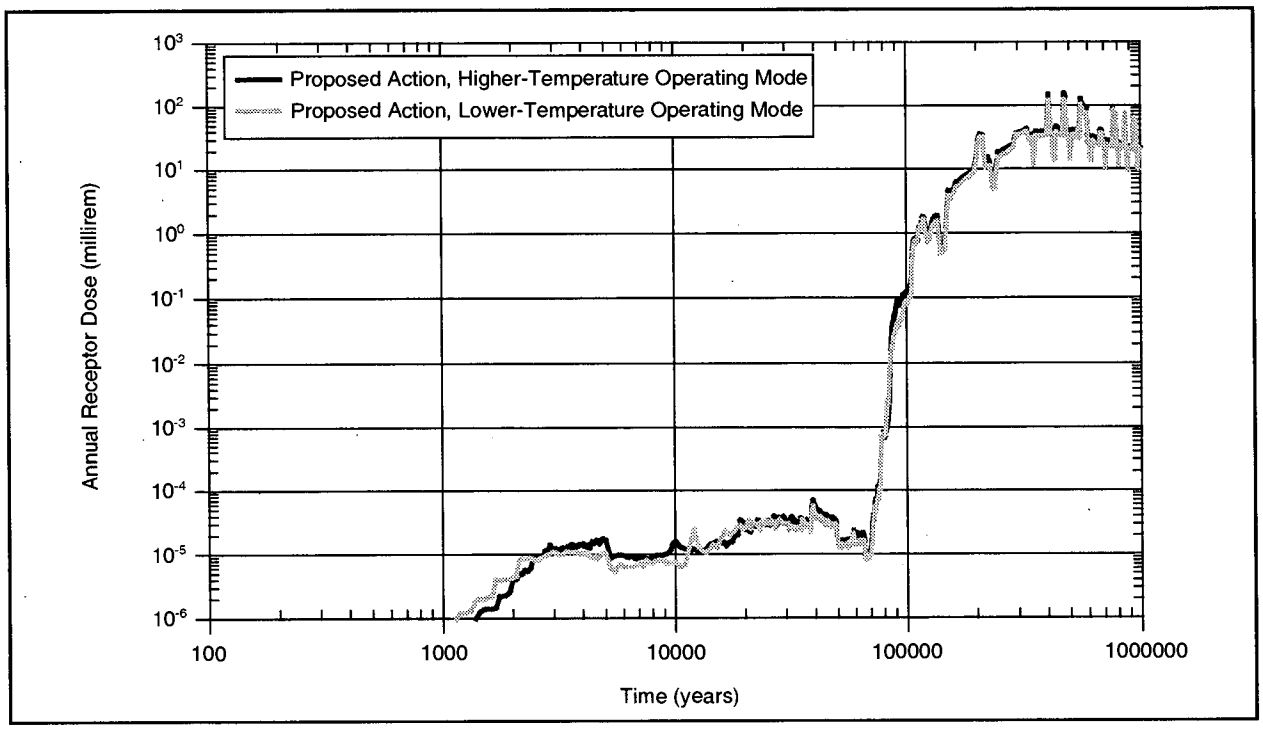

Figure 8-4. Comparison of mean annual individual dose (based on 300 simulations of total system performance, each using random samples of uncertain parameters) at the RMEI location for the higher- and lower-temperature operating modes. (Note use of logarithmic scale for both axes.)

8.3.1.2.2 *Waterborne Chemically Toxic Material Impacts*

A number of nonradioactive materials that DOE would place in the repository are hazardous to human health at high concentrations in water. This section examines the consequences to individuals in the Amargosa Desert from releases of these nonradioactive materials under Inventory Module 1.

The inventory of chemically toxic materials that would be emplaced in the repository under the Proposed Action is identified by element in Appendix I, Section I.3. Based on this inventory, a screening analysis (described in Appendix I, Section I.6.1) identified which of the chemically toxic materials might pose a risk to human health. Only chromium, molybdenum, nickel, and vanadium were identified as potentially posing such a risk, and these elements were further evaluated in a bounding consequence analysis, as described in Appendix I, Section I.6.2. The analysis was performed under the conservative assumption that all chromium dissolves in hexavalent form. The results of the bounding analysis are summarized for both the Proposed Action and Inventory Module 1 in Table 8-50. In some cases a Maximum Containment Level or Maximum Contaminant Level Goal was available for comparison to the calculated concentration. In other cases, only an Oral Reference Dose was available. The Oral Reference Dose can be compared to intake that would result for a 70-kilogram (154-pound) person drinking 2 liters (0.53 gallon) of water per day. More detail on these comparative measures can be found in Chapter 5, Section 5.6, and Appendix I, Section I.6.2.5.

Table 8-50. Peak concentration of waterborne chemical materials released during 10,000 years after closure estimated using bounding calculations for the Proposed Action and Inventory Module.

Modeled inventory	Material	Estimated concentration in well water (milligram per liter)	Maximum Contaminant Level Goal (milligram per liter)	Estimated intake rate for a 70-kilogram person (milligram per kilogram per day)	Oral Reference Dose (milligram per kilogram per day)
Proposed Action	Chromium (VI)	0.01	0.1[a]	0.0004	0.005[b]
	Molybdenum	0.009	NA[c]	0.0003	0.005[d]
	Nickel	0.04	NA	0.001	0.02[e]
	Vanadium	0.0002	NA	0.000006	0.007[f]
Inventory Module 1	Chromium (VI)	0.02	0.1[a]	0.0006	0.005[b]
	Molybdenum	0.01	NA	0.0004	0.005[d]
	Nickel	0.05	NA	0.002	0.02[e]
	Vanadium	0.0003	NA	0.000009	0.007[f]

a. 40 CFR 191.51.
b. DIRS 148224-EPA (1999, all).
c. NA = not available.
d. DIRS 148228-EPA (1999, all).
e. DIRS 148229-EPA (1999, all).
f. DIRS 103705-EPA (1997, all).

Because the bounding concentration of chromium, molybdenum, nickel, and vanadium in well water is calculated to be below the Maximum Contaminant Level Goal or yield intakes well below the Oral Reference Dose for Inventory Module 1, there is no further need to refine the calculation to account for physical processes that would limit mobilization of this material or delay or dilute it during transport in the geosphere.

8.3.1.2.3 *Atmospheric Radioactive Material Impacts*

Using the analysis methods described in Chapter 5, Section 5.5, DOE estimated the impacts of carbon-14 releases to the atmosphere within 10,000 years past closure for Inventory Module 1. As explained in Appendix I, Section I.7.1, the maximum release rate to the ground surface for this period is the same for both Inventory Modules 1 and 2 as for the Proposed Action. Therefore, there would be no incremental atmospheric radioactive material impacts for Inventory Module 1 for the Proposed Action.

8.3.1.3 INCREMENTAL IMPACTS FOR INVENTORY MODULE 2

DOE addressed the long-term consequences from Inventory Module 2 by analyzing the effects of disposing waste packages containing Greater-Than-Class-C and Special-Performance-Assessment-Required wastes in addition to the material in Inventory Module 1. Table 8-43 lists the average inventory of the additional waste packages containing Greater-Than-Class-C and Special-Performance-Assessment-Required wastes. The following sections discuss these impacts in terms of waterborne radioactive releases, chemically toxic materials waterborne release, and atmospheric radioactive material releases.

8.3.1.3.1 *Waterborne Radioactive Material Impacts*

The addition of Greater-Than-Class-C and Special-Performance-Assessment-Required wastes is the only difference between Inventory Modules 1 and 2. Inventory Module 2 was modeled as an incremental inventory; specifying only the Greater-Than-Class-C and Special-Performance- Assessment-Required waste as the radionuclide inventory. The results of the incremental inventory simulations constitute the additional impacts of Inventory Module 2 over those of Module 1. In addition, they represent the dose attributable solely to the Greater-Than-Class-C and Special- Performance-Assessment-Required waste.

Table 8-51 lists the incremental consequences for an individual from the Greater-Than-Class-C and Special-Performance-Assessment-Required wastes in Inventory Module 2 during 10,000 years and 1 million years following repository closure. Peak impacts from waterborne radioactive materials for Module 2 would be less than 1 percent higher for 1,000,000 years after repository closure. For the first 10,000 years following the repository closure, the Module 2 impact would remain very small (mean annual individual dose of 0.0007 millirem, compared to the Environmental Protection Agency standard of 15 millirem for this period as defined in 40 CFR Part 197).

Table 8-51. Incremental increase (millirem) in mean peak individual annual dose at the RMEI location[a] under Inventory Module 2 over the mean peak individual annual dose under Inventory Module 1 during 10,000 and 1 million years after repository closure.

Postclosure period	Incremental Increase[b]
10,000 years	0.0007
1,000,000 years	0.3

a. The RMEI location, defined in 40 CFR Part 197, is where the predominant groundwater flow path crosses the boundary of the controlled area and is approximately 18 kilometers (11 miles) downgradient from the repository.

b. Based on 300 simulations each for Inventory Modules 1 and 2 using random samples of uncertain parameters.

8.3.1.3.2 *Waterborne Chemically Toxic Material Impacts*

A number of nonradioactive materials that DOE would place in the repository are hazardous to human health at high concentrations in water. This section examines the consequences to individuals in the Amargosa Desert from releases of these nonradioactive materials under Inventory Module 2.

The inventory of chemically toxic materials that would be emplaced in the repository under the Proposed Action is identified by element in Appendix I, Section I.3. Based on this inventory, a screening analysis (described in Appendix I, Section I.6.1.) identified which of the chemically toxic materials could pose a risk to human health. Only chromium, molybdenum, nickel, and vanadium were identified as posing such a risk, and these elements were further evaluated in a bounding consequence analysis, as described in Appendix I, Section I.6.2. The results of the bounding analysis are summarized for both the Proposed Action and Inventory Module 2 in Table 8-52. In some cases a Maximum Contaminant Level Goal was available for comparison to the calculated concentration. In other cases, only an Oral Reference Dose was available. The Oral Reference Dose can be compared to the intake that would result for a 70-kilogram (154-pound) person drinking 2 liters (0.53 gallon) of water per day. More detail on these comparative measures can be found in Chapter 5, Section 5.6, and Appendix I, Section I.6.2.5.

Table 8-52. Peak concentration of waterborne chemical materials released during 10,000 years after closure estimated using bounding calculations for the Proposed Action and Inventory Module 2.

Modeled inventory	Material	Estimated concentration in well water (milligram per liter[a])	Maximum Contaminant Level Goal (milligram per liter)	Estimated intake rate for a 70-kilogram person (milligram per kilogram per day)	Oral Reference Dose (milligram per kilogram per day)
Proposed Action	Chromium (VI)	0.01	0.1[a]	0.0004	0.005[b]
	Molybdenum	0.009	NA[c]	0.0003	0.005[d]
	Nickel	0.04	NA	0.001	0.02[e]
	Vanadium	0.0002	NA	0.000006	0.007[f]
Inventory Module 2	Chromium (VI)	0.02	0.1	0.0006	0.005[b]
	Molybdenum	0.01	NA	0.0004	0.005[d]
	Nickel	0.06	NA	0.002	0.02[e]
	Vanadium	0.0003	NA	0.00001	0.007[f]

a. 40 CFR 191.51.
b. DIRS 148224-EPA (1999, all).
c. NA = not available.
d. DIRS 148228-EPA (1999, all).
e. DIRS 148229-EPA (1999, all).
f. DIRS 103705-EPA (1997, all).

Because the bounding concentration of chromium, molybdenum, nickel, and vanadium in well water is calculated to be below the Maximum Containment Level Goal or yield intakes well below the Oral Reference Dose for Inventory Module 2, there is no further need to refine the calculation to account for physical processes that would limit mobilization of this material or delay or dilute it during transport in the geosphere.

The incremental (that is, the increase in) consequences for an individual from the Greater-Than-Class-C and Special-Performance-Assessment-Required wastes in Inventory Module 2 over Inventory Module 1 during 10,000 years and 1 million years following repository closure is 4 percent for all four waterborne chemical materials of concern (chromium, molybdenum, nickel, and vanadium).

8.3.1.3.3 *Atmospheric Radioactive Material Impacts*

There would be no incremental impact for airborne carbon-14 releases for Inventory Module 2. None of the additional waste packages would contain a waste form in which carbon-14 would exist in gaseous form (that is, as carbon dioxide). As for the Proposed Action and Inventory Module 1, radon-222 would be released as a gas but would decay to a solid isotope before escaping from the repository region (see Appendix I, Section I.7.3).

8.3.2 CUMULATIVE IMPACTS FROM OTHER FEDERAL, NON-FEDERAL, AND PRIVATE ACTIONS

This section discusses potential cumulative impacts from other Federal, non-Federal, and private actions that could contribute to doses at the locations considered in the performance assessment of the Yucca Mountain Repository. The actions identified with the potential for long-term cumulative impacts are past, present, and reasonably future actions at the Nevada Test Site and past actions at the low-level radioactive waste disposal facility near Beatty, Nevada.

8.3.2.1 Past, Present, and Reasonably Foreseeable Future Actions at the Nevada Test Site

Historically, the primary mission of the Nevada Test Site was to conduct nuclear weapons tests. Nuclear weapons testing and other activities have resulted in radioactive contamination and have the potential for radioactive and nonradioactive contamination of some areas of the Nevada Test Site. These areas and the

associated contamination and the potential for contamination were evaluated for potential cumulative impacts with postclosure impacts from the proposed Yucca Mountain Repository. This section discusses these Nevada Test Site activities, the locations where these activities occurred, and the potential for cumulative long-term impacts with the repository.

Unless otherwise identified, DOE derived the information in this section from the Nevada Test Site Final EIS (DIRS 101811-DOE 1996, all). The Yucca Mountain site is in the southwestern portion of the Nevada Test Site along its western boundary, as shown in Figure 8-2.

At the Nevada Test Site, seven categories of activities have resulted in radioactive contamination or have the potential to result in radioactive and nonradioactive contamination:

1. *Atmospheric Weapons Testing.* One hundred atmospheric detonations occurred before the signing of the Limited Test Ban Treaty in August 1963. Atmospheric tests included detonations at ground level, from towers or balloons, or from airdrops.

2. *Underground Nuclear Testing.* Approximately 800 underground nuclear tests have occurred at the Nevada Test Site. Chapter 3, Figure 3-2 shows the locations of these tests in relation to Yucca Mountain. They included deep underground tests to study weapons effects, designs, safety, and reliability, and shallow underground tests to study the peaceful application of nuclear devices for cratering.

3. *Safety Tests.* Between 1954 and 1963, 16 above-ground tests studied the vulnerability of weapons designs to possible accident scenarios.

4. *Nuclear Rocket Development Station.* Twenty-six experimental tests of reactors, nuclear engines, ramjets, and nuclear furnaces occurred between 1959 and 1973. Figure 8-3 shows the location of the Nuclear Rocket Development Station.

5. *Shallow Land Radioactive Waste Disposal.* DOE disposed of some radioactive waste generated during testing in shallow cells, pits, and trenches. Because of the significant thickness of alluvial material and high mean annual temperatures and low precipitation under the current climate regime, downward advection of groundwater to the water table is highly unlikely. Therefore, shallow burial continues to be an important waste disposal activity at the Nevada Test Site (DIRS 155159-REECo, 1994, all; DIRS 108774-Tyler et al. 1996, all).

Section 8.3.2.1.3 discusses present and potential future low-level radioactive waste disposal activities.

6. *Crater Disposal.* DOE disposed of contaminated soils and equipment collected during the decontamination of atmospheric testing areas and the consolidation of radioactively contaminated structures, and other bulk wastes, in subsidence craters at Yucca Flat in Area 3. Figure 8-3 shows the location of Area 3 on the Nevada Test Site.

7. *Greater Confinement Disposal.* In 1981, Greater Confinement Disposal began at Area 5 for low-level radioactive wastes not suitable for shallow land disposal. This waste includes some transuranic radionuclides. Figure 8-3 shows the location of Area 5 on the Nevada Test Site.

Table 8-53 lists the approximate inventory for each of these categories. Atmospheric testing, shallow underground testing, safety testing, and nuclear rocket development all resulted in a small (less-than-40-curie) source term, which would not contribute substantially to cumulative impacts. Additionally, the inventories represented by crater disposal and shallow-land disposal were determined to not be important to cumulative impact considerations. Only the deep underground testing and greater confinement

Table 8-53. Summary of radioactivity on the Nevada Test Site (January 1996).[a]

Source	Area	Environmental media	Major known isotopes or wastes	Depth range	Approximate inventory (curies)
Atmospheric weapons testing	Aboveground nuclear weapon proving area	Surficial soils and test structures	Americium, cesium, cobalt, plutonium, europium, strontium	At land surface	20
Underground testing: shallow underground tests	Underground nuclear testing areas	Soils and alluvium	Americium, cesium, cobalt, europium, plutonium, strontium	Less than 61 meters[b]	1 at land surface; unknown at depth
Underground testing: deep underground tests	Underground nuclear testing areas	Soils, alluvium, and consolidated rock	Tritium, fission, and activation products	Typically less than 640 meters, but might be deeper	130 million[c]
Safety tests	Aboveground experimental areas	Surficial soils	Americium, cesium, cobalt, plutonium, strontium	Less than 0.9 meter	35
Nuclear rocket development area	Nuclear rocket motor, reactor, and furnace testing area	Surficial soils	Cesium, strontium	Less than 3 meters	1
Shallow land disposal	Waste disposal landfills	Soils and alluvium	Dry-packaged low-level and mixed wastes	Less than 9 meters	500,000[d,e]
Crater disposal	Test-induced subsidence crater with sidewalls, cover, and drainage	Soils and alluvium	Bulk contaminated soils and equipment	Less than 30 meters	1,250[d,f]
Greater confinement disposal	Monitored underground waste disposal	Soils and alluvium	Tritium, americium	37 meters	9.3 million[d,g]

a. Source: DIRS 101811-DOE (1996, p. 4-6). This table uses information and terminology from that document and is for information purposes only.
b. To convert meters to feet, multiply by 3.2808.
c. Source: DIRS 157116-Bowen et al. (2001, Table V, p. 21)
d. Inventory at time of disposal (not corrected for decay).
e. Inventory does not include prospective future low-level radioactive and mixed waste disposal (see Section 8.3.2.1.3).
f. Volume of waste considered for inventory was approximately 205,000 cubic meters (7.25 million cubic feet).
g. Volume of waste considered for inventory was approximately 300 cubic meters (10,000 cubic feet).

disposal categories represent substantial inventories that could, when combined with the repository inventory, potentially result in increased cumulative impacts.

8.3.2.1.1 *Underground Nuclear Testing*

The United States began a moratorium on the explosive testing of nuclear weapons in October 1992. As discussed in the Nevada Test Site EIS (DIRS 101811-DOE 1996), however, other weapons testing continues at the Test Site, including dynamic, hydrodynamic, and explosive tests. These tests are necessary for the continued assurance of the nuclear arsenal but do not result in nuclear explosions like

those that were common during the Cold War. Environmental contamination is due largely to past weapons testing and not to the current limited activities at the Test Site. Although there are potential past and present impacts of the explosive testing of nuclear weapons, the long-lived radionuclides that such testing deposited far underground could pose future impacts, which this section evaluates.

As of September 23, 1992, the estimated total radionuclide source term for all tests was about 130 million curies (DIRS 157116-Bowen et al. 2001, Table V, p. 21). Because these radionuclides are either in or close to the water table and therefore subject to dissolution and possible transport by groundwater, they are referred to as the hydrologic source term. This source term represents the remaining radioisotopes (as of September 23, 1992) that could be available to the groundwater regime. However, because of the existence of multiple, complex migration pathways and limited characterization data, there is considerable uncertainty concerning the actual hydrologic source term. In recent years, the drilling of new characterization wells and the retrofitting of existing boreholes and wells have provided valuable new data that are now being integrated into the overall database so new evaluations can be made. These studies and planned future studies will help reduce the current levels of uncertainty concerning the quantity of radionuclides available for groundwater transport as well as uncertainty concerning both the mechanisms and consequences of radionuclide transport by groundwater flow at the Nevada Test Site. Testing with subcritical assemblies since 1994 has added quantities of material that are very small compared to the historical testing. Thus, the Department has based its analysis on the much larger inventory from historical testing (DIRS 156758-Crowe 2001, all).

There is recent evidence of plutonium migration from one underground test. Groundwater monitoring results indicate that plutonium has migrated about 1.3 kilometers (0.8 mile), possibly facilitated by the movement of very small and relatively mobile particles called *colloids* in the groundwater (DIRS 103282-Kersting et al. 1999, p. 59). No radioactive contamination attributable to underground tests has been detected in monitoring wells off the Nevada Test Site. DOE is conducting further monitoring and research to study these and other potential radionuclide migration phenomenon.

The above information indicates that groundwater could transport radionuclides from underground nuclear tests at the Nevada Test Site. This transport could result in releases from underground testing at the sites analyzed for releases from the proposed repository. DOE did not make long-term performance assessment calculations for the underground testing inventory with the same rigor as the analyses for the repository, and there is much uncertainty related to the hydrogeologic system. Since issuing the Draft EIS, DOE has continued to evaluate design features and operating modes that would reduce uncertainties in or improve long-term repository performance, including the waste package design, and improve operational safety and efficiency. The result of the design evolution process was the development of the Science and Engineering Report flexible design (DIRS 153849-DOE 2001, all). In addition, DOE has continued technical development of the Total System Performance Assessment since the publication of the Draft EIS, including further site characterization, improvements to the engineered system design, system performance assessment calculations, and quality assurance and validation of results. These efforts have resulted in an updated performance assessment referred to as the Total System Performance Assessment-Site Recommendation (TSPA-Site Recommendation; DIRS 153246-CRWMS M&O 2000). The results of this analysis for long-term impacts from the Yucca Mountain Repository are reported in Chapter 5 of this Final EIS. The TSPA-Site Recommendation evaluated the long-term performance of the Science and Engineering Report flexible design and included the best available information related to contaminant fate and transport. The results for the groundwater impacts from the repository in this analysis are substantially lower than reported in the Draft EIS. However, an update of this simplified scaling analysis used to estimate the potential cumulative impact from underground testing at the Nevada Test Site was not performed for the Final EIS because the principal factors affecting contaminant fate and transport remained essentially unchanged between the TSPA-Viability Assessment and the TSPA-Site Recommendation. DOE considers the estimates of Nevada Test Site groundwater impacts developed

using the simplified model conservative and applicable for environmental evaluation. Further, any minor enhancements to these factors incorporated into the TSPA-Site Recommendation would have yielded results for an updated cumulative analysis well within the uncertainty reported for the analysis based on the TSPA-Viability Assessment. Therefore, DOE developed a simplified analysis that uses the TSPA-Viability Assessment (DIRS 101779-DOE 1998, all) repository infiltration and groundwater fate and transport models to scale groundwater impacts that could result from the underground test inventory. The analysis made the following assumptions for this calculation:

- The total 130-million-curie radionuclide inventory from underground testing at the Nevada Test Site would be available for transport. Tritium constitutes about 90 percent of the total underground testing inventory (DIRS 157116-Bowen et al. 2001, Table V, p. 21). However, the short half-life of tritium (about 12.5 years) would mean that radioactive decay would deplete the tritium inventory to insignificant levels in about 200 years, long before any Yucca Mountain releases would occur. Since potential impacts from tritium migration from the Test Site would not overlap repository impacts temporally, they would not be cumulative. Therefore, DOE did not consider them in this analysis.

- The radionuclide inventory available for transport at the repository would be the estimated curie content of the source material that would become wet in the 10,000-year analysis period. The analysis determined this amount by estimating the quantity of source material in the waste packages and cladding that are predicted to fail (*juvenile* and new *failures*) during the analysis period. Assuming that DOE would emplace 10,000 waste packages in the repository, the package failure rates developed in the TSPA-Viability Assessment indicate two waste package failures with 100 percent of contained elements exhibiting failed cladding. Since issuing the Draft EIS, DOE has continued to evaluate design features and operating modes that would reduce uncertainties in or improve long-term repository performance, including the waste package design, and improve operational safety and efficiency. The result of the design evolution process was the development of the Science and Engineering Report flexible design (DIRS 153849-DOE 2001, all). In addition, DOE has continued technical development of the Total System Performance Assessment since publication of the Draft EIS, including further site characterization, improvements to the engineered system design, system performance assessment calculations, and quality assurance and validation of results. These efforts have resulted in an updated performance assessment referred to as the Total System Performance Assessment-Site Recommendation [TSPA-Site Recommendation (DIRS 153246-CRWMS M&O 2000)]. The results of this analysis for long-term impacts from the Yucca Mountain Repository are reported in Chapter 5 of this Final EIS. The TSPA-Site Recommendation evaluated the long-term performance of the updated Science and Engineering Report flexible design and included the best available information related to contaminant fate and transport. The results for the groundwater impacts from the repository in this analysis are substantially lower than reported in the Draft EIS. However, an update of this simplified scaling analysis used to estimate the potential cumulative impact from underground testing at the Nevada Test Site was not performed for the Final EIS because the principal factors affecting contaminant fate and transport remained essentially unchanged between the TSPA-Viability Assessment and the TSPA-Site Recommendation. DOE considers the estimates of Nevada Test Site groundwater impacts developed using the simplified model conservative and applicable for environmental evaluation. Further, any minor enhancements to these factors incorporated into the TSPA-Site Recommendation would have yielded results for an updated cumulative analysis well within the uncertainty reported for the analysis based on the TSPA-Viability Assessment.

- The estimated total inventory for all underground tests at the Nevada Test Site was 130 million curies as of September 23, 1992 (DIRS 157116-Bowen et al. 2001, Table V, p. 21). As discussed above, the contribution to the total inventory from subcritical experiments is very small and is adequately accounted for by analyzing the inventory from historical testing (DIRS 156758-Crowe 2001, all). The Department only evaluated the radionuclides of interest (that is, those that result in 99 percent of

the impact; technetium-99, iodine-129, and carbon-14) in this inventory (see Section 5.4.1 of the Draft EIS for details.)

- The total underground testing inventory available for transport would migrate through the same locations as those considered in this EIS for dose calculations for releases from the repository. This is very conservative because much of the water migrating from the underground test locations would discharge to locations other than those for releases from the proposed repository. Such locations include Oasis Valley, Ash Meadows, or the Amargosa Desert.

- The radionuclide-specific distribution coefficients, k_d, are assumed to be equal for source materials at the repository and the Nevada Test Site. This assumption recognizes that most of the nonvolatile radionuclide inventory at the Test Site is captured within the glass-like material resulting from the intense heat generated by past underground tests. The analysis assumed that the leachability of this material is not remarkably different than that of ceramic spent nuclear fuel pellets. Concentrations of the contaminants (curies per milliliter) in leachates are directly proportional to the source material (curies per gram) and the radionuclide-specific distribution coefficients.

- All contaminants originating on the Nevada Test Site would flow to the same discharge points as contaminants from Yucca Mountain, as modeled by the TSPA-Viability Assessment, and the peak groundwater concentrations of contaminants from the Test Site would coincide (in time and space) with the peak groundwater concentrations from repository contaminants.

- Concentrations of radionuclides in the groundwater would be diluted by total infiltration through the repository footprint and groundwater recharge for the repository and the Nevada Test Site, respectively.

The absolute potential cumulative Nevada Test Site groundwater impact can be estimated by comparison with the 10,000-year impacts presented in Table 5-4 of the Draft EIS. Based on these tables, the estimated cumulative Test Site impacts for the Proposed Action for the maximally exposed individual would be about 0.007 millirem per year at 20 kilometers. The dose to the RMEI at 18 kilometers, as described in Chapter 5, would be slightly higher. Therefore, the estimated total potential cumulative impact (Yucca Mountain impact plus Nevada Test Site impact) would be essentially (because of the small contribution from the proposed repository) 0.007 millirem per year to the RMEI.

Because of the large uncertainties in the current level of understanding of the hydrogeologic system, DOE has not attempted to model the actual groundwater transport of the Nevada Test Site with this simplified model. However, by assuming that the radionuclide contaminants in the groundwater at the Test Site would be transported in an identical manner to those from the repository and that peak concentrations would occur at precisely the same time, the Department believes that the resulting estimates of cumulative impacts from underground testing activities represent a reasonable upper bound of the actual cumulative impacts.

Uncertainties associated with Nevada Test Site groundwater impacts:

- *Source material concentration* – The concentration of contaminants within the source material is the parameter with the most sensitivity to outcome but also the parameter that the least is known about at the Nevada Test Site. However, the actual Test Site concentrations could be higher than those estimated for this analysis and still have little effect on the outcome. This is because, as the density of the Test Site inventory increases (that is, the radionuclide inventory is assumed to occupy a smaller volume), the quantity of infiltration "seen" by the contaminant would decrease because of the reduced footprint of the source term. Since both of these terms (radionuclide density and water infiltration per unit area) are directly proportional to the calculated groundwater concentration, they

would tend to offset one another. However, for conservatism, the assumption was made that all of the Test Site source term for radionuclides of interest was concentrated only in the affected soil at Yucca Flat. This assumption could have resulted in an overestimate of the Test Site concentration and potential impacts by as much as two.

- *Travel distances and times* – The conservative assumption was made that the contaminants from Yucca Mountain and the Nevada Test Site would travel along the same pathways (those assumed for Yucca Mountain in the TSPA-Viability Assessment) and at the same time to maximize potential impacts. If more realistic modeling had been performed, the peak contaminate concentrations from Yucca Mountain and the Test Site probably would not coincide and the Test Site contribution to the cumulative impacts would therefore be smaller than those estimated.

- *Solute partition coefficients* – These coefficients as described in the literature are known to vary by orders of magnitude depending on soil and source zone material types. Because the precise nature of the soils at the Nevada Test Site was not considered in the simplified analysis, the actual result could be different. However, these values are not readily available and are impossible to estimate accurately with currently available data.

- *Contaminant mobilization* – To simplify the analysis, the assumption was made that the waste isolated in engineered barrier systems for the Yucca Mountain Repository and the waste dispersed in glass-like material from underground nuclear blasts at the Nevada Test Site will have the same release characteristics. The actual mechanisms for waste mobilization for Test Site underground testing contamination are largely unknown. The actual differences in the mobilization of the contaminants could result in changes (larger or smaller) in the impact estimates, however, due to the relative size of the calculated impacts, coupled with the other conservatisms assumed in this simplified analysis, they are not likely to influence the conclusion.

- *Groundwater flow direction and discharge points* – If realistic modeling was performed, and adequate characterization data to support that modeling was available, then it is extremely unlikely that the modeling would show that all contaminants resulting from underground testing across the Nevada Test Site would migrate to only one discharge point and that point would be the same point of discharge as the releases from the Yucca Mountain Repository. More detailed information on actual groundwater flow would likely serve to reduce the estimated impact of the Test Site inventory.

8.3.2.1.2 *Greater Confinement Disposal*

Waste disposed of at the Nevada Test Site under Greater Confinement Disposal constitutes a radiological source term that is less than 10 percent of the repository radionuclide source term immediately available for groundwater transport when the first waste packages at the Yucca Mountain Repository are assumed to have initially degraded (that is, 2 percent of the total repository radionuclide source term). The waste disposed of by Greater Confinement Disposal was placed in boreholes that are approximately 37 meters (120 feet) deep; the waste itself is no closer than approximately 21 meters (70 feet) to the surface. DOE has reviewed analyses related to the Nevada Test Site and has concluded that there is no credible pathway for long-term releases of materials by resuspension of nonvolatile radionuclides because the material is sufficiently far below the surface. In addition, evapotranspiration exceeds precipitation in this region, which, coupled with the fact that the boreholes are sufficiently above the water table (more than 125 meters), indicates that there is no credible release scenario for Greater Confinement Disposal material to enter the groundwater. Therefore, DOE expects no cumulative impacts from Greater Confinement Disposal activities.

8.3.2.1.3 *Future Nevada Test Site Low-Level Waste Disposal*

The Nevada Test Site is a disposal site for low-level radioactive waste generated by DOE-approved generators. Managed radioactive waste disposal operations began in the early 1960s, and DOE has disposed of low-level, transuranic, mixed, and classified low-level wastes in selected pits, trenches, landfills, and boreholes on the Nevada Test Site. Environmental impacts from the disposal of low-level waste at the Nevada Test Site are discussed in the Nevada Test Site Final EIS (DIRS 101811-DOE 1996, pp. 2-15 to 2-17). The current source term of low-level and mixed wastes in shallow land disposal on the Nevada Test Site does not constitute a substantial inventory in relation to the radionuclide source term immediately available for groundwater transport from the repository when the first waste packages initially degrade (that is, 2 percent of the total repository radionuclide source term). However, shallow burial of low-level radioactive waste continues to be an important waste disposal activity at the Nevada Test Site. Therefore, this section evaluates reasonably foreseeable future activities in this category as a potential cumulative impact.

Waste disposal activities on the Nevada Test Site occur at two specific locations. They are the Area 3 and Area 5 Radioactive Waste Management Sites. The Area 3 Radioactive Waste Management Site is on Yucca Flat and covers an area of approximately 0.2 square kilometer (50 acres). DOE uses conventional landfill techniques to dispose of contaminated debris from the Nevada Test Site Atmospheric Testing Debris Disposal Program and packaged bulk low-level waste from other DOE sites in subsidence craters from underground nuclear tests. The estimated total remaining capacity for low-level waste in the Area 3 site is 1.8 million cubic meters (64 million cubic feet) (DIRS 103224-DOE 1998, Section A.5.2) .

DOE has used the Area 5 Radioactive Waste Management Site since 1961 to dispose of low-level waste and classified low-level waste from Nevada Test Site operations. In 1978, the Test Site began accepting low-level waste generated by other DOE sites. The total area of the Area 5 site is 3 square kilometers (740 acres). The developed portion occupies 0.37 square kilometer (92 acres) in the southeast corner and contains 17 landfill cells (pits and trenches), 13 Greater Confinement Disposal boreholes, and a transuranic waste storage pad. DOE is seeking a Resource Conservation and Recovery Act permit for Pit 3 as a mixed-waste disposal unit. In the future, if the mixed-waste volume warranted it, the Department might consider obtaining a new unit and, hence, a new permitted facility. However, current projected waste volumes do not indicate the need for an additional mixed-waste disposal unit at this time. The estimated total remaining capacity for low-level waste in the Area 5 Radioactive Waste Management Site is 1.2 million cubic meters (42 million cubic feet) (DIRS 103224-DOE 1998, Section A.5.3).

As discussed in Section 8.2.12.1, DOE projects a need for 1.1 million cubic meters of capacity for low-level waste disposal at the Nevada Test Site through 2070 (DIRS 155856-DOE 2000, Table 4-1).

The Final Waste Management Programmatic EIS (DIRS 101816-DOE 1997, Summary) reported volumes of radioactive waste DOE may dispose of at the Nevada Test Site for "current plus 20 years" of waste disposal. The current inventory plus 20 years of additional disposal inventory would total 3,000 cubic meters (106,000 cubic feet) of low-level mixed waste, 1,700 cubic meters (60,000 cubic feet) of low-level waste, and 610 cubic meters (21,500 cubic feet) of transuranic waste (DIRS 101816-DOE 1997, Summary, p. 102). The Nevada Test Site Final EIS (DIRS 101811-DOE 1996, Table 4-1, p. 4-6) estimates the total current inventory already in shallow disposal at the Nevada Test Site to be 500,000 curies at the time of disposal (uncorrected for decay to the present time).

According to the Final Waste Management Programmatic EIS, the only expected groundwater impacts from low-level mixed, low-level radioactive, and transuranic waste disposal at the Nevada Test Site in excess of regulatory limits are for the hazardous chemicals 1,2-dichloroethane, methylene chloride, and benzene, and those only under Regionalized Alternative 3 and the Preferred Alternative in that EIS (DIRS 101816-DOE 1997, p. 11-61). None of these hazardous chemicals would be in the Yucca Mountain

Repository inventory, so there would be no potential cumulative impacts from those chemicals from the Proposed Action or Inventory Module 1 or 2.

DOE has estimated potential long-term impacts from radioactive material disposed of at the Nevada Test Site. DOE based its calculations of long-term atmospheric releases for the Nevada Test Site on estimates of the inventory at the Test Site that could be accessible by residents around the area. For this calculation, the Department considered three potential sources of radionuclide releases:

- The Area 3 radioactive waste disposal area
- The Area 5 radioactive waste disposal area
- Soil sites around the Nevada Test Site that are contaminated at or near the surface from nuclear weapons testing

Because this material is not near the water table and because evapotranspiration exceeds precipitation in this area, there is no credible release scenario for this material to enter the groundwater. DOE postulated that, over time, weathering at the site could resuspend contaminants in the air and transport them from the contaminated areas to offsite residents. Therefore, DOE performed calculations using current meteorological information for the Nevada Test Site and site-specific resuspension factors to estimate the amount of material that could be released off the site. To ensure conservatism in the estimate, DOE assumed that the three sources listed above were in the same location (even though in reality they are separated by large distances) and that a future resident could be as near as 100 meters (330 feet) from the site. Analyses based on these assumptions are likely to overestimate the true impacts to a future resident because they result in a calculated total emission and radiation dose that is probably higher than if a resident were within 100 meters of a single site.

Based on these conservative assumptions, DOE calculated that the total radiation dose from the three sources could be approximately 7 millirem for each year of exposure during the first 10,000 years, and DOE does not expect that the dose would increase beyond that value for as long as 1,000,000 years. If a resident received this dose as long as 70 years, that person's lifetime dose could be as high as 490 millirem, which could result in an increased risk of fatal cancer of 0.0002.

8.3.2.2 Past Actions and Present Actions at the Beatty Low-Level Radioactive Waste Disposal and Hazardous Waste Treatment Storage and Disposal Facilities

A low-level radioactive waste disposal facility, formerly operated by U.S. Ecology, a subsidiary of American Ecology, is 16 kilometers (10 miles) southeast of Beatty, Nevada, and 180 kilometers (110 miles) northwest of Las Vegas. This site is about 15 kilometers (9.3 miles) west of the proposed Yucca Mountain Repository (see Figure 8-2). The disposal facility, which opened in 1962, covers roughly 0.14 square kilometer (35 acres) of unlined trenches. Acceptance of low-level radioactive waste ended December 31, 1992 (DIRS 101815-DOE 1997, Chapter 4, Table 4-17). The Nevada State Health Division formally accepted permanent custody of the low-level radioactive commercial waste disposal in a letter to American Ecology dated December 30, 1997 (DIRS 148088-AEC 1998, all). An adjacent U.S. Ecology facility remains open for hazardous waste disposal.

From 1962 through 1992, the inventory shipped to the Beatty low-level radioactive waste facility totaled 137,000 cubic meters (4.8 million cubic feet) in volume (DIRS 101815-DOE 1997, Chapter 4, Table 4-17) with radioactivity of about 640,000 curies (DIRS 101815-DOE 1997, Chapter 4, Table 4-18). The radioactivity in this sum was measured by year of shipment (that is, it is not corrected for decay since that time).

The Manifest Information Management System (DIRS 148160-MIMS 1992, all) calculated the total radionuclide inventory the Beatty facility received from 1986 through 1992, which represents 29 percent of the total undecayed inventory at that facility. Even if multiplied by a factor of 3 to 4 to compensate for the period (1962 to 1985) for which the Manifest Information Management System did not provide information, the source term represents a small percentage of the radionuclide source term immediately available for groundwater transport from the repository when the first waste packages initially degrade (that is, 2 percent of the total repository radionuclide source term). Therefore, cumulative long-term impacts from the Beatty Low-Level Radioactive Waste Disposal Facility with the repository would be very small.

The U.S. Ecology Hazardous Waste Treatment, Storage and Disposal Facility is a Resource Conservation and Recovery Act-permitted facility, with engineered barriers and systems and administrative controls that minimize the potential for offsite migration of hazardous constituents.

8.4 Cumulative Transportation Impacts

This section discusses the results of the cumulative impact analysis of transportation. Paralleling the transportation analyses of the Proposed Action in Chapter 6, potential national transportation cumulative impacts from Inventory Module 1 or 2, and past, present, and reasonably foreseeable future actions, are presented in Section 8.4.1. Potential cumulative impacts with construction and operation of the Nevada transportation implementing rail and heavy-haul truck alternatives are included in Section 8.4.2.

The shipment of Inventory Module 1 or 2 to the repository would use the same transportation routes, but would take more shipments and an additional 14 years compared to the Proposed Action. Table 8-2 lists the estimated number of shipments for Modules 1 and 2. Impacts from Module 1 or 2 would be similar because the shipping rate would be the same for spent nuclear fuel and high-level radioactive waste and only about 3 percent more shipments would be made over the 38-year period under Module 2 to transport Greater-Than-Class-C and Special-Performance-Assessment-Required wastes. Because the difference in impacts between Inventory Modules 1 and 2 would be small, the following discussions present the impacts from both modules as being the same.

8.4.1 NATIONAL TRANSPORTATION

This section describes cumulative impacts from national transportation. Section 8.4.1.1 presents potential cumulative impacts from shipping Inventory Module 1 or 2 from commercial nuclear generating sites and DOE facilities to the proposed Yucca Mountain Repository (Section 8.4.1.1). Section 8.4.1.2 presents potential cumulative national transportation impacts for the Proposed Action and Module 1 or 2 when combined with past, present, and reasonably foreseeable future shipments of radioactive material.

8.4.1.1 Inventory Module 1 or 2 Impacts

This section describes the potential cumulative impacts of loading operations at generating sites and incident-free radiological impacts, vehicle emission impacts, and accident impacts associated with transportation activities for Inventory Module 1 or 2. Cumulative impact results are provided for the mostly legal-weight truck and mostly rail scenarios which are described in Chapter 6. The section also describes potential cumulative impacts from transportation of other materials, personnel, and repository-generated waste for Modules 1 or 2. Appendix J contains additional detailed analysis results.

Loading operations would be extended for an additional 14 years to load the greater quantities of spent nuclear fuel and high-level radioactive waste under Inventory Module 1 or 2. The impacts of routine loading operations described for the Proposed Action in Chapter 6, Section 6.2.2, would increase for Module 1 or 2 due to the additional inventory. Therefore, the increase in dose to the public would be

about 42 person-rem based on 0.001 person-rem per metric ton of heavy metal and 42,000 additional MTHM (46,000 tons) (DIRS 104731-DOE 1986, Volume 2, p. E.6) for Modules 1 and 2. This dose could result in an additional 0.02 cancer fatality in the exposed population. Table 8-54 lists estimated radiological and industrial hazard impacts to involved workers for the routine loading operations under Module 1 or 2. The Proposed Action impacts are listed for comparison.

Table 8-54. Radiological and industrial hazard impacts to involved workers from loading operations.[a,b]

	Proposed Action[b]		Inventory Module 1 or 2	
Impact	Mostly legal-weight truck scenario	Mostly rail scenario	Mostly legal-weight truck scenario	Mostly rail scenario
Radiological				
Maximally exposed individual				
Dose (rem)[c]	12	12	12	12
Probability of latent cancer fatalities	0.005	0.005	0.005	0.005
Involved worker population				
Dose (person-rem)	15,000	4,200	32,000	8,400
Number of latent cancer fatalities	6.0	1.7	13	3.4
Industrial hazards				
Total recordable cases[d]	380	130	770	260
Lost workday cases[e]	200	70	400	130
Fatalities[f]	0.88	0.3	1.8	0.6

a. Includes all involved workers at all facilities and does not vary by operating mode.
b. Source: Chapter 6, Section 6.2.
c. Assumes 500 millirem per year to radiation workers. The average individual exposure was assumed to be 24 years for both the Proposed Action and Inventory Module 1 or 2 since 24 years is a conservatively long time to assume an individual would be involved in loading operations.
d. Total recordable cases based on a loss incidence rate of 0.084.
e. Lost workday cases based on a loss incidence rate of 0.046.
f. Fatalities based on a loss incidence rate of 0.000218.

Because noninvolved workers would not have tasks that involved radioactive exposure, there would be no or very small radiological impacts to noninvolved workers. For the reasons identified in Chapter 6, Section 6.2.2.2, industrial hazard impacts to noninvolved workers would be about 25 percent of the impacts to the individual worker shown in Table 8-54.

The impacts of loading accident scenarios under Inventory Module 1 or 2 would be the same as those described for the Proposed Action in Chapter 6, Section 6.2.4.1. The same type of single accident event and its impacts are applicable to shipments under the Proposed Action or Module 1 or 2. As summarized in Chapter 6, Section 6.2.4.1, the analysis results indicate that there would be no or very small potential radiological consequences from loading accident scenarios involving spent nuclear fuel or high-level radioactive waste. These consequences would bound the consequences from similar accidents involving Greater-Than-Class-C or Special-Performance-Assessment-Required waste because of the lower available radionuclide inventory (see Appendix A).

Table 8-55 lists radiological impacts to involved workers and the public and vehicle emission impacts from incident-free transportation for the mostly legal-weight truck and mostly rail scenarios. The analysis of impacts for the mostly legal-weight truck scenario assumed that shipments would use commercial motor carriers for highway transportation and general freight commercial services for rail transportation for the naval spent fuel shipments that cannot be transported by legal-weight trucks. The mostly rail analysis accounts for legal-weight truck shipments that would occur for the commercial nuclear generator sites that do not currently have the capacity to handle or load rail casks. In addition, for the mostly rail analysis, DOE assumed that it would use either a branch rail line or heavy-haul trucks in conjunction with an intermodal transfer station in Nevada to transport the large rail casks to and from the

Table 8-55. Radiological and vehicle emission impacts from incident-free national transportation.

Category	Proposed Action[a,b]		Inventory Module 1 or 2[c]	
	Mostly legal-weight truck scenario[d]	Mostly rail scenario[e]	Mostly legal-weight truck scenario[d]	Mostly rail scenario[e]
Involved worker				
Collective dose (person-rem)	14,000	3,700 - 4,600	28,000	7,100 - 8,800
Estimated number of latent cancer fatalities	5.6	1.5 - 1.9	11.2	2.8 - 3.5
Public				
Collective dose (person-rem)	5,000	1,200 - 1,600	9,700	2,200 - 3,100
Estimated number of latent cancer fatalities	2.5	0.6 - 0.82	5.0	1.1 - 1.6
Estimated vehicle emission-related fatalities	0.95	0.5 - 0.8	1.9	0.9 - 1.4

a. Source: Chapter 6, Section 6.2.3.
b. Impacts are totals for shipments over 24 years.
c. Impacts are totals for shipments over 38 years.
d. Includes rail shipments of naval spent nuclear fuel to Nevada, and intermodal transfer station and heavy-haul truck operations for this fuel in Nevada.
e. Includes legal-weight truck shipments from commercial nuclear generator sites that do not have the capacity to handle or load rail casks, and the rail and heavy-haul truck implementing alternatives for Nevada described in Chapter 6.

repository. The range provided in the table for the mostly rail scenario addresses the different possible rail and heavy-haul truck implementing alternatives described in Chapter 6. The lower end of the range reflects use of a branch rail line in Nevada and the upper end of the range reflects use of heavy-haul trucks in Nevada. The involved worker impacts in Table 8-55 include estimated radiological exposures of truck and rail transportation crews and security escorts for legal-weight truck and rail shipments; the public doses account for the public along the route, the public sharing the route, and the public during stops. The Inventory Module 1 or 2 impacts would exceed those of the Proposed Action due to the additional number of shipments.

DOE does not expect radiological impacts for maximally exposed individuals to change from the Proposed Action due to the conservative assumptions used in the analysis of the Proposed Action (see Chapter 6, Section 6.2.3). The assumptions for estimating radiological dose include the use of the maximum allowed dose rate and conservative estimates of exposure distance and time. For example, the U.S. Department of Transportation maximum allowable dose rate of 10 millirem per hour at a distance of 2 meters (6.6 feet) [40 CFR 173.44(b)] was used for estimating exposure to individuals. In addition, the conservative assumptions for exposure distance and time for workers (that is, crew members, inspectors, railyard crew member) and the public (that is, resident along route, person in a traffic jam, person at a service station, resident near a rail stop) for the Proposed Action are unlikely to be exceeded for Inventory Module 1 or 2 (see Chapter 6, Section 6.2.3).

Table 8-56 lists the radiological accident risk and traffic fatalities for transportation by mostly legal-weight truck and mostly rail for Inventory Module 1 or 2. The radiological accident risk measures the total impact of transportation accidents over the entire shipping campaign (24 years for the Proposed Action and 38 years for Module 1 or 2). The consequences from a maximum reasonably foreseeable accident scenario would be identical to those discussed for the Proposed Action (see Chapter 6, Sections 6.2.4.2.1 and 6.2.4.2.2) because the parameters and conditions for the hypothetical accident event involving spent nuclear fuel or high-level radioactive waste would be the same for a shipment under the Proposed Action or Module 1 or 2. In addition, the hypothetical accident would be bounding for accident scenarios involving Greater-Than-Class-C and Special-Performance-Assessment-Required wastes.

As summarized in Chapter 6, Section 6.1.3, and further described in Appendix J, in addition to the transportation of spent nuclear fuel and high-level radioactive waste to the repository, other materials

Table 8-56. Accident risk for mostly legal-weight truck and mostly rail scenarios.

Category	Proposed Action[a]		Inventory Module 1 or 2	
	Mostly legal-weight truck scenario	Mostly rail scenario	Mostly legal-weight truck scenario	Mostly rail scenario
Radiological accident risk				
Collective dose risk (person-rem)	0.46	0.8 - 1.0	0.87	1.3 - 1.6
Estimated number of latent cancer fatalities	0.00023	0.00041 - 0.00050	0.00043	0.00066 - 0.00080
Traffic accident fatalities	4.9	2.3 - 3.1	8.7	4.2 - 5.9

a. Source: Chapter 6, Section 6.2.4.2.

would require transportation to and from the proposed repository. These materials would include construction materials, consumables, repository components (disposal containers, drip shields, etc.), office and laboratory supplies, mail, and laboratory samples. Required transportation would also include personnel commuting to the Yucca Mountain site and the shipment of repository-generated wastes offsite for treatment, storage, or disposal.

The implementation of Inventory Module 1 or 2 would increase this transportation as a result of the additional required subsurface development and the longer time required for repository development, emplacement, and closure. However, even with the increased transportation of other material, personnel, and repository-generated wastes for Module 1 or 2, DOE would expect these transportation impacts to be small contributors to the total transportation impacts on a local, state, and national level with no large cumulative impacts based on the analysis of the Proposed Action in Section 6.1.3. The annual air quality impacts for Inventory Module 1 or 2 would be the same as those conservatively estimated in Section 6.1.3 and, therefore, no cumulative air quality impacts would be expected in the Las Vegas airshed, which is in nonattainment for carbon monoxide. Table 8-57 summarizes fatalities from transporting other materials, personnel, and repository-generated waste. The estimated fatalities assume truck shipments in Nevada which would have higher potential impacts than shipments by rail. The Proposed Action impacts are listed in the table for comparison.

Table 8-57. Impacts from transportation of materials, consumables, personnel, and waste.[a,b]

Category	Proposed Action		Inventory Module 1 or 2	
	Kilometers traveled[c]	Fatalities	Kilometers traveled (Module 1/Module 2)	Fatalities (Module 1/Module 2)
Materials (including repository components)	130,000,000 - 270,000,000	4.1 - 7.8	170,000,000 - 310,000,000	5.6 - 9.8
Personnel	480,000,000 - 800,000,000	5.4 - 9.2	640,000,000 - 930,000,000	7.3 - 11
Repository-generated waste				
Hazardous	57,000 - 71,000	0.001 - 0.002	110,000 - 170,000	0.002 - 0.003
Low-level radioactive	230,000 - 320,000	0.004 - 0.006	430,000 - 1,000,000	0.008 - 0.02
Nonhazardous solid	5,600,000 - 10,400,000	0.1 - 0.2	7,000,000 - 9,500,000	0.13 - 0.18
Totals	***610,000,000 - 1,100,000,000***	***9.6 - 17***	***820,000,000 - 1,300,000,000***	***13 - 20***

a. Totals might differ from sums of values due to rounding.
b. Source: Appendix J, Section J.3.6.
c. To convert kilometers to miles, multiply by 0.62137.

8.4.1.2 Cumulative Impacts from the Proposed Action, Inventory Module 1 or 2, and Other Federal, Non-Federal, and Private Actions

The overall assessment of cumulative national transportation impacts for past, present, and reasonably foreseeable future actions concentrated on the cumulative impacts of offsite transportation, which would yield potential radiation doses to a greater portion of the general population than onsite transportation and would result in fatalities from traffic accidents. The collective dose to workers and to the general population was used to quantify overall cumulative radiological transportation impacts. This measure

was chosen because it could be related directly to latent cancer fatalities using a cancer risk coefficient and because of the difficulty in identifying a maximally exposed individual for shipments throughout the United States from 1943 through 2047. Operations at the Hanford Site and the Oak Ridge Reservation began in 1943, and 2047 is when the EIS analysis assumed that radioactive material shipments to the repository for Inventory Module 1 or 2 would end. The source of this cumulative transportation impacts analysis is the Yucca Mountain EIS Environmental Baseline File on transportation (DIRS 104800-CRWMS M&O 1999, Section 7.0), with the exception of impacts from the Proposed Action and Module 1 or 2, which are from Table 8-55.

The cumulative impacts of the transportation of radioactive material would consist of impacts from:

- Historic DOE shipments of radioactive material associated with the Nevada Test Site, the Idaho National Engineering and Environmental Laboratory, the Savannah River Site, the Hanford Site, the Oak Ridge Reservation, and naval spent nuclear fuel and test specimens

- Reasonably foreseeable actions that include the transportation of radioactive material identified in DOE Environmental Policy Act analyses; for example, the Nevada Test Site Environmental Impact Statement (DIRS 101811-DOE 1996, all), the Department of Energy Spent Nuclear Fuel Management Environmental Impact Statement (DIRS 101802-DOE 1995, all; DIRS 101812-DOE 1996, all), and the Final Department of Energy Waste Management Environmental Impact Statement (DIRS 101816-DOE 1997, all) (see Table 8-58). In some cases, transportation impacts included impacts that may have been double counted. For example, the transportation impacts from shipping 40,000 MTHM of spent nuclear fuel to a potential Private Fuel Storage Facility in Tooele County, Utah (DIRS 152001-NRC 2000, all) were included in Table 8-58, but the transportation impacts from the Proposed Action were not decreased to account for this 40,000 MTHM. Table 8-58 also includes reasonably foreseeable projects that include limited transportation of radioactive material (for example, shipment of submarine reactor components from the Puget Sound Naval Shipyard to the Hanford Site for burial, and shipments of uranium billets and low-specific-activity nitric acid from the Hanford Site to the United Kingdom). In addition, for reasonably foreseeable future actions where a preferred alternative was not identified or a Record of Decision has not been issued, the analysis used the alternative estimated to result in the largest transportation impacts. While this is not an exhaustive list of the projects that could include limited transportation of radioactive material, it indicates that the transportation impacts associated with such projects are low in comparison to major projects or general transportation.

- General radioactive materials transportation that is not related to a particular action; for example, shipments of radiopharmaceuticals to nuclear medicine laboratories and shipments of commercial low-level radioactive waste to commercial disposal facilities

- Shipments of spent nuclear fuel, high-level radioactive waste, Greater-Than-Class-C waste, and Special-Performance-Assessment-Required waste under the Proposed Action or Inventory Module 1 or 2

Table 8-58 summarizes the worker and general population doses from the transport of radioactive material. The estimated total cumulative transportation-related collective worker doses from the mostly legal-weight truck shipments (past, present, and reasonably foreseeable actions) with the Proposed Action would be about 360,000 person-rem (140 latent cancer fatalities), and with Inventory Module 1 or 2 about 410,000 person-rem (160 latent cancer fatalities). The estimated total general population doses for the mostly legal-weight truck shipments would be about 320,000 person-rem (160 latent cancer fatalities) with the Proposed Action, and about 350,000 person-rem (180 latent cancer fatalities) with Module 1 or 2. Most of the dose for workers and the general population would be due to general transportation of radioactive material. The estimated total cumulative number (workers plus population) of latent cancer fatalities with the Proposed Action would be about 300, and about 340 with Module 1 or 2. To place

Table 8-58. Cumulative transportation-related radiological doses, latent cancer fatalities, and traffic fatalities.[a]

Category	Worker dose (person-rem)	General population dose (person-rem)	Traffic fatalities
Historical DOE shipments (DIRS 101811-DOE 1996, all)	330	230	NL[b]
Reasonably foreseeable actions			
Private Fuel Storage Facility (DIRS 152001-NRC 2000, all)	29	190	0.78
Sodium-Bonded Spent Nuclear Fuel (DIRS 157167-DOE 2000, all)	0.0044	0.032	0.0001
Idaho High-Level Waste and Facilities (DIRS 155100-DOE 1999, all)	530	2,900	0.1
Surplus Plutonium Disposition (DIRS 118979-DOE 1999, all)	60	67	0.053
Sandia National Laboratories Site-Wide EIS (DIRS 157155-DOE 1999, all)	94	590	1.3
Depleted Uranium Hexafluoride (DIRS 152493-DOE 1999, all)	--[c]	750	4
Tritium Production in a Commercial Light Water Reactor (DIRS 157166-DOE 1999, all)	16	80	0.06
Parallex Project (DIRS 157153-DOE 1999, all)	0.00001	0.00007	0.00005
Los Alamos National Laboratory Site-Wide EIS (DIRS 157154-DOE 1999, all)	580	310	8
Plutonium Residues at Rocky Flats (DIRS 155932-DOE 1998, all)	2.1	1.3	0.0078
Import of Russian Plutonium-238 (DIRS 157156-DOE 1993, all)	1.8	4.4	0.0036
Nevada Test Site expanded use (DIRS 101811-DOE 1996, all)	--	150[d]	8
Spent nuclear fuel management (DIRS 101802-DOE 1995, all; DIRS 101812-DOE 1996, all)	360	810	0.77
Waste Management PEIS (DIRS 101816-DOE 1997, all)[e]	16,000	20,000	36
Waste Isolation Pilot Plant (DIRS 101814-DOE 1997, all)	790	5,900	5
Molybdenum-99 production (DIRS 101813-DOE 1996, all)	240	520	0.1
Tritium supply and recycling (DIRS 103208-DOE 1995, all)	--	--	0.029
Surplus HEU disposition (DIRS 103216-DOE 1996, all)	400	520	1.1
Storage and Disposition of Fissile Materials (DIRS 103215-DOE 1996, all)	--	2,400[d]	5.5
Stockpile Stewardship (DIRS 103217-DOE 1996, all)	--	38[d]	0.064
Pantex (DIRS 103218-DOE 1996, all)	250[f]	490[d]	0.006
West Valley (DIRS 101729-DOE 1996, all)	1,400	12,000	3.6
S3G and D1G prototype reactor plant disposal (DIRS 103221-DOE 1997, all)	2.9	2.2	0.010
S1C prototype reactor plant disposal (DIRS 103219-DOE 1996, all)	6.7	1.9	0.0037
Container system for Naval spent nuclear fuel (DIRS 101941-USN 1996, all)	11	15	0.045
Cruiser and submarine reactor plant disposal (DIRS 103479-USN 1996, all)	5.8	5.8	0.00095
Submarine reactor compartment disposal (DIRS 103477-USN 1984, all)	--	0.053	NL
Uranium billets (DIRS 103189-DOE 1992, all)	0.50	0.014	0.00056
Nitric acid (DIRS 103212-DOE 1995, all)	0.43	3.1	NL
General radioactive material transportation			
1943 to 2033	310,000	260,000	19
1943 to 2047	330,000	290,000	22
Subtotal of non-repository-related transportation impacts			
1943 to 2033	**330,000**	**310,000**	**94**
1943 to 2047	**350,000**	**340,000**	**97**
Proposed Action			
Mostly legal-weight truck	29,000	5,000	4.5
Mostly rail	7,900 - 8,800	1,200 - 1,600	2.3 - 3.1
Module 1 or 2[g]			
Mostly legal-weight truck	60,000	9,700	8.7
Mostly rail	16,000 - 17,000	2,200 - 3,100	4.2 - 5.9
Total collective dose (total latent cancer fatalities)[h] *and total traffic fatalities*			
Proposed Action			
Mostly legal-weight truck	360,000 (140)	320,000 (160)	98
Mostly rail	340,000 (140)	310,000 (160)	97
Module 1 or 2[g]			
Mostly legal-weight truck	410,000 (160)	350,000 (180)	110
Mostly rail	370,000 (150)	340,000 (170)	100

a. Sources: DIRS 104800-CRWMS M&O (1999, Section 7) except for the Proposed Action and Inventory Module 1 or 2, which are from Table 8-54. All references in this table refer to the original source of information cited in DIRS 104800-CRWMS M&O (1999, Section 7).
b. NL = not listed.
c. -- = reported or included with the general population dose.
d. Includes worker and general population doses.
e. Includes mixed low-level waste and low-level waste; transuranic waste included in DIRS 101814-DOE (1997, Volume 1).
f. Includes all highly enriched uranium shipped to Y-12.
g. The transportation-related radiological collective doses for Inventory Module 1 or 2 include the doses from the Proposed Action (see the definition of Modules 1 and 2 in Section 8.1.2.1).
h. The conversion factors for worker and general population dose to latent cancer fatalities are 0.0004 and 0.0005 latent cancer fatality per person-rem, respectively (DIRS 101856-NCRP 1993, p. 31) occurred in the United States. Therefore, the number of vehicular accident fatalities was used to quantify the cumulative impacts of transportation accidents.

these numbers in perspective, there were 541,532 deaths in the United States during 1998 due to cancer, although the number for any given year understandably fluctuates (DIRS 153066-Murphy 2000, p. 83). This section presents an estimate of latent cancer fatalities slightly greater than 300 over a period of about 100 years (that is, an average of about 3 latent cancer fatalities per year). This value would be indistinguishable from the natural fluctuations in the death rate from cancer.

For transportation accidents involving radioactive material, the dominant risk is due to accidents that are not related to the cargo (traffic or vehicular accidents). Typically, the radiological accident risk (latent cancer fatalities) from transportation accidents is less than 1 percent of the vehicular accident risk (see Table 8-56). In addition, no acute radiological fatalities due to transportation accidents have ever occurred in the United States. Therefore, the number of vehicular accident fatalities was used to quantify the cumulative impacts of transportation accidents.

From 1943 through 2033 an estimated 4 million people would be killed in motor vehicle accidents and 180,000 people would be killed by railroad accidents. From 1943 through 2047, an estimated 4.4 million people would be killed in motor vehicle accidents and 200,000 people would be killed in railroad accidents. Based on the estimated number of traffic fatalities for the reasonably foreseeable actions and for the Proposed Action and Inventory Module 1 or 2 listed in Table 8-58, the transport of radioactive material would contribute about 110 fatalities to these totals.

8.4.2 NEVADA TRANSPORTATION

This section analyzes potential cumulative impacts that Inventory Module 1 or 2 and past, present, and other reasonably foreseeable future Federal, non-Federal, and private actions could have on the construction and operation of a branch rail line or the construction and operation of an intermodal transfer station and associated highway upgrades for heavy-haul trucks in the State of Nevada. The analysis included potential cumulative impacts in the vicinity of the five potential branch rail line corridors, the three potential intermodal transfer station locations, and the five associated potential highway routes for heavy-haul trucks.

With respect to potential cumulative impacts from Inventory Module 1 or 2, there would be no cumulative construction impacts because the need for a new branch rail line or new intermodal transfer station and associated highway upgrades for heavy-haul trucks would not change; that is, whatever DOE would build for the Proposed Action would also serve Module 1 or 2. In addition, because the planned annual shipment rate of spent nuclear fuel and high-level radioactive waste to the Yucca Mountain Repository would be about the same for Module 1 or 2 and the Proposed Action, the only cumulative operations impacts would result because of the extra 14 years of shipping time required for Module 1 or 2. With this basis, the operation and maintenance of a branch rail line or an intermodal transfer station and associated highway route for heavy-haul trucks were analyzed for potential cumulative impacts from Module 1 or 2.

Land-use and ownership impacts identified in Chapter 6 (Section 6.3) would be avoided or otherwise resolved to implement the Proposed Action. However, additional conflicts associated with continued use of the affected land areas could occur due to shipping operations being excluded 14 years beyond that analyzed in the Proposed Action. DOE expects no cumulative impacts from the extended 14 years of operation for Inventory Module 1 or 2 to air quality; hydrology (surface water and groundwater); biological resources and soils; cultural resources; socioeconomics; noise; aesthetics; and utilities, energy, and materials, the impacts of which were assessed on a per shipment, weekly, or annual basis (see Chapter 6, Section 6.3).

Cumulative impacts from Inventory Module 1 or 2 to occupational and public health and safety are included in the occupational and public health and safety impacts of national transportation in

Section 8.4.1. The operation of an intermodal transfer station for more years under Module 1 or 2 would affect waste management impacts. Because of the additional years of operation, more waste of the same types would be generated than for the Proposed Action. However, the small waste quantities generated for Module 1 or 2 would have a minimal impact to the receiving treatment and disposal facilities. Because there would be no large cumulative impacts for any of the resource areas from Module 1 or 2, disproportionately high and adverse cumulative impacts to minority or low-income populations or to Native Americans would be unlikely.

Other than Inventory Module 1 or 2, one other Federal action and several private actions could have the potential for cumulative impacts with the construction and operation of a new branch rail line or intermodal transfer station and associated highway route for heavy-haul trucks.

One private action that could lead to cumulative impacts with the Carlin rail corridor implementing alternative is by Cortez Gold Mine, Inc., which has an existing Pipeline Project mining operation and processing facility (DIRS 103078-BLM 1996, all), a proposed Pipeline Infiltration Project (DIRS 103081-BLM 1999, all), and a possible Pipeline Southeast Expansion Project (DIRS 103078-BLM 1996, p. 5-7) in the Crescent Valley area of Nevada through which the Carlin branch rail line would pass (see Section 8.1.2.3 and Figure 8-5). Because the Carlin corridor would pass through the general area of these projects, there could be cumulative land-use and ownership impacts that would require mitigation.

The analysis for the Carlin rail corridor represents the maximum impact; other rail corridor implementing alternatives would have smaller impacts. Cumulative impacts for the mostly legal-weight truck scenario would also have smaller impacts.

Another private action that could result in cumulative impacts would be shared use of a branch rail line that DOE constructed and operated to transport spent nuclear fuel and high-level radioactive waste to the Yucca Mountain Repository by others (for example, mine operators, private freight shippers) because of the increased rail traffic. Because predicting the increase in rail traffic is not possible at this time, this analysis cannot estimate the cumulative impacts. There could be some added impacts to all the resource areas beyond those evaluated for the Proposed Action in Chapter 6, but there could also be benefits from the improved economic potential for resource development in interior areas of Nevada as well as greater economic development potential for nearby communities. DOE would have to consider these impacts in any decision it made to allow shared use of the branch rail line.

One Federal action and one private action could lead to cumulative impacts with the construction and operation of the Caliente intermodal transfer station. DOE has specified the Caliente site as one of four possible locations for the construction and operation of an intermodal transfer station for the shipment of low-level radioactive waste to the Nevada Test Site (DIRS 103225-DOE 1998, pp. 2-4 to 2-12). In addition, a commercial venture planned by Apex Bulk Commodities for the Caliente site would construct an intermodal transfer station for the transport of copper concentrate. Figure 8-6 shows a possible layout plan for these intermodal transfer stations at Caliente. Section 8.1 provides more information on the potential DOE and Apex intermodal transfer stations. The following sections describe the potential cumulative impact analysis at the Caliente site from the construction and operation of an intermodal transfer station to support the proposed Yucca Mountain Repository, coupled with an intermodal transfer station for shipment of low-level radioactive waste to the Nevada Test Site and an intermodal transfer station proposed by Apex Bulk Commodities.

8.4.2.1 Land Use and Ownership

Chapter 6, Section 6.1.2.1, discusses reasonably foreseeable actions along the rail corridors and heavy-haul truck routes as they would apply to the Proposed Action. The differences in Module 1 and Module 2 in comparison to the Proposed Action are discussed below.

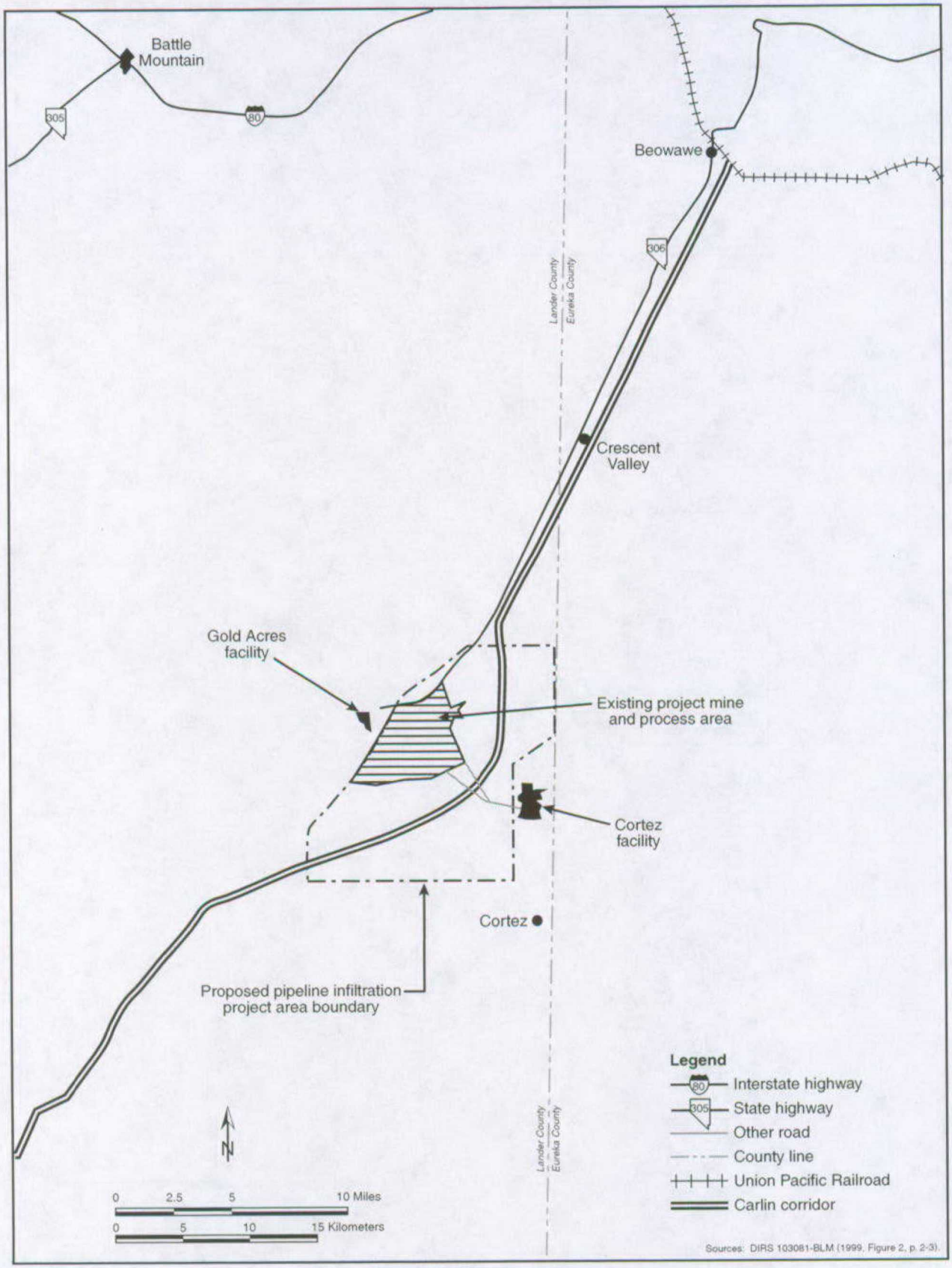

Figure 8-5. Cortez Gold Mine existing pipeline project and proposed pipeline infiltration project.

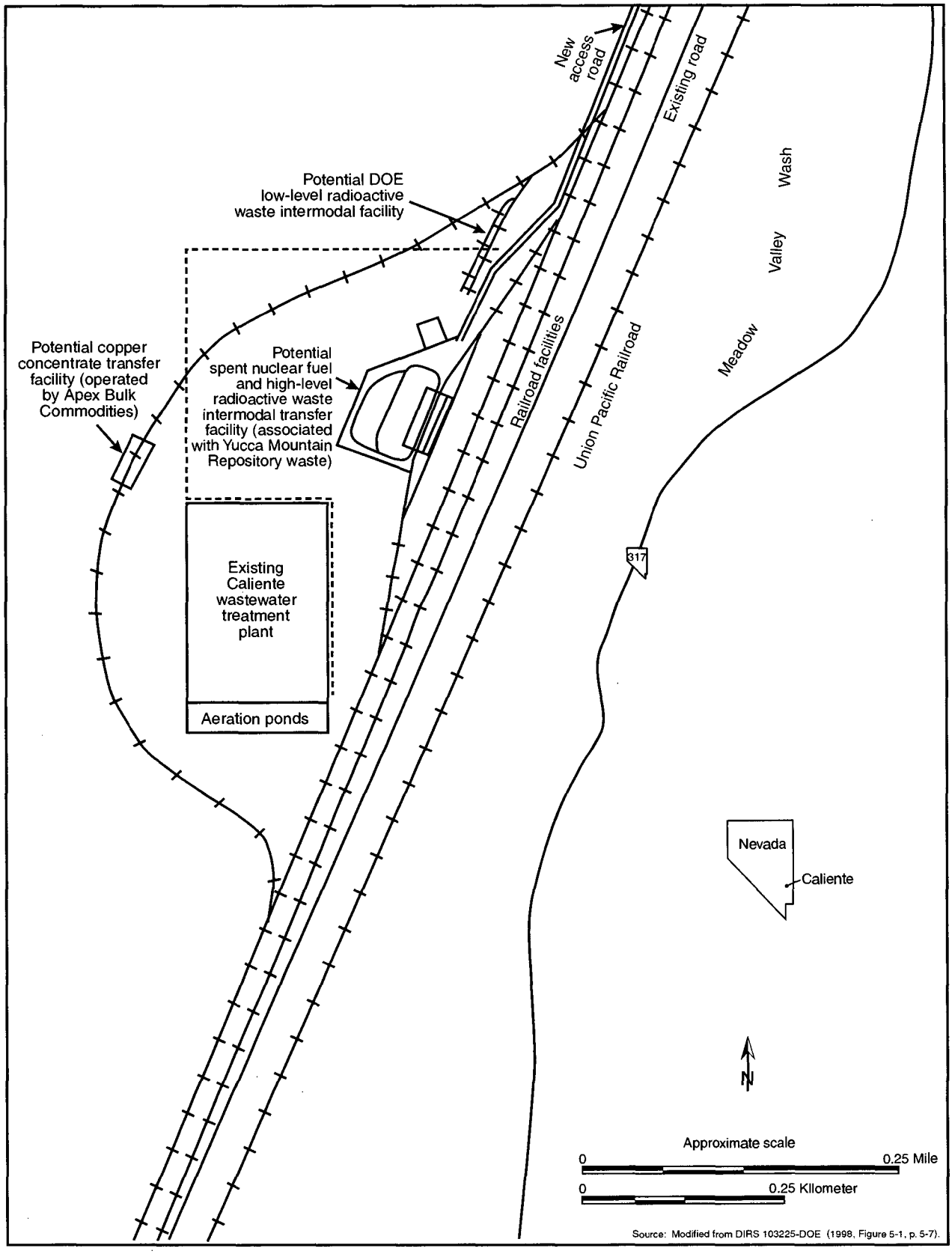

Figure 8-6. Potential locations of intermodal transfer stations at Caliente.

As discussed in Chapter 6, Section 6.3.2.1 there are currently 20 new electric generating plants proposed for the State of Nevada. Of these, 13 are proposed for Clark County in southern Nevada. Currently, plant details are not readily available for a detailed evaluation. However, should these plants be constructed, the rights-of-way necessary for transmission lines and/or natural gas supply lines will most likely be constructed on Bureau of Land Management lands. This would increase the amount of public lands in Nevada that would not be available to other users. Actual impacts associated with the rights-of-way, especially to the candidate rail corridors, would be similar to existing rights-of-way discussed in Section 6.3.2.1.

Section 6.3 of Chapter 6 and Section J.3.1.1 of Appendix J also discuss potential land use and ownership conflicts along candidate rail corridors that could result from the Proposed Action. These include potential conflicts with land areas on the Nellis Air Force Range, Timbisha Shoshone trust land parcel near Scottys Junction, Nevada, planned Ivanpah Valley regional airport, and wilderness study areas. If DOE decided to construct and operate a branch rail line in a rail corridor, it would avoid or mitigate any associated land use and ownership conflicts to implement the Proposed Action. However, additional conflicts associated with continued use of affected land areas could occur due to shipping operations being extended for 14 years beyond that of the Proposed Action.

The land required for the DOE low-level radioactive waste and Apex intermodal transfer stations would add to the approximately 0.21 square kilometer (50 acres) of property that would be required for the intermodal transfer station that would support the proposed Yucca Mountain Repository. The rail spur and facility for the low-level radioactive waste intermodal transfer station would disturb approximately 0.02 square kilometer (5 acres) of land. The Apex transfer facility would be in a building about 90 by 30 meters (300 by 100 feet). In addition, Apex would have a truck maintenance facility in a building about 30 by 18 meters (100 by 60 feet) that it could share with the low-level radioactive waste intermodal facility. The incremental impacts resulting from the changes in land use associated with the three intermodal transfer stations would not result in a substantial cumulative impact.

In addition to the cumulative changes in land use and ownership, DOE considered potential conflicts with plans and policies issued by various government entities along the alternative transportation corridors. In particular, DOE reviewed the Las Vegas 2020 Master Plan (DIRS 157274-City of Las Vegas 2001, all) and various other planning documents, including master plans for the Cities of Caliente (DIRS 157312-Sweetwater and Anderson 1992, all) and Alamo (DIRS 157275-Intertech and Sweetwater 1990, all), and the Lander County Revised Policy for Federally Administered Lands (DIRS 157310-Lander County 1999, all). The Las Vegas Master Plan provides broad policy direction for future land use decisions and related aspects in the City of Las Vegas through 2020. While the Alamo plan deals primarily with zoning issues, the Caliente plan discusses actions for dealing with potential population growth generated by the construction and operation of a repository at Yucca Mountain. The Caliente document generally expresses a need to annex lands that are contiguous to and south of the City in Meadow Valley Wash. The Caliente Intermodal Transfer Facility would be in Meadow Valley Wash (see Chapter 6, Figure 6-17). In general, local government policy indicates a goal of minimizing the conversion of private lands for public use. The transportation corridors and routes described in the EIS, particularly the rail corridors, were developed to minimize impacts to private lands. Section 6.3.2 discusses the amount of private land encountered along the rail corridors and a minimum-to-maximum range for each corridor, including variations and options. However, definitive information is not available on specific tracts of land that could be required for a specific transportation mode or route. Once DOE selected a transportation mode and a specific transportation corridor, more definitive information could be developed on potential conflicts with land uses and various agency plans and policies and, ultimately, the mitigation measures that could be needed to resolve conflicts and impacts on a given area.

8.4.2.2 Air Quality

Air quality cumulative impacts during construction of three intermodal transfer stations—one for intermodal transfers of casks containing spent nuclear fuel and high-level radioactive waste, one for intermodal transfers of low-level radioactive waste shipments to the Nevada Test Site, and one for intermodal transfers of Apex copper concentrate—would not be expected to occur since construction activities would likely occur at different times. The area in which the construction would occur is in attainment of the National Ambient Air Quality Standards and is outside of the Las Vegas Valley particulate matter (PM_{10}) and carbon monoxide nonattainment areas. Even if construction for all three intermodal transfer stations occurred concurrently, administrative controls would be implemented to prevent an adverse impact from collective emissions and dust-generating activities.

Emissions from all sources would be less than applicable standards for repository activities. Emissions would also be below established standards for a mostly legal-weight truck transportation scenario. For a mostly rail scenario, criteria pollutants would be emitted during earthmoving operations for branch rail line or intermodal transfer station and highway upgrade construction projects. Cumulative impacts would be greatest for activities occurring in the Las Vegas air basin, which is currently in nonattainment for particulate matter (PM_{10}) and carbon monoxide. For rail implementing alternatives, emissions into the Las Vegas air basin would exceed emission standards only for construction of a Valley Modified branch rail line. Emission standards could be exceeded by up to 90 percent for PM_{10} and up to 60 percent for carbon monoxide. Emissions from upgrading highways for a Caliente/Las Vegas heavy-haul truck route could also exceed standards for the Las Vegas air basin. PM_{10} emissions could slightly exceed the standard and carbon monoxide emissions could exceed the standard by 10 percent. All other activities would not cause emissions that exceeded emission standards.

During operations, there would be approximately one or two repository rail shipments and as many as 11 associated heavy-haul trucks a week, an average of about three trains and seven trucks a day for DOE low-level radioactive waste shipments, and one truck an hour for the Apex copper concentrate transport. At present, an average of one train an hour and light highway traffic travels through Caliente. The incremental increase in air pollutants from rail and highway traffic resulting from the three actions would cause slight, temporary increases in pollutants, but would not exceed Federal standards (Chapter 6, Section 6.3.2; DIRS 103225-DOE 1998, pp. 4-13, 5-4, and 5-8). Criteria pollutants released during routine operations of the intermodal transfer stations would include nitrogen dioxide, sulfur dioxide, carbon monoxide, and particulate matter. DOE expects these emissions would also be well within Federal standards.

8.4.2.3 Hydrology

Surface Water

Mitigation measures used during the construction of the intermodal transfer stations would minimize surface-water impacts. Floodplain impacts probably would occur if DOE selected the Caliente intermodal transfer station (see Appendix L). If that location was selected, DOE would conduct a detailed floodplain/wetland assessment and integrate good construction practices to minimize impacts. Construction probably would involve some permanent drainage alterations. Runoff rates would differ from natural or existing terrain but, given the relatively small size of the area, there would be little effect on overall runoff quantities for the area (Chapter 6, Section 6.3.3.1; DIRS 103225-DOE 1998, pp. 4-13 and 5-8). DOE expects very small impacts to surface waters during the construction and operation of the stations.

Groundwater

Construction activities for the intermodal transfer stations would disturb and loosen the ground for some time, which could result in higher infiltration rates. However, these activities and their resultant

short-term impacts probably would occur at different times for the three stations. The relatively small sizes of the three facilities would minimize changes in groundwater infiltration rates during operations. Potential sources of contamination would include one to three diesel fuel tanks for the standby generators and heavy equipment for all three stations. The small overall water demand could be met by installing wells or by existing water distribution systems. In addition, the operation of the Apex copper concentrate and DOE low-level radioactive waste intermodal transfer station would only overlap with the beginning years of spent nuclear fuel and high-level radioactive waste shipment to the proposed Yucca Mountain Repository.

8.4.2.4 Biological Resources and Soils

The proposed locations of the intermodal transfer stations are in an irrigated pasture area that is partly wetland. However, because the area was modified as pasture and the native habitat has been degraded, cumulative impacts to biological resources would be low. Construction activities could lead to soil erosion. Water would be applied to suppress dust and compact soil. The operation of the stations would have small cumulative impacts on soils. Erosion damage control would be performed as necessary throughout the operational periods.

8.4.2.5 Cultural Resources

Cumulative impacts could occur to archaeological, historic, and traditional Native American cultural sites from the construction of the intermodal transfer stations. Cultural resource surveys of a portion of the Meadow Wash Area have identified two archaeological sites in the vicinity of the proposed Caliente DOE low-level radioactive waste intermodal site (DIRS 103225-DOE 1998, p. 4-13). Neither site falls within the proposed intermodal transfer station areas. However, Native American consultants have identified these archaeological sites as having significant cultural values for present-day Native American tribes, and construction and operation of the intermodal transfer station at this location could create a cumulative impact to these cultural values. DOE would perform ethnographic studies and archaeological surveys during the engineering design phases and before construction to identify these impacts and address their mitigation.

Impacts to cultural resources could occur along each of the candidate rail corridors where site file and literature searches have indicated a potential for archaeological, historic, and traditional cultural properties (see Chapter 3, Section 3.2.2.1.5). Some impacts to these resources could be cumulative, such the intersection of the National Historic Pony Express Trail by variations of the Carlin Corridor or the construction and operation of a branch rail line in Crescent Valley along the Carlin Corridor, where Native Americans believe that operations at the Cortez Mine have already had an impact on a Native American cemetery. After determining the mode of transportation and the preferred routing, DOE would undertake archaeological field studies and ethnographic evaluations of the corridor to identify further potential impacts and possible mitigative actions to reduce the effects of those impacts.

Some impacts associated with the use of existing highways could be cumulative, depending on the route selected. For example, Native American consultants have identified several places or areas along some of the highways that have cultural significance to regional tribes (see Chapter 3, Section 3.2.2.2.5). Heavy-haul truck traffic could have a cumulative adverse effect on the Goldfield National Register Historic District, although the potential for specific impacts to buildings in the historic district has yet to be fully evaluated. As with other potential components of the Nevada transportation scenario, DOE would complete additional archaeological, historical and ethnographic studies during the engineering design phase to identify and evaluate these types of potential impacts.

8.4.2.6 Socioeconomics

Employment levels for operation of the repository, Apex, and DOE low-level radioactive waste intermodal transfer stations would be 66, 25, and 14 employees, respectively (Chapter 6 and Section 8.1.2.2). Employment associated with the repository and low-level radioactive waste intermodal transfer stations includes operations personnel and truck drivers. Concurrent operations for all three stations would occur over a portion of the entire 24- or 38-year shipping period for the Proposed Action or Inventory Module 1 or 2, respectively. Employment levels would increase gradually to the maximum values listed above and then decrease gradually toward the end of emplacement activities for repository-related workers. Impacts to employment, population, personal income, Gross Regional Product, and state and local government expenditures during station operations would be small for Lincoln County (Chapter 6, Section 6.3.2.2; DIRS 103225-DOE 1998, pp. 4-14 and 5-9).

The truck traffic in the Caliente area would be increased from the three intermodal transfer stations. The small increase would have a very small impact on U.S. Highway 93, which would be used when entering and leaving the intermodal transfer station access road. U.S. 93 is currently characterized as having light traffic. The period of concurrent truck traffic from the three intermodal transfer stations would also occur only over a portion of the 24- or 38-year shipping duration for the Proposed Action or Inventory Module 1 or 2, respectively.

8.4.2.7 Occupational and Public Health and Safety

The incremental impacts resulting from an increase in radiological risk associated with the intermodal transfer stations for the repository and low-level radioactive waste shipments at Caliente would not result in a substantial cumulative impact. The estimated total collective worker dose from the entire DOE low-level radioactive waste intermodal shipping campaign, including transportation impacts, would be about 4.21 person-rem (DIRS 103225-DOE 1998, p. 4-10). This dose, added to the total repository intermodal transfer station and rail and heavy-haul truck shipments worker dose of about 2,200 to 3,300 person-rem for the Caliente intermodal transfer station for Inventory Module 1 or 2 (Appendix J, Table J-59) would be an increase of less than 1 percent. The population dose associated with low-level radioactive waste shipments by truck from the Caliente intermodal transfer station would be 7.55 person-rem for the entire shipping campaign (DIRS 103225-DOE 1998, Table C-11, p. C-23). This dose, added to the dose from shipments in Nevada that use heavy-haul trucks of about 600 person-rem over 38 years, would increase the population dose and associated health effects by less than 1 percent.

In addition to incremental impacts resulting from increases in radiological risk, there would be increments in nonradiological impacts of transportation in Nevada that are not included in the national impacts of transporting spent nuclear fuel and high-level radioactive waste to a Yucca Mountain Repository. These increases would arise from 14 additional years of operating a branch rail line or of maintaining highways for use by heavy-haul trucks and operating an intermodal transfer station. The increments in nonradiological impacts for operation of a branch rail line would include increased traffic fatalities from worker commuting and the transportation of spent nuclear fuel and high-level radioactive waste, as well as repository materials. The increases would range from 0.45 to 1.1 fatalities (see Tables 6-78, 6-79, 6-85, 6-86, 6-93, 6-94, J-61, J-62, and J-63).

8.4.2.8 Noise

There would be an increase in noise levels at Caliente from any of the three candidate intermodal transfer station sites and the associated train switching operations and truck traffic. Noise levels would increase during daytime and night hours for rail activities and during daytime hours for truck shipment activities associated with the repository heavy-haul trucks and the DOE low-level radioactive waste trucks. Apex truck shipments would occur once an hour, 24 hours a day. Noise associated with railcar shipments

would occur as the railcars were uncoupled from trains and transferred in and out of the stations, which could occur during the day or night. Elevated noise levels would occur during loading and unloading operations and briefly as trucks passed on the highway. Trucks would not travel through Caliente for shipments to either Yucca Mountain or the Nevada Test Site. Overall, the elevation of noise levels associated with rail and truck activity near a level that would cause concern would be unlikely. In addition, due to the location of the intermodal transfer stations in an uninhabited canyon area, noise impacts from rail and truck loading and unloading would be low. Cumulative effects would also be limited because operations at the DOE low-level radioactive waste and Apex intermodal transfer stations would overlap only a portion of the shipping campaign associated with the proposed repository.

Future development of the Timbisha Shoshone Trust Lands parcel near Scottys Junction could result in additional impacts. Residences and commercial ventures located near the transportation corridor on this parcel (the Bonnie Claire variation of the Caliente and Carlin rail corridors) could encounter noise levels that would not exceed 90 dB at 15 meters (49 feet) from the route.

8.4.2.9 Aesthetics

Chapter 6, Section 6.1.2.9 discusses direct impacts from the candidate rail corridors and heavy-haul truck routes. Section 6.3.2 discusses indirect visual impacts as they could affect land use along the rail corridors.

The alteration of the landscape immediately surrounding the Bureau of Land Management Class II lands [within about 8 kilometers (5 miles) of the Kershaw-Ryan State Park] could exceed the Class II objective. In addition, the Wilson Pass Option in the Jean Corridor passes through Class II lands [55 kilometers (34 miles)] in the vicinity of Wilson Pass in the Spring Mountains. Class II designation by the Bureau of Land Management could require retention of the existing character of the landscape. However, the area proposed for the Caliente intermodal transfer station has been classified as Class III, which would require partial retention of the existing character of the landscape. The intermodal facilities would not greatly alter the landscape more than the current passing trains and sewage treatment operations. The Class II lands of the Wilson Pass Option would require retention of the existing character of the landscape. Public exposure would be limited due to obstruction by natural vegetation. Therefore, visual impacts would be very small (DIRS 103225-DOE 1998, pp. 4-12 and 5-8).

8.4.2.10 Utilities, Energy, and Materials

Electric power lines with adequate capacity are available near the site. Electric power, water supply, and sewage disposal facilities are currently provided to the sewage treatment facility near the proposed location of the intermodal transfer stations (DIRS 103225-DOE 1998, p. 4-12). Therefore, cumulative impacts to utilities would be small. The quantities of concrete, asphalt, and steel needed to build the intermodal facilities (associated mostly with the repository intermodal transfer station) would be unlikely to affect the regional supply system.

8.4.2.11 Management of Intermodal Transfer Station-Generated Waste and Hazardous Materials

The expected quantities of sanitary waste, small amounts of hazardous waste, and low-level radioactive waste associated with radiological surveys would be unlikely to have large impacts to landfill, treatment, and disposal facilities available for use by this site. Therefore, cumulative impacts for waste management would be small. Only limited quantities of hazardous materials would be needed for station operations, and DOE does not expect these needs to affect the regional supply system (DIRS 103225-DOE 1998, pp. 4-12, 4-13, and 5-8).

8.4.2.12 Environmental Justice

Because there would be no large cumulative impacts to human health and safety from the construction or operation of the intermodal transfer stations, there would be no disproportionately high and adverse impacts to minority and low-income populations. The absence of large cumulative environmental impacts for the general population means that there would be no disproportionately high and adverse environmental impacts for the minority or low-income communities. An evaluation of subsistence lifestyles and cultural values confirms these general conclusions. The foregoing conclusions and evaluations and the commitment by DOE to ensure minimal impacts to cultural resources show that construction and operation of the intermodal transfer stations would not be expected to cause or contribute to disproportionately high and adverse impacts to Native Americans (DIRS 103225-DOE 1998; pp. 4-14 and 5-9).

8.5 Cumulative Manufacturing Impacts

This section describes potential cumulative environmental impacts from the manufacturing of the repository components required to emplace Inventory Module 1 or 2 in the proposed Yucca Mountain Repository. No adverse cumulative impacts from other Federal, non-Federal, or private actions have been identified because no actions have been identified that, when combined with the Proposed Action or Inventory Module 1 or 2, would exceed the capacity of existing manufacturing facilities.

The overall approach and analytical methods and the baseline data used for the evaluation of cumulative manufacturing impacts for Inventory Module 1 or 2 were the same as those discussed in Chapter 4, Section 4.1.15 for the Proposed Action. The evaluation focused on ways in which the manufacturing of the repository components could affect environmental resources at a representative manufacturing site and potential impacts to material sources and supplies.

Table 8-59 lists the total number of repository components required for the Proposed Action and Inventory Modules 1 and 2. As listed, the total number would increase by approximately 30 to 50 percent for Modules 1 and 2 in comparison to the Proposed Action depending on the operating mode and packaging scenario. The highest total number of repository components would be for Module 2, assuming the lower-temperature operating mode using derated waste packages, and this was the number used in the cumulative impact analysis.

Based on the total number of components that would be required over a 38-year period for Inventory Module 1 or 2, the annual manufacturing rate would remain the same as that for the Proposed Action.

Based on the number of drip shields required over a 12-year period for Inventory Module 1 or 2, the annual manufacturing rate would increase about 30 percent over that for the Proposed Action 10-year drip shield manufacturing period.

Thus, the annual Module 1 or 2 impacts for air quality, socioeconomics, material use, and waste generation would be as much as 30 percent higher than those for drip shield manufacturing discussed in Chapter 4, Section 4.1.15 for the Proposed Action, and these impacts would continue for 12 years rather than the 10 years for the Proposed Action. The total number of worker injuries and illness or fatalities would increase in proportion to the increase in components manufactured. The potential number of injuries and illnesses over the entire 50-year period for Module 1 or 2 would be from 930 to 1,300 and the estimated number of fatalities would be 0.44 to 0.63 (that is, no expected fatalities), depending on the operating mode and packaging scenario. As for the Proposed Action, there would be few or no impacts on other resources because existing manufacturing facilities would meet the projected manufacturing needs and new construction would not be necessary and environmental justice impacts (that is, disproportionately high and adverse impacts to minority or low-income populations) would be unlikely.

Table 8-59. Number of offsite-manufactured components required for the Proposed Action and Inventory Modules 1 and 2.

		Operating mode/packaging scenario								
		Proposed Action			Module 1			Module 2		
		UC	C	UC/C[a]	UC	C	UC/C[a]	UC	C	UC/C[a]
Component	Description	HT		LT	HT		LT	HT		LT
Disposal containers	Containers for disposal of SNF[a] and HLW[a]	11,300	11,300	11,300 - 16,900	16,650	16,650	16,650 - 25,350	17,250	17,250	17,250 - 26,000
Rail shipping casks or overpacks	Storage and shipment of SNF and HLW	0	120	0 - 120	0	152	0 - 197	0	157	0 - 202
Legal-weight truck shipping casks	Storage and shipment of uncanistered fuel	120	8	8 - 120	227	13	13 - 227	241	13	13 - 241
Drip shields	Titanium cover for a waste package	10,500	10,500	11,300 - 15,900	15,600	15,600	16,650 - 23,400	16,300	16,300	17,250 - 24,700
Emplacement pallet	Support for emplaced waste package	11,300	11,300	11,300 - 16,900	16,650	16,650	16,650 - 25,350	17,250	17,250	17,250 - 26,000
Solar panels[b]	Photovoltaic solar panels–commercial units	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000
Dry storage cask shells[c]	Metal shell structure of storage vault for aging	0	0	0 - 4,000	0	0	0 - 4,000	0	0	0 - 4,000

a. UC = uncanistered packaging scenario; C = canistered; HT = higher-temperature operating mode; LT = lower-temperature operating mode; SNF = spent nuclear fuel; HLW = high-level radioactive waste.

b. Number of panels in use at any one time.

c. Necessary only if DOE used surface aging as part of a lower-temperature operating mode.

8.6 Summary of Cumulative Impacts

As shown throughout Chapter 8, DOE has examined many actions in the region to determine the potential for cumulative impacts. These impacts could arise from a variety of sources, including other activities in the area and reasonably foreseeable activities.

Table 8-60 summarizes cumulative impacts from all origins. Where qualitative descriptions are more meaningful, these have been included in lieu of quantitative values, although the quantitative values might be provided in this chapter. In other cases, the quantitative values have been provided to give a better representation of the potential impacts.

Table 8-60. Summary of cumulative impacts presented in Chapter 8 (page 1 of 2).

Discipline area	Cumulative impact
Land use and ownership	About 600 square kilometers (150,000 acres) of land would be withdrawn for the repository, but land is already under Federal control. Other actions in the area would cause additional withdrawals, but some land would also be returned under the Southern Nevada Public Land Management Act. Overall, total land withdrawal analyzed in this EIS is less than 0.5 percent of total Federal lands in Nevada.
Air quality	*Nonradiological:* Emissions from all sources would be less than applicable standards for repository activities. Emissions would also be below established standards for a mostly legal-weight truck transportation scenario. For a mostly rail scenario, criteria pollutants would be emitted during earthmoving operations for branch rail line or intermodal transfer station and highway upgrade construction projects. Cumulative impacts would be greatest for activities occurring in the Las Vegas air basin, which is currently in nonattainment for particulate matter (PM_{10}) and carbon monoxide. For rail implementing alternatives, emissions into the Las Vegas air basin would exceed emission standards only for construction of a Valley Modified branch rail line. Emission standards could be exceeded by up to 90 percent for PM_{10} and up to 60 percent for carbon monoxide. Emissions from upgrading highways for a Caliente/Las Vegas heavy-haul truck route could also exceed standards for the Las Vegas air basin. PM_{10} emissions could slightly exceed the standard and carbon monoxide could exceed the standard by 10 percent. All other activities would not cause emissions that exceeded emission standards. *Radiological:* Short-term air emissions from nearby facilities would result in a dose to the maximally exposed individual of no greater than 2.5 millirem per year. Emissions from past nuclear weapons testing could have resulted in a dose of 150 millirem over the lifetime of those individuals exposed during atmospheric weapons testing. Long-term atmospheric releases from the Nevada Test Site and Beatty Low-Level Waste Facility are not expected to result in a dose greater than 0.007 millirem per year in the future.
Hydrology	*Surface Water:* Cumulative impacts on surface water quality are not expected because of the transient nature of the surface water bodies around the repository. Minor changes to runoff and infiltration rates could occur. Construction of access routes at the repository site could have minor and localized effects on several washes at Yucca Mountain. Elsewhere in Nevada, routes being considered for the movement of waste to Yucca Mountain would pass through or near floodplains and wetlands and would be assessed in more detail once a route is selected. *Groundwater:* Groundwater demands from the repository are below the perennial yield of the western two-thirds of the Jackass Flats basin. When combined with Nevada Test Site activities, the annual water withdrawal (600 acre-feet) could exceed the lowest estimate of perennial yield but would not exceed highest estimate of perennial yield. No short-term impacts to groundwater quality are expected. Long-term impacts to groundwater could be as high as 0.007 millirem per year under the conservative assumption that impacts from the Nevada Test Site and the repository overlap spatially and chronologically.
Biological resources and soils	Disturbance of desert tortoise habitat would occur. Wildlife would be displaced as a result of repository and transportation activities that used additional land in the region. Little or no loss of wetland habitat is expected. No expected impacts to any species.
Cultural resources	Adverse impacts to cultural resources are not expected. Potential for encountering cultural resources exists along transportation corridors. DOE would use practices to avoid or mitigate adverse impacts in these areas.
Socioeconomics	As many as 3,400 direct jobs during peak employment year from repository activities. Intermodal transfer station or rail line in Lincoln County could change employment estimates by 5 percent.

Table 8-60. Summary of cumulative impacts presented in Chapter 8 (page 2 of 2).

Discipline area	Cumulative impact
Occupational and public health and safety	*Nonradiological:* Repository activities, including transportation, could result in up to 37 fatalities[a] from construction to closure of the repository.
	Radiological: Radiation exposure could result in up to 32 latent cancer fatalities[a] to workers. Short-term radiation exposure to the public could result in up to 5 latent cancer fatalities[a] in the population. Short-term radiation exposure to the maximally exposed individual could cause an increased cancer risk of about 1.2×10^{-6}. Emissions from past nuclear weapons testing could have caused an increased risk of about 7.5×10^{-5} for affected individuals. Long-term releases from the repository and other actions in the area could cause an increased risk of fatal cancer in the future of 0.000006 over the lifetime of an exposed individual.
Noise	Noise levels would be transient and would not be expected to cause adverse impacts for repository operation. Future development of the Timbisha Shoshone Trust Lands near Scottys Junction could result in residents of that parcel being subjected to transient noise from a candidate rail corridor through the parcel.
Aesthetics	Placement of exhaust stacks on top of Yucca Mountain could impact visual resources because stacks would be visible from some distance. If the stacks were equipped with beacons, the visual effect would be more noticeable at night. Disturbed areas would be likely on former Federal lands that are used for commercial and private purposes. Acquisition of private lands by the Federal Government could result in reduced aesthetics impacts and possible return of land to natural state.
Utilities, energy, materials, and site services	Peak electrical power demand would require upgrade to electrical transmission and distribution system. Other site systems and nearby suppliers of materials would be sufficient to meet repository and transportation needs. Construction of electrical generating facilities in the region surrounding the repository would increase the electrical generating capacity for the area.
Waste management	If nonradioactive, nonhazardous solid waste was disposed of at the Nevada Test Site, existing landfills would need to be expanded. Other waste types could be disposed of at nearby facilities without exceeding capacities of those facilities.
Environmental justice	No disproportionately high and adverse cumulative impacts to minority or low-income populations would occur for repository, transportation, or other activities. DOE recognizes that Native American people living in the region near Yucca Mountain have concerns about the protection of traditions and the spiritual integrity of the land that extend to the propriety of the proposed repository, and that implementing the Proposed Action would continue restrictions on access to the proposed site.

a. These values represent the maximum for each environmental resource area. Because the maximum could occur for different implementing alternatives in the various resource areas, simple addition of these maximums could overstate the impacts due to mixing of incompatible alternatives.

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Note: In an effort to ensure consistency among Yucca Mountain Project documents, DOE has altered the format of the references and some of the citations in the text in this Final EIS from those in the Draft EIS. The following list contains notes where applicable for references cited differently in the Draft EIS.

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9

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9. MANAGEMENT ACTIONS TO MITIGATE POTENTIAL ADVERSE ENVIRONMENTAL IMPACTS

This chapter describes management actions that the U.S. Department of Energy (DOE or the Department) is considering to reduce or mitigate adverse impacts to the environment that could occur if the Department implemented the Proposed Action to construct, operate and monitor, and eventually close a geologic repository for the disposal of spent nuclear fuel and high-level radioactive waste at Yucca Mountain. In keeping with previous chapters in this environmental impact statement (EIS), this chapter contains separate discussions for the mitigation of repository impacts and the mitigation of impacts from transportation activities. Mitigation includes activities that (1) avoid the impact altogether by not taking a certain action or parts of an action; (2) minimize impacts by limiting the degree or magnitude of the action and its implementation; (3) repair, rehabilitate, or restore the affected environment; (4) reduce or eliminate impacts over time by preservation or maintenance operations during the life of the action; or (5) compensate for the impact by replacing or substituting resources or environments.

This chapter also describes mitigations in environmental resource areas where DOE has identified adverse impacts and analysis has indicated that mitigation has the potential to reduce those impacts. This chapter does not discuss mitigations for environmental resource areas for which analyses have not identified a potential for impacts.

Changes in repository design have resulted in modifications to some planned or potential mitigation measures identified in the Draft EIS. In addition, DOE has identified some new mitigation measures.

Apart from the impact findings and mitigations discussed in this EIS, Section 116(c) of the Nuclear Waste Policy Act, as amended (NWPA) states that "the Secretary shall provide financial and technical assistance to (an affected unit of local government or the State of Nevada)... to mitigate the impact on such (an affected unit of local government or the State of Nevada) of the development of (a) repository and the characterization of (the Yucca Mountain) site." Such assistance can be given to mitigate likely "economic, social, public health and safety, and environmental impacts." Within that broad framework, neither Section 116 nor any other provision of the NWPA limits the impacts that are subject to assistance under Section 116 to the environmental impacts considered in this EIS.

The fact that the EIS analysis has determined that the implementation of the Proposed Action would not cause substantial socioeconomic impacts to communities in Nevada or to the State of Nevada does not prevent local governments or the State government from receiving assistance to address economic, social, public health, or environmental impacts under Section 116(c).

The Section 116 impact assistance review process and the Yucca Mountain Repository EIS process are distinct from one another, and the implementation of one would not depend on the implementation of the other. The provision of assistance under Section 116 would not necessarily be limited either by the impacts identified in this EIS or by its findings on such impacts. Any decision to provide assistance under Section 116 will be based on an evaluation of a report submitted by an affected unit of local government or the State of Nevada pursuant to Section 116 to document likely economic, social, public health and safety, and environmental impacts.

9.1 Types of Management Actions

The design, construction, operation and monitoring, and closure planning for the proposed repository incorporate physical features, procedures, and safeguards to reduce environmental consequences. Some of these features, procedures, and safeguards are the result of DOE determinations based on site characterization activities and the ongoing evaluation of planning and design for the proposed repository.

To complement the measures already incorporated, DOE is considering a range of additional mitigation measures aimed at reducing consequences of the proposed repository project. The repository and transportation mitigation analyses in this chapter discuss impact reduction measures that DOE expects to implement as well as other mitigations DOE is considering.

9.1.1 DOE-DETERMINED IMPACT REDUCTION FEATURES, PROCEDURES, AND SAFEGUARDS

DOE has studied the Yucca Mountain site, vicinity, and regions of influence for more than a decade and has accumulated considerable knowledge. The Department has identified many improvements in its project design and plan to reduce potential impacts. The Proposed Action includes commitments to reduce impacts that DOE has made as a result of its site characterization studies and the ongoing evaluation of repository planning and design. DOE would undertake these measures if the Secretary of Energy recommended the site for development and authorization was provided to proceed with the Proposed Action. This chapter identifies these commitments in appropriate areas.

9.1.2 MITIGATION MEASURES UNDER CONSIDERATION FOR INCLUSION IN PROJECT PLAN AND DESIGN

DOE has conducted extensive site characterization studies, and continues to evaluate whether to commit to additional mitigation measures in the event the site is designated and the Nuclear Regulatory Commission grants a license for the repository project. DOE is considering these additional measures to reduce the potential effects of the repository project. This chapter identifies measures under consideration in appropriate subject areas.

9.1.3 ONGOING STUDIES THAT COULD INFLUENCE MITIGATION MEASURES IN THE PROJECT PLAN AND DESIGN

Accelerator Transmutation of Waste technology has been under consideration for many years as a process for the treatment of nuclear waste. This technology would involve the use of a chemical separation process, a linear accelerator, and a subcritical nuclear assembly. The chemical process would separate transuranic and certain long-lived radioisotopes from the spent nuclear fuel. The linear accelerator and subcritical nuclear assembly would change the transuranic and long-lived radioisotopes into short-lived radioisotopes and stable (nonradioactive) elements.

The National Research Council studied Accelerator Transmutation of Waste and other technologies for use in the treatment of spent nuclear fuel (DIRS 103403-National Research Council 1996, all). The study concluded that:

- The use of separation and transmutation to treat spent nuclear fuel is technically feasible.
- Treatment would cost many tens of billions of dollars and require many decades to implement.
- While other technologies would be based on considerable experience, Accelerator Transmutation of Waste technology would require extensive development before DOE could realistically assess its technical feasibility.
- No separation and transmutation technology offers sufficient promise to abandon current spent nuclear fuel management programs or delay the opening of the first nuclear waste repository.
- Even with a successful separation and transmutation program, a monitored geologic repository would still be necessary because the process would be unlikely to provide perfect transmutation, in which

case there would be residual materials requiring long-term isolation from human populations and concentrations of human activity.

- Separation and transmutation technology might delay or eliminate the need for a second repository, but there are legislative and less expensive technical ways to increase the capacity of the first repository by an equivalent amount.

In the Fiscal Year 1999 Energy and Water Appropriation Act, Congress directed DOE to conduct an Accelerator Transmutation of Waste study and to prepare a plan for the development of this technology in Fiscal Year 1999. In October 1999, DOE submitted to Congress *A Roadmap for Developing Accelerator Transmutation of Waste (ATW) Technology* (DIRS 110625-DOE 1999, all). Key elements of the report include:

- The identification of technical issues requiring resolution
- The delineation of a 6-year science-based program to begin addressing resolution of technical issues
- If technical issues are resolved, a research and development plan for construction of a demonstration facility to become operational in 2035
- If research and development are successful, a production plan for transmutation of 79,000 metric tons (87,000 tons) of civilian waste over 90 years
- A listing of possible collaborative efforts with other countries
- The identification of institutional challenges of an Accelerator Transmutation of Waste program
- A discussion of possible benefits to other programs
- An estimate of the life-cycle costs for transmutation and processing of the currently projected inventory of civilian spent nuclear fuel

The report conclusions include the following:

- The implementation of Accelerator Transmutation of Waste technology will require years of additional research.
- The implementation of Accelerator Transmutation of Waste technology would require a significant investment in research and development funding.
- Accelerator Transmutation of Waste is technically feasible, but it would require billions of dollars and many decades to fully construct and operate a transmutation facility, and it would not eliminate the need for a repository.
- Complex institutional and public acceptance issues regarding the technology would have to be resolved.

A successful Accelerator Transmutation of Waste program would last approximately 117 years and would cost at least $281 billion dollars. Such a program could reduce the radioactivity of commercial waste by a factor of 10 to 100.

Since the October 1999 publication of the Accelerator Transmutation of Waste Roadmap, DOE's transmutation research and development program has undergone significant changes. It is currently managed as an Advanced Accelerator Applications program, with the goal of evaluating the technical feasibility of nuclear waste transmutation using a broader technology base than was covered by the earlier Roadmap. A general description of the modified program was presented in *The Advanced Accelerator Applications Program Plan* on March 30, 2001 (DIRS 156711-DOE 2001, all).

Among other aspects of the program, the plan discusses the proposed design and operation of an Accelerator Driven Test Facility as part of a research and development program that would evaluate combinations of critical and subcritical transmutation systems. These have the potential for utilizing the strengths of each transmutation technology in combination, the effectiveness of which is expected to be greater than either taken separately. A revised roadmap describing the program's new directions is currently being prepared.

The elimination or reduction of certain radionuclides in the disposal inventory could add flexibility to the design of the repository and reduce uncertainties about its performance. DOE will incorporate information from any future studies in its decisions during the preparation of a Mitigation Action Plan for this EIS and during the repository licensing process, if those became necessary.

9.1.4 MITIGATION ACTION PLAN

To minimize potential impacts from the Proposed Action (if the repository site was designated), DOE is evaluating the preparation of a Mitigation Action Plan containing specific commitments for mitigating adverse environmental impacts associated with the Proposed Action. The plan would describe specific actions DOE would take to implement mitigation commitments and would reflect available information about the course of action. DOE could revise this Plan as more specific and detailed information became available.

The Mitigation Action Plan would incorporate all practicable measures to avoid or minimize adverse environmental and human health impacts that could result from the implementation of the Proposed Action. The Plan would contain:

1. An introduction describing the basis, function, and organization of the Plan
2. A summary of the impacts to be mitigated
3. A statement of mitigation goals, objectives, and performance standards
4. A description of specific mitigation actions
5. A description of the Mitigation Action Plan monitoring and reporting system that DOE would implement to ensure that elements of the Plan were met

Precise mitigation measures cannot be identified at present. For example, transportation route selection decisions would affect the potential for impacts to areas of importance to Native Americans, to local communities, or to the general environment; repository or transportation corridor construction activities could reveal new cultural resource sites. DOE would consult with Native American tribes and local governments in developing the Mitigation Action Plan. If activities associated with the Proposed Action could affect specific sacred or ceremonial areas or resources or other areas of importance, DOE could develop procedures for controlled access as long as project integrity was not compromised.

DOE would prepare the Mitigation Action Plan in compliance with applicable regulations. The Plan would accompany any License Application to the Nuclear Regulatory Commission.

9.1.5 MONITORING

DOE would conduct the following monitoring activities during all phases of the project to ensure the implementation of the Proposed Action as described and to ensure mitigation of impacts:

- Continue the performance confirmation program which consists of tests, experiments, and analyses, during all phases of the repository project to evaluate the accuracy and adequacy of the information it used to determine with reasonable assurance that the repository would meet the performance objective for the period after permanent closure.
- Monitor groundwater quality, air emissions, and the repository workplace to ensure project worker safety and other aspects of project interaction with the natural and human environment during the construction, operation and monitoring, and closure phases of the project.
- Conduct cultural resources monitoring activities as appropriate before and during surface disturbance activities to identify and assess the potential for impacts to previously unidentified archaeological resources.
- Conduct monitoring and reporting activities to ensure the implementation and effectiveness of mitigation measures and to ensure in general the accomplishment of the elements of the Mitigation Action Plan.
- Monitor material emplaced in the repository starting with the first emplacement of waste packages and continuing through closure.
- After the completion of emplacement, continue to monitor and inspect waste packages and continue performance confirmation activities.
- After sealing the repository openings, conduct postclosure monitoring to ensure acceptable repository performance. Details of this program would be defined during processing of the license amendment for repository closure rather than now to take advantage of appropriate technology, including technology that might not be currently available.

9.2 Yucca Mountain Repository

This section discusses mitigation measures DOE has determined it would implement, or has identified for consideration, to reduce potential impacts from the construction, operation and monitoring, and eventual closure of the proposed repository.

9.2.1 LAND USE

The Yucca Mountain site is remote and is partly withdrawn for specific Federal uses. The permanent withdrawal of land for the repository would prevent public use of the withdrawn lands for other purposes.

Land Use Measures Under the Proposed Action

- Reclaim lands disturbed during the construction process and not required for permanent use by the repository and surface support facilities.

9.2.2 AIR QUALITY

Construction and operation activities such as vehicle movement, clearing, grading, rock pile maintenance, and excavating could generate substantial quantities of fugitive dust. Standard mitigation measures could reduce dust emissions from fugitive dust-generating activities at the Yucca Mountain site. Other dust-generating sources such as operation of the concrete batch plant and backfill preparation facilities would be comparatively small contributors. DOE expects concentrations of other criteria pollutants to be less than 1 percent of regulatory limits (see Chapter 4, Section 4.1.2). Activities that would generate other criteria pollutants include the operation of internal combustion engines in construction equipment, boiler operation, and similar devices, along with limited emissions of radionuclides.

Air Quality Measures Under the Proposed Action

- Reduce fugitive dust emissions using standard dust control measures routinely applied during construction projects including, for example, routine watering of unpaved surfaces; wet suppression for material storage, handling, and transfer operations; and wind fences to control windblown dust. The efficiency of these controls tends to vary depending on site characteristics, but it ranges from a 60- to 80-percent reduction in fugitive dust emissions (DIRS 103676-Cowherd, Muleski, and Kinsey 1988, p. 5-22).

- Reduce maximum fugitive dust concentrations with working controls such as scheduling construction operations to minimize concurrent generation by activities that were near each other (for example, conducting adjacent clearing and grading activities at different times).

- High-efficiency particulate air filters and modern facility design to minimize the potential for airborne contamination.

9.2.3 HYDROLOGY

This section describes potential mitigation measures for surface water and groundwater.

9.2.3.1 Surface Water

Potential impacts to surface water from the construction, operation and monitoring, and eventual closure of the proposed repository would fall into the following categories: (1) introduction of contaminants, (2) alteration of drainage either by changing infiltration and runoff rates or channel courses, and (3) flood hazards. Changes in infiltration and runoff rates could alter flow rates in channels, cause ponding, and increase erosion. DOE expects such impacts to be minimal (see Chapter 4, Section 4.1.3). Nevertheless, the mitigation of impacts could produce such benefits as erosion control and pollution prevention.

Flash floods could spread contamination from accidental spills. Design and operational controls could mitigate the potential for contamination of surface water from accidental releases of radiological or hazardous constituents. DOE's intent would be to respond rapidly with appropriate cleanup actions.

Surface-Water Measures Under the Proposed Action

- Minimize disturbance of surface areas and vegetation, thereby minimizing changes in surface-water flow and soil porosity that would change infiltration and runoff rates.

- Mitigate flood hazards by designing facilities to withstand or accommodate a 100-year flood, and by designing facilities that would manage radiological materials to withstand the calculated probable maximum flood.

- Minimize physical changes to drainage channels by building bridges or culverts where roadways would intersect areas of intermittent water flow. Use erosion and runoff control features such as proper placement of pipe, grading, and use of rip-rap at these intersections to enhance the effectiveness of the bridges or culverts.

- Maintain natural contours to the maximum extent feasible, stabilize slopes, and avoid unnecessary offroad vehicle travel to minimize erosion.

- In and near floodplains, follow reclamation guidelines (DIRS 102188-YMP 1995, all) for site clearance, topsoil salvage, erosion and runoff control, recontouring, revegetation, siting of roads, construction practices, and site maintenance.

- Implement best management practices, including training employees in the handling, storage, distribution, and use of hazardous materials, to provide practical prevention and control of potential contamination sources.

- Conduct fueling operations and store hazardous materials and other chemicals in bermed areas away from floodplains to decrease the probability of an inadvertent spill reaching the floodplains.

- Provide rapid response cleanup and remediation capability, techniques, procedures, and training for potential spills.

- Use sediment-trapping devices such as hay or straw bales, fabric fences, and devices to control water flow and discharge to trap sediments moved by runoff.

Surface-Water Measures Under Consideration

- Use physical controls such as secondary containment for fuel storage tanks to reduce the potential for releases to mingle with stormwater runoff.

9.2.3.2 Groundwater

Impacts to groundwater from the proposed repository could include introduction of contaminants and alteration of infiltration and runoff rates that could change the rate of recharge to the aquifer. Design and operational actions to reduce such impacts for the active life of the repository and the alteration of infiltration and runoff rates would be identical to those described above for surface-water impacts.

The purpose of proposing a monitored geologic repository is to provide a natural setting that, with engineered repository and waste package barriers, would provide long-term confinement and isolation of spent nuclear fuel and high-level radioactive waste. Two aspects of groundwater analysis—(1) the ability of the repository and the engineered barriers to keep waste packages isolated from groundwater over time, and (2) the extent to which groundwater could become contaminated with radionuclides from breached waste packages and transport radionuclides to places where human exposure could occur—are central elements in determining the potential for a proposed repository to succeed.

DOE's detailed study of the Yucca Mountain site has resulted in the inclusion of many engineered barrier elements to complement the site's natural characteristics to keep unsaturated zone groundwater from reaching and transporting radionuclides and, thereby, to reduce the long-term potential for impacts. The following summarizes the engineered barrier elements that would contribute to a reduction of the long-term potential for impacts from radionuclides isolated in a Yucca Mountain Repository.

Groundwater Measures Under the Proposed Action

- The Yucca Mountain site has several characteristics (as described in Chapter 3) that indicate a high potential for reducing possible long-term impacts from the disposal of spent nuclear fuel and high-level radioactive waste, including:
  - The Yucca Mountain vicinity is isolated from concentrations of human population and human activity and is likely to remain so.
  - The climate is arid and conducive to evapotranspiration, resulting in a relatively small volume of water that has the capability to move as groundwater within the unsaturated zone of the mountain.
  - The groundwater table is substantially below the level at which DOE would locate a repository, providing additional separation from materials emplaced in waste packages.
  - The sparsely populated hydrogeologic basin into which groundwater from Yucca Mountain flows is closed, providing a barrier to a general spread of radionuclides in the event waste packages were breached and radionuclides reached groundwater.
- Use performance confirmation measures to detect any departure from expected capability of the repository in confining and isolating waste.
- Recycle water collected in subsurface areas for use in dust suppression and other activities, to minimize water consumption.
- Implement measures to minimize the potential for water used during operations to interfere with waste isolation in the repository.
- Minimize surface disturbance, thereby minimizing changes in surface-water flow and soil porosity that could change infiltration and runoff rates.
- Use corrosion-resistant waste packages and other engineered barriers, such as drip shields, to prevent water intrusion.
- Monitor to detect and define unanticipated spills, releases, or similar events.
- Evaluate scenarios to minimize the potential for different heat levels to have a direct effect on corrosion rates and the integrity of containers, as well as on the hydrology, geochemistry, and stability of the drifts. High levels could indirectly affect general groundwater flow and the transport of radionuclides.
- Use stainless-steel-lined concrete basins that include leak detection systems, pool cleanup equipment, and transfer equipment capable of moving waste in the event of a leak, and that are designed to seismic standards to minimize the potential for leaks in fuel transfer and holding pools located inside surface facilities.
- Use drip shields to deflect water migrating downward through the unsaturated zone to waste emplacement areas.

9.2.4 BIOLOGICAL RESOURCES AND SOILS

Potential impacts to biological resources and soils from repository construction, operation and monitoring, and closure could result from land clearing, vehicle movement, materials placement,

trenching and excavation, and accidents. This section discusses the potential mitigation of impacts that could affect the desert tortoise and biological resources and soils in general.

9.2.4.1 Desert Tortoise

The desert tortoise is the only Federally protected species that resides on the site of the proposed repository (see Chapter 3, biology sections). Activities that could cause impacts to desert tortoises include site clearing, vehicle traffic, pond management, and taking of habitat. Since 1990, DOE has been conducting site characterization activities in accordance with Fish and Wildlife Service biological opinions on the potential for impacts to desert tortoises (DIRS 104618-Buchanan 1997, pp. 1 and 2). During these activities, five desert tortoises are known to have been killed by site characterization activities, all by vehicle traffic. A recent report (DIRS 103194-CRWMS M&O 1998, p. 9) indicates that 27 of 28 tortoise relocations were successful and that two nest relocations were also successful. The one unsuccessful relocation involved a tortoise that returned to the area of disturbance and became one of those killed by traffic.

DOE submitted to the U.S. Fish and Wildlife Service a biological assessment of the effects of construction, operation and monitoring, and closure of a geologic repository at Yucca Mountain. The U.S. Fish and Wildlife Service has produced a Final Biological Opinion on the effects of construction, operation and monitoring, and closure of a geologic repository at Yucca Mountain (see Appendix O). The Final Biological Opinion establishes conditions for repository construction, operation and monitoring, and eventual closure as well as for the remaining site activities prior to repository construction (if the site was approved). The Final Biological Opinion does not evaluate effects that could occur to the desert tortoise from the construction of transportation infrastructure and transportation of materials.

In its Final Biological Opinion, the U.S. Fish and Wildlife Service lists five reasonable and prudent measures to minimize impacts to the desert tortoise, and then lists 18 terms and conditions with which DOE must comply to implement the five measures. The Final Biological Opinion states reporting requirements upon the location of an injured or dead desert tortoise and conservation recommendations to minimize or avoid adverse effects on listed species or critical habitat. If the repository was authorized, DOE would observe and implement all terms and conditions, reporting requirements, and conservation recommendations that the U.S. Fish and Wildlife Service has established in its Final Biological Opinion to protect the desert tortoise. DOE expects to observe and implement all terms and conditions, reporting requirements, and conservation recommendations in any future biological opinions regarding the effects of transportation or other project activities on the desert tortoise or other listed species.

As discussed in Chapter 4, the proposed repository location is at the extreme northern edge of the range of the desert tortoise, and the population of tortoises at that location is small in relation to other portions of its range. No part of the repository location has been declared critical habitat for the desert tortoise.

Desert Tortoise Measures under the Proposed Action

DOE adopts all impact reduction measures and all terms and conditions established by the U.S. Fish and Wildlife Service to protect the desert tortoise.

The following text summarizes the five reasonable and prudent measures established in the U.S. Fish and Wildlife Service's Final Biological Opinion (see Appendix O), and identifies the terms and conditions that the Biological Opinion has set forth to implement each reasonable and prudent measure:

1. Minimize take of desert tortoises due to project-related activities and operation of heavy equipment

- A qualified biologist would conduct clearance surveys for tortoises before vegetation removal or soil disturbance of more than 0.02 square kilometer (5 acres) or when records indicated that tortoises could occur in the area to be disturbed. Project activity would be moved if there was an adjacent area free of tortoises on which the activity could be conducted. If no suitable site was available, the biologist would determine the site having the smallest impact on tortoises and their habitat.

- The biologist would conduct 100 percent coverage clearance surveys the day before or the day of surface-disturbing activity, during the tortoise activity season, and within 7 days before surface-disturbing activity during hibernation. If tortoises or eggs were found, they would be moved pursuant to U.S. Fish and Wildlife Service guidelines. Burrows would be conspicuously flagged and avoided by at least 9 meters (30 feet).

- Unavoidable burrows would be inspected. If unoccupied, burrows would be collapsed to prevent tortoise entry. If tortoises or eggs were present, they would be excavated by hand and moved.

- If removed from a burrow, a tortoise would be placed in the shade of a shrub or an existing, similar, unoccupied burrow. A tortoise moved when in hibernation, estivation, or brumination (dormant states due to heat or cold) would be placed in an adequate unoccupied or constructed burrow.

- Project activities that could endanger a tortoise would cease if a tortoise was found on a project site and would not resume until after the tortoise moved or was moved out of danger by the biologist.

- A desert tortoise biologist or environmental monitor would be at the site during all phases of construction to ensure compliance with the Biological Opinion and to protect tortoises from harm. The environmental monitor would be responsible for: (1) enforcing the litter-control program; (2) ensuring that tortoise-proof fences were maintained; (3) ensuring that tortoise habitat disturbance was restricted to authorized areas; (4) ensuring storage of all equipment and materials within construction zones or previously disturbed areas; (5) ensuring that all vehicles used existing graded or paved roads or stayed within construction zones; (6) ensuring inspection of open trenches and other excavations; (7) ensuring that speed limits were observed; and (8) ensuring compliance with all terms and conditions of the Biological Opinion. Environmental monitors would not be authorized to handle tortoises.

- Vehicles would not be driven off existing roads in nonemergency situations unless authorized by DOE. Vehicle paths would be cleared of tortoises pursuant to terms of the Biological Opinion.

- Vehicles would be driven at speeds within posted limits on existing roads, and would not exceed 40 kilometers (25 miles) per hour on unposted roads.

- DOE would continue to present a tortoise education program to all employees on the project site and would address specific issues identified in the Biological Opinion. The education program would include definition of "take" and specification, actions that must be avoided, procedures for handling tortoises found on roads, and identification of personnel authorized to handle or otherwise capture and relocate tortoises.

- Marking or telemetry of tortoises would not be allowed.

2. Minimize entrapment of tortoises in open trenches.

   - During tortoise active season, all open trenches with slopes steeper than 0.3 meter (1 foot) rise per 0.9 meter (3 feet) of length would be fenced off, covered, or constructed with escape ramps if they were not immediately backfilled.

   - Open trenches would be inspected for entrapped animals immediately prior to backfilling.

   - If a tortoise was discovered in a trench, all activities associated with the trench would cease until a qualified biologist had removed the tortoise.

3. Minimize predation on tortoises by ravens drawn to the project area.

   - DOE would implement a litter control program that would include the use of covered, raven-proof trash receptacles; disposal of edible trash in trash receptacles after each workday; and disposal of trash in a sanitary landfill. Materials placed in a landfill would be covered often enough to prevent ravens and other predators from feeding in the area.

4. Minimize destruction of tortoise habitat due to project activities

   - DOE would revegetate areas no longer required by the project in accordance with existing procedures and pursuant to site-specific rehabilitation plans prepared in accordance with the Biological Opinion.

5. Ensure compliance with reasonable and prudent measures, terms and conditions, reporting requirements, and reinitiation requirements in the Biological Opinion.

   - DOE personnel would have to acquire appropriate State permits from the Nevada Division of Wildlife prior to handling a desert tortoise, carcass, or egg.

   - DOE would designate a field representative (who could also serve as the environmental monitor), who would be responsible for overseeing compliance with protective stipulations and for coordinating compliance with the terms and conditions of the Biological Opinion, and who would have authority to halt construction equipment activities that could be in violation of the protective stipulations.

   - DOE would keep an up-to-date log of all actions related to the consultation, including acreage affected, habitat rehabilitation actions completed, number of desert tortoises taken and by what means (injured, killed, captured and displaced, or found in trenches or pits). The information would be provided to the U.S. Fish and Wildlife Service Las Vegas Office in the form of an annual report on February 28 of each year during which activities addressed by the Biological Opinion occurred.

9.2.4.2 General Biological Resources and Soils

Impacts to biological resources at the Yucca Mountain site could include habitat fragmentation, loss of individual members of different species, and encroachment of noxious weeds.

Potential soil impacts or concerns related to the proposed repository can be categorized as (1) increased soil erosion rates, (2) slow recovery rate of disturbed soils in the Yucca Mountain environment, and (3) introduction of contaminants. Erosion could result in the loss of the thin topsoil from the disturbed

areas, which could affect long-term recovery, be a threat to structures in the region, and result in increased depositions downhill.

General Biological Resources and Soils Measures Under the Proposed Action

- Use the measures described in Section 9.2.2 to control erosion, dust, and particulate matter and therefore to lessen the consequences for biological resources and soils from repository construction, operation and monitoring, and closure.
- Use dust suppression measures such as application of water or environmentally sensitive methods to minimize wind and other erosion and aid recovery on disturbed areas.
- Conduct preconstruction surveys in floodplains to ensure that work would not affect important biological resources and to determine the reclamation potential of sites.
- Consider measures to relocate or avoid sensitive species in floodplains.
- If construction could threaten important biological resources in floodplains, and modification or relocation of the roads and rail line would not be reasonable, develop additional mitigation.

General Biological Resources and Soils Measures Under Consideration

- Align and locate facilities, roadways, cleared areas, laydown areas, and similar construction activities to minimize fragmentation of habitat potentially affected by the proposed project.
- Mitigate potential soil erosion by minimizing areas of surface disturbance and using engineering practices to stabilize disturbed areas. These practices could include such measures as stormwater runoff control through the use of holding ponds, baffles, and other devices and the compacting of disturbed ground, relocated soil, or excavated material in places outside desert tortoise habitat.
- Mitigate the introduction of contaminants to soils, using methods similar to those described for surface-water impacts (see Section 9.2.3.1).
- To aid recovery, strip and stockpile topsoil from disturbed areas (excavated rock pile, etc.). When the disturbed areas are no longer needed, spread the topsoil over the areas and reseed the soil to improve the success of vegetation reestablishment and prevent encroachment of invasive species.
- Provide escape ramps from ponds and basins.

9.2.5 CULTURAL RESOURCES

Land clearing, excavation, and construction activities have the potential to disturb or cause the relocation of cultural artifacts. The operation of industrial facilities can degrade the value of traditional sites or uses. In addition, human activity in project areas causes concern that members of the workforce could affect cultural resource sites, especially those at buried locations or with artifacts.

Actions that DOE would take to mitigate adverse impacts to cultural resources at Yucca Mountain include those required by law or regulation and those that DOE determined the project would include to reduce such impacts. In some cases, precise mitigation measures cannot be identified due to the limited nature of the data (for example, construction activities could reveal previously unidentified sites). To address these cases, programmatic mitigation measures that comply with historic preservation laws and regulations are in place to ensure that DOE would implement appropriate measures following the identification and evaluation of important cultural resources.

The *Programmatic Agreement Between the United States Department of Energy and the Advisory Council on Historic Preservation for the Nuclear Waste Deep Geologic Repository Program, Yucca Mountain, Nevada* (DIRS 104558-DOE 1988, all) contains the requirements and general procedures for the mitigation of adverse effects at important archaeological and historic sites in the Yucca Mountain region during site characterization. DOE would work to review and update that agreement to establish requirements and procedures for mitigation of any adverse effects at important archaeological and historic sites during construction, operation and monitoring, and closure of the proposed repository in the event the repository was authorized.

The *Research Design and Data Recovery Plan for the Yucca Mountain Project* (DIRS 103196-DOE 1990, all) outlines more detailed approaches and procedures for implementing the mitigation of impacts to archaeological sites. Along with other topics, that document provides specific guidelines for determining the rationale, methods, analytical requirements, and logistics for archaeological mitigation measures at Yucca Mountain. In addition, the Department would consult with affected Native American tribes and organizations to ensure that repository activities avoided or minimized adverse impacts to resources or places that are important to American Indians.

Cultural Resources Measures Under the Proposed Action

- Ensure that onsite employees complete cultural resource sensitivity and protection training to reduce the potential for intentional or accidental harm to sites or artifacts. The training could include descriptions of the importance of different cultural resource types, procedures to follow if resources were encountered in the field, and employment-related and legal penalties for not following the requirements.

- Continue to use the Yucca Mountain Project Native American Interaction Program, which has been in existence since 1985, to promote a government-to-government relationship with Native American tribes and concentrate on the continued protection of important cultural resources. A considerable part of this effort could continue to be directed at protecting these resources and mitigating adverse effects to the fullest extent possible. Historically, as part of this program, members of Native American tribes have made recommendations to DOE about potential adverse effects, mitigation procedures that involve required consultation with tribal governments, and direct involvement of Native Americans in proposed project activities that could affect cultural resources or values (DIRS 102043-AIWS 1998, pp. 1-1, 2-3, and B-1 *et seq.*). Examples of suggested mitigations include incorporating the assistance of Native American people, continued protection of archaeological sites, funding Native American studies on impacts to natural resources and impacts from transportation (DIRS 102043-AIWS 1998, pp. 4-8 to 4-12).

- Conduct preconstruction surveys to ensure that work would not affect important archaeological resources and to determine the research potential of sites.

- If construction could threaten important archaeological resources, and modification or relocation of roads or rail lines would not be reasonable, develop additional mitigation measures.

9.2.6 OCCUPATIONAL HEALTH AND PUBLIC SAFETY

There would be a potential for repository workers to be exposed to radiation during the operation and monitoring and closure phases of repository activities or to be injured or killed as a result of hazards present in the industrial workplace (Chapter 4, Sections 4.1.7 and 4.1.8; Chapter 8, Section 8.2.7).

Erionite and cristobalite are hazardous materials that occur naturally in the Yucca Mountain subsurface. Erionite occurs in strata at varying depths below the planned level of the repository. DOE is mapping these strata as part of a general approach that emphasizes avoidance of erionite. If erionite was

encountered during drilling, DOE would shut down the affected portion of its operation until it could put proper controls in place.

Cristobalite, which occurs generally in the subsurface rock structure, could be released during excavation operations or in fugitive dust from the excavated rock pile. There would be a potential for cristobalite to be an inhalation hazard to workers. Implementing specific health and safety plans to prevent worker exposure would minimize risks. Chapter 4, Section 4.1.7, discusses erionite and cristobalite.

After closure, there would be potential for human intrusion that could result in release of radioactive materials.

Occupational and Public Health and Safety Measures Under the Proposed Action

- Avoid erionite-bearing strata where practicable during repository construction and drift development.
- If drilling encountered erionite, close operations in potentially affected areas until proper controls were in place.
- Use high-efficiency particulate air filters or similar controls if drilling occurred in an area where there is potential for encountering erionite.
- Design repository construction procedures to reduce the risk of worker inhalation of cristobalite or erionite.
- Specify features of ventilation systems and other underground equipment to ensure the elimination of opportunities for occupational exposure to health and safety hazards.
- Use ventilation, planned transfer of cristobalite from work areas, and scrubbing of in-place dust to minimize exposure. Use monitoring devices and respirators as appropriate.
- Use ventilation to keep radon levels low in subsurface areas. Use higher ventilation rates and shorter air travel paths to reduce worker exposure to radon.
- Unload, handle, and package spent nuclear fuel and high-level radioactive waste remotely in hot cells or under water.
- Provide appropriate shielding during operations and during shipping and handling of packages when personnel would be present and could be exposed.
- Minimize to the extent practicable the amount of time workers would spend in the subsurface environment.
- Design task procedures to reduce the potential for accidents.
- Implement health and safety procedures and administrative controls to minimize risks to construction and operations workers.
- Design task procedures to reduce the potential for accidents that could lead to radioactivity releases in the workplace environment.

9.2.7 AESTHETICS

Construction, operation and monitoring, and closure of the proposed repository would require the lighting of certain areas of the repository at night. While the repository site is remote, and there are existing sources of nighttime light in the region, nighttime darkness is a valued component of the solitude experience sought by many individuals. Nighttime darkness enhances astronomy and stargazing activities and is one of the important scenic resources of Death Valley National Park.

Aesthetics Measures Under the Proposed Action

- Use exterior lighting only where needed to accomplish facility tasks.
- Limit the height of exterior lighting units, focusing more light on the ground surface and reducing the effects of night lighting on surrounding areas. This limitation would enable the use of reduced wattage output lamps, but could require the use of additional lighting units to obtain the same amount of ground coverage.
- Use shielded or directional lighting to limit the effects of the lighting to areas where it is needed.

Aesthetics Measures Under Consideration

- Orient ventilation system stacks and support structures and use re-contouring and natural vegetation to reduce facility visibility.

9.2.8 UTILITIES, ENERGY, AND MATERIALS

A monitored repository at Yucca Mountain would require a range of utility services, energy to power a variety of activities, and a number of diverse materials. DOE intends to promote efficiency in the use of utilities, energy, and materials.

Utility, Energy, and Materials Measures Under the Proposed Action

- Implement procedures and equipment that would minimize the use of utility services, energy, and materials.

9.2.9 MANAGEMENT OF REPOSITORY-GENERATED WASTE AND HAZARDOUS MATERIALS

As part of the repository design, DOE would institute a waste minimization program similar to the waste minimization and pollution prevention awareness plan successfully implemented during site characterization activities to minimize quantities of generated waste and to prevent pollution (DIRS 103203-YMP 1997, all). In addition, DOE would consider innovations to augment the existing program. The Department could keep the size of the Restricted (for radiological control) Area as small as possible, and it could implement programs to ensure that construction and operation activities used, as practicable, smaller quantities of products such as solvents and cleaners. The design of the proposed repository would incorporate pollution prevention measures and would provide cradle-to-grave waste management, as DOE provided during site characterization.

Waste and Hazardous Materials Measures Under the Proposed Action

- Recycle wastewater to reduce the amount of water needed for repository facilities and the amount of wastewater that could require disposal (DIRS 100248-CRWMS M&O 1997, p. 14).
- Use practical, state-of-the-art decontamination techniques such as pelletized solid carbon dioxide blasting that would reduce waste generation in comparison with other techniques (DIRS 100248-CRWMS M&O 1997, pp. 9-13 and 9-14).

- Institute preventive maintenance and inventory management programs to minimize waste from breakdowns and overstocking (DIRS 104508-CRWMS M&O 1999, p. 55).

- Whenever practicable, recycle nonradioactive materials such as paper, plastic, glass, nonferrous metals, steel, fluorescent bulbs, shipping containers, oils, and lubricants rather than dispose of them (DIRS 104508-CRWMS M&O 1999, pp. 62 and 70). Encourage the reuse of materials and the use of recycled materials.

- Avoid use of hazardous materials where feasible.

Waste and Hazardous Materials Measures Under Consideration

- When protective of the environment and cost effective, recycle dual-purpose canisters.

- Recycle solar panels if cost-effective and environmentally sound recycling options are available.

9.2.10 LONG-TERM REPOSITORY PERFORMANCE

DOE proposes a repository at Yucca Mountain to provide for permanent disposal of spent nuclear fuel and high-level radioactive waste. DOE's proposal includes a natural geologic setting that, with engineered repository and waste package barriers, would provide long-term isolation of spent nuclear fuel and high-level radioactive waste. In its design process, DOE is considering many features and approaches to contain and isolate the materials it proposes to place in the repository.

DOE's detailed study of the Yucca Mountain site and vicinity has resulted in the evaluation of three categories of potential measures: Barriers to limit the release and transport of radionuclides, measures to control heat and moisture in the confined environment of the repository, and measures to improve operational efficiency or safety. Each of these measures has the potential to complement the site's natural characteristics. These measures are conceptual in nature. The following sections summarize design features that could contribute to a reduction of the long-term potential for impacts from radionuclides isolated in a Yucca Mountain Repository. Long-term performance measures are discussed in more detail in Appendix E.

Long-Term Performance Measures Under the Proposed Action

DOE has designed an engineered barrier system that would complement the geologic and hydrologic properties of Yucca Mountain to isolate radionuclides in spent nuclear fuel and high-level radioactive waste from accessible portions of the environment. Design features that are part of the Proposed Action are presented below. The repository flexible design described in Chapter 2 of this EIS can be operated in a range of operating modes, from higher- to lower-temperature. Measures that are unique to only one operating mode are so noted.

- Use two-layer waste packages designed to remain intact for thousands of years (at a minimum), with layers that would fail only from different mechanisms and at different rates.

- Encapsulate spent nuclear fuel (normally in zirconium-alloy cladding) and immobilize high-level radioactive waste (normally in borosilicate glass or ceramic matrices) in the waste packages.

- Use nickel-chromium alloy (Alloy-22) emplacement pallets to hold waste packages off the floors of emplacement drifts.

- Use heat generated from the decay of radioactive material to heat the surrounding rock to drive water and gas away from the emplaced waste packages (higher-temperature operating mode).

- Use drip shields to provide a partial barrier to divert infiltrating water away from waste packages in an emplacement drift.

- Ground support options – Placing an engineered system into repository drifts to ensure drift stability before closure could both enhance safety during emplacement and potential retrieval and improve long-term repository performance by reducing or delaying damage to canisters from rockfall (damaged areas are locations for enhanced corrosion even if the canister is not breached by the rockfall).

- Increase the spacing between waste packages or drifts, or reduce the size of waste packages and maintain spacing to potentially reduce uncertainties regarding elevated temperature of the host rock and reduce waste package material corrosion rates (lower-temperature operating mode).

- Waste package spacing and drift spacing – Emplacing waste packages nearly end-to-end [that is, with a 0.1-meter (0.3-foot)-gap] with no consideration of individual waste package characteristics would provide a more intense and uniform heat source along the length of emplacement, requiring an increase in emplacement drift spacing and, potentially, continuous ventilation of emplacement drifts, but also would keep emplacement drifts hot and dry for a longer period, decrease the amount of water that could contact waste packages, and reduce the number of emplacement drifts needed for waste emplacement (higher-temperature operating mode).

- Use preemplacement aging and blending of spent nuclear fuel and high-level radioactive waste to provide thermal performance benefits. Aging would reduce the total thermal energy that the repository must accommodate, and blending would reduce the variability in the distribution of the thermal energy in the repository drifts. Potential benefits would be improved rock stability and retardation of waste package degradation (lower-temperature operating mode).

- Continuous preclosure ventilation – Continuous ventilation in the emplacement drifts before repository closure would reduce rock wall and air temperatures and remove moisture to reduce corrosion rates and increase the stability of the ground support system.

- Timing of repository closure – Extending the period before final closure, together with a maintenance program to accommodate an extended long-term repository service life and ground support components designed and maintained for a service life of up to 300 years, would allow for reduction of waste package heat output after closure, extended monitoring before closure, and an extended retrieval period for the waste (lower-temperature operating mode).

Long-Term Performance Measures Under Consideration

The design features listed below are being considered, though some are not currently under active consideration. These features are organized by their design purpose, either to limit release and transport of radionuclides, control heat and moisture in the repository environment, or support operational considerations.

Barriers to Limit Release and Transport of Radionuclides. The most direct method to provide the long-term isolation of contaminants is to use structures and techniques that have the potential to inhibit directly the release of contaminants from waste packages or to reduce the likelihood of the transport of released contaminants from the repository. DOE is considering a range of barrier measures that could enhance resistance to corrosion, delay or reduce water transport, retard radionuclide movement and release rates, and reduce the potential for damage to canisters. The Department will continue to evaluate the potential benefits and consequences of these measures together with their compatibility with overall repository system design.

- Ceramic coatings on the exterior of the waste package – Could increase waste package life and repository waste isolation performance by reducing corrosion of the waste package surface and delaying the release of radionuclides.

- Diffusive barrier under waste packages – Loose, dry, granular material placed in the space between each waste package and the bottom of the emplacement drift to form a restrictive barrier to seepage, potentially slowing fluid and radionuclide movement to the natural environment.

- Getter under waste package – Placing a fine-grained material [either phosphate rock (apatite) or iron oxide (hematite, geothite, etc.] with an affinity for sorption of radionuclides in the recess below waste packages prior to waste emplacement could improve long-term waste isolation through retardation of radionuclide movement from the repository drifts.

- Canistered assemblies and waste-specific disposal containers – Placing spent fuel assemblies in canisters at the Waste Handling Building before inserting them into waste packages could provide an additional barrier and further limit mobilization of radionuclides if the waste package was breached.

- Additives and fillers – Placing materials (for example, oxides of iron and aluminum) into waste packages (in addition to those normally required for the basket material) to fill the basket and waste form void spaces could improve both the long-term repository performance (by retarding of release of radionuclides to the groundwater) and the long-term *criticality control.*

Measures to Control Heat and Moisture in the Repository Environment. Long-term influence over heat and moisture in the repository environment could increase the ability of the waste packages to isolate waste. DOE has evaluated measures that have the potential to control temperature and humidity levels in the repository to reduce corrosion rates, increase structural and support system stability, and increase the capability to retain released radionuclides in the repository. The Department will continue to examine the potential for enhancements in repository performance offered by these measures, other consequences of implementing them, and their compatibility with overall repository system design. DOE is considering the items listed below:

- Tailored waste package spatial distribution – Tailoring spatial distribution of the waste packages within the repository block according to waste package heat production, or the tendency of radionuclides in different packages to travel, resulting in a more uniform temperature across the repository. This would improve the performance of waste packages by delaying and reducing contact of water and/or increasing sorption of released radionuclides by zeolites in the unsaturated zone, thereby potentially improving repository waste isolation performance.

- Continuous postclosure ventilation design – Continuous ventilation of the emplacement drifts during the postclosure period could increase removal of moisture from air around the waste packages for a period of time (though moisture would eventually reestablish itself), and it could improve performance by retarding waste package corrosion.

- Drift diameter – A smaller diameter drift would be more stable (less rockfall potential), could reduce seepage into the drifts, and could reduce the need for ground support systems, while a larger diameter drift would allow for other modes of emplacement, such as horizontal or vertical borehole emplacement.

- *Near-field* rock treatment during construction – Filling cracks in a portion of the rock above each emplacement drift with grout to reduce or retard water seepage into the drifts after closure of the repository.

- Surface modification (alluvium) – Covering the surface of Yucca Mountain above the repository footprint with alluvium (soil) could decrease the net infiltration of precipitation water into the repository.

- Surface modification (drainage) – Removing the thin alluvium layer over the footprint of the repository would promote rapid runoff of surface water, potentially reducing infiltration from the top and improving long-term isolation of the waste.

Repository Designs to Support Operational Considerations. Including elements in the design that would enhance the repository's operational capabilities could improve access to waste packages after their emplacement, increase access for conducting performance confirmation, inspection, and maintenance activities, ease any effort to augment the repository system with later-developed materials or processes, and facilitate retrieval of waste packages if retrieval became necessary. DOE is considering measures that could provide additional shielding for personnel, increase usable space in drifts, increase opportunities for monitoring, and reduce the potential for moisture to contact waste packages. The Department will continue to assess the potential for design modifications to assist operational activities within the context of overall repository system design. DOE is considering the following potential design modification measures:

- Rod consolidation – Rod consolidation would involve bringing fuel rods into close contact with one another, allowing the capacity of waste packages to be increased and/or the size of waste packages to be reduced, potentially reducing the size or number of waste packages and, if consolidation were accomplished at the reactor sites, possibly reducing waste transportation shipments.

- Waste package self shielding – Adding a shielding material on the outside of waste packages would reduce the radiation in the drifts to levels such that personnel access would be possible.

- Repository horizon – A two-level repository would increase repository capacity without moving out of the characterized area. It would increase thermal load to reduce the amount of water that could come in contact with waste packages; add flexibility in emplacing waste packages on the lower level, which could be shielded from moisture infiltration by the upper level; and potentially facilitate retrieval due to the ability to operate two independent retrieval operations at the same time.

9.3 Transportation

This section discusses mitigation measures DOE is required to implement, has determined to implement, or has identified for consideration, to reduce potential impacts from the national transportation of spent nuclear fuel and high-level radioactive waste. These measures address impacts from the possible construction of a branch rail line or an intermodal transfer station in Nevada; construction of other transportation routes; upgrading of existing Nevada highways to accommodate heavy-haul vehicles; transportation of spent nuclear fuel and high-level radioactive waste from existing storage sites to the proposed repository; and fabrication of casks and canisters.

9.3.1 LAND USE

Mitigation measures could address three types of potential land-use impacts resulting from the construction and operation of a rail line or an intermodal transfer station: (1) impacts to publicly used lands such as grazing allotments, (2) direct and indirect land loss, and (3) displacement of capital improvements. Mitigation would not necessarily be associated with the potential selection of a route for heavy-haul trucks, which would follow existing rights-of-way and would require little additional land disturbance.

Land Use Measures Under the Proposed Action

- Ensure that construction activities were consistent with best management practices, by:
  - Ensuring that the location selection and final route alignment for a branch rail line or location selection for an intermodal transfer station, in consultation with parties controlling the surrounding lands, consider (1) the minimum impacts to private lands, capital improvements, floodplains or wetlands, areas containing cultural resources, or other environmentally sensitive areas, and (2) indirect loss of land or loss of use of land (the division of property or limitation of access) such as the use of grazing allotments.
  - Minimizing the size and number of easements.
  - During the rail construction phase, locating construction camps and staging areas along the rail line in consultation with parties controlling the surrounding lands.
  - Reclaiming disturbed areas outside the permanent right-of-way as soon as practicable after completion of construction.

Land Use Measures Under Consideration

- For grazed lands (lands grazed on by cattle), provide access across routes via underpasses, revegetate disturbed land, and aid in water provision (if access to water sources by herds is impeded).
- Coordinate DOE transportation schedules with U.S. Air Force training schedules to ensure that transportation of spent nuclear fuel and high-level radioactive waste through Air Force-controlled lands to a Yucca Mountain Repository would not result in safety-related restrictions being imposed on Air Force training activities.
- Implement additional rail realignments where feasible to avoid safety-imposed restrictions on U.S. Air Force use of lands the Air Force controls and uses for training purposes.
- If DOE selected the Bonnie Claire Alternate to the Caliente or Carlin rail corridor as part of its transportation route to Yucca Mountain, evaluate the potential for realignment of this alternate to reduce or eliminate the taking of land from the Timbisha Shoshone Trust Lands.
- Initiate no construction that would cross any presently designated wilderness study area unless that study area had been released from interim status by the State Director of the Bureau of Land Management as nonsuitable for wilderness or Congress has acted to remove the Wilderness Study Area designation.

9.3.2 AIR QUALITY

If DOE selected the Valley Modified rail corridor, mitigation measures could be needed to reduce fugitive dust emissions from rail line construction and carbon monoxide emissions from operations in the Las Vegas Valley nonattainment area. As described in Chapter 6, Section 6.3.2.2.5, fugitive dust emissions during the construction phase could be above the General Conformity Rule minimal levels for particulates. Vehicles used to transport workers and trains used to transport materials would generate criteria pollutants. States could place requirements for control of emissions of volatile organic compounds and nitrous oxide on facilities that manufacture containers and casks.

Air Quality Measures Under Consideration

- Employ two construction crews at half pace from opposite ends if the Valley Modified rail line was selected. Because only approximately 50 percent of the corridor length is in the Las Vegas Valley air basin, emission rates would be reduced to levels at or below General Conformity thresholds.

- Use buses to transport workers, reducing nitrogen oxide and hydrocarbon emissions.

- Reduce fugitive dust emissions using standard dust control measures routinely applied during construction projects including, for example, routine watering of unpaved surfaces; wet suppression for material storage, handling, and transfer operations; and wind fences to control windblown dust. The efficiency of these controls tends to vary depending on site characteristics, but it ranges from a 60- to 80-percent reduction in fugitive dust emissions (DIRS 103676-Cowherd, Muleski, and Kinsey 1988, p. 5-22).

- Reduce maximum fugitive dust concentrations with working controls such as scheduling construction operations to minimize concurrent generation by activities that were near each other (for example, conducting adjacent clearing and grading activities at different times).

9.3.3 HYDROLOGY

This section describes potential mitigation actions for both surface water and groundwater.

9.3.3.1 Surface Water

Three categories of potential impacts to surface water from the construction and operation of a Nevada transportation route are (1) the introduction of contaminants, (2) the alteration of drainage patterns or runoff rates, and (3) flood hazards. The spread of contamination by surface water could result in adverse impacts to plants and animals or to human health in the immediate area. It could also result in the recharge of contaminated water to groundwater. DOE's intent is to respond rapidly to such spills with appropriate cleanup actions.

Surface-Water Measures Under the Proposed Action

- Minimize disturbance of surface areas and vegetation, thereby minimizing changes in surface-water flow and soil porosity that would change infiltration and runoff rates.

- Mitigate flood hazards by designing facilities to withstand or accommodate a 100-year flood.

- Minimize the potential for contamination spread or other physical impacts to surface water by avoiding spills in unconfined areas and areas subject to flash floods, where practicable, and by locating the alignment of a branch rail line or heavy-haul road to avoid floodplains and surface waters, including wetlands, springs, and riparian areas, when possible, and to minimize any potential impacts to these features.

- Maintain natural contours to the maximum extent feasible, stabilize slopes, and avoid unnecessary offroad vehicle travel to minimize erosion.

- Minimize physical changes to drainage channels by building bridges or culverts where roadways would intersect areas of intermittent water flow. Use erosion control features such as proper placement of pipe, revegetation, and use of erosion control at these intersections where practicable to enhance the effectiveness of the bridges or culverts.

- Use physical controls such as secondary containment for fuel storage tanks to reduce the potential for releases to mingle with stormwater runoff.

- In and near floodplains, follow reclamation guidelines (DIRS 102188-YMP 1995, all) for site clearance, topsoil salvage, erosion and runoff control, recontouring, revegetation, siting of roads, construction practices, and site maintenance.

- Implement best management practices including training employees in the handling, storage, distribution, and use of hazardous materials to provide practical prevention and control of potential contamination sources.

- Conduct fueling operations and store hazardous materials and other chemicals in bermed areas away from floodplains to decrease the probability of an inadvertent spill reaching the floodplains.

- Provide rapid response cleanup and remediation capability, techniques, procedures, and training for potential spills.

Surface-Water Measures Under Consideration

- Designate bermed or contained sites outside areas subject to flash flooding for fueling and chemical handling to minimize the potential for contamination spreading if spills occurred.

9.3.3.2 Groundwater

Potential transportation-related impacts to groundwater would be most likely to occur from construction activities associated with a potential Nevada transportation route and could include introduction of contaminants and alteration of infiltration and runoff rates that could change the rate of recharge to the aquifer. Design and operational actions to reduce impacts would be identical to those described above for surface-water impacts.

Groundwater Measures Under the Proposed Action

- Implement best management practices, such as training employees in the handling, storage, distribution, and use of hazardous materials, to provide practical prevention and control of potential contamination sources.

- Minimize surface disturbance, thereby minimizing changes in surface-water flow and soil porosity that could change infiltration and runoff rates.

Groundwater Measures Under Consideration

- Place construction wells only in undesignated basins. (A Designated Groundwater Basin is one in which the quantity of appropriated water approaches or exceeds the perennial yield as *determined* by the Nevada State Engineer.)

- Employ water-use minimization and recycling techniques to reduce water consumption.

9.3.4 BIOLOGICAL RESOURCES AND SOILS

9.3.4.1 Desert Tortoise

The desert tortoise is a Federally protected species that resides at or along the candidate rail corridors, intermodal transfer station locations, and routes for legal-weight and heavy-haul trucks in Nevada (see Chapter 6, Sections 6.3.1, 6.3.2.1, and 6.3.3.1). Activities that could cause impacts to desert tortoises include site clearing, vehicle traffic, pond management, and taking of habitat.

DOE has been conducting site characterization activities in accordance with Fish and Wildlife Service biological opinions on the potential for impacts to desert tortoises (DIRS 104618-Buchanan 1997, pages 1 and 2). During these activities, five desert tortoises are known to have been killed by site characterization activities, all by vehicle traffic. A recent report (DIRS 103194-CRWMS M&O 1998, page 9) indicates that 27 of 28 individual tortoise relocations were successful and that two nest relocations were also successful. The one unsuccessful relocation involved a tortoise that returned to the area of disturbance and became one of the five killed by traffic.

If the proposed project proceeded, the U.S. Fish and Wildlife Service would establish measures, terms, and conditions for transportation activities that DOE would have to observe to protect the desert tortoise. DOE would implement terms and conditions established in any future biological opinions regarding the effects of repository-related transportation activities on the desert tortoise. As discussed in Chapter 6, areas that would be affected by transportation activities are at the extreme northern edge of the range of the desert tortoise, and the population of tortoises in these areas is low in relation to other portions of its range. No part of any of the candidate transportation routes has been declared critical habitat for the desert tortoise.

The final biological opinion on site characterization (DIRS 104618-Buchanan 1997, pp. 19 to 25) identified the following actions as requirements that DOE would need to implement to minimize impacts on desert tortoises. The U.S. Fish and Wildlife Service could establish similar conditions as prerequisites for transportation activities associated with the proposed project.

- Alignment and final siting of facilities, construction roadways, cleared areas, laydown areas, and similar elements of construction activity could avoid sensitive areas, lessen the likelihood of entrapment of tortoises, and minimize the fragmentation of known desert tortoise habitat.

- Measures to control erosion, dust, and particulate matter would lessen consequences of repository construction, operation and monitoring, and closure for desert tortoises. Similarly, approaches to minimize soil compaction and crushing of vegetation would lessen consequences for desert tortoises.

- Clearance surveys for desert tortoises before vegetation removal or soil disturbances of more than about 2 hectares (5 acres).

- Removal of tortoises or tortoise eggs found in areas to be disturbed, and tortoises in immediate danger along roads or near ongoing activities to safe nearby locations, with project activity ceasing until removal occurred.

- Prohibitions against driving vehicles off existing roads in nonemergency situations unless authorized. All workers at Yucca Mountain would participate in a required tortoise education program.

- A litter-control program that would include the use of covered, raven-proof trash receptacles, disposal of edible trash in trash receptacles following the end of each workday, and disposal of trash in a designated sanitary landfill.

- Revegetation of project areas no longer required.

- Construction and maintenance of tortoise-proof fencing to lessen the potential for endangerment to desert tortoises from project-related activities.

- Placement of escape ramps in trenches and inspection of trenches before filling.

Desert Tortoise Measures Under the Proposed Action

If a consultation process resulted from a determination that construction or operation of a transportation corridor associated with the proposed repository could affect threatened or endangered species or their habitat, DOE will adopt all reasonable and prudent measures to protect the desert tortoise or other species that could be stated in future biological opinions on transportation corridors.

The following text discusses potential transportation-related measures DOE has identified for the protection of the desert tortoise based on determinations the U.S. Fish and Wildlife Service made for site characterization.

- Align and locate facilities, roadways, and cleared areas and place appropriate signs to lessen the likelihood of trapping tortoises and to minimize habitat fragmentation.
- Minimize soil compaction and vegetation crushing.
- Move desert tortoises or desert tortoise eggs from areas to be disturbed, from roadways, and from proximity to ongoing activities to safe nearby locations; stop project activity until completion of these actions.
- Require authorization for nonemergency offroad vehicle travel.
- Ensure that all workers on the Yucca Mountain Project participate in a tortoise education program.
- Establish a litter-control program that would include the use of covered, raven-proof trash receptacles, disposal of edible trash in trash receptacles at the end of each workday, and disposal of trash in a designated sanitary landfill located away from desert tortoise habitat in order to avoid attracting potential predators.
- Revegetate project areas no longer required for the Proposed Action.
- Post road signs to remind drivers of the presence of desert tortoises and other animals, and enforce speed limits.
- Construct and maintain tortoise-proof fencing around actively used construction and operation sites to lessen the potential for danger from project-related activities.
- Provide escape ramps from trenches; inspect trenches before filling them.

9.3.4.2 General Biological Resources and Soils

Certain herds of migratory animals could be substantially affected if they were prevented from moving between ranges used at different times of the year. Some of the transportation routes under consideration cross game management areas and wild horse and wild burro management areas. Some routes cross areas traversed by herds of antelope, mule deer, elk, and mountain sheep. Fencing would not be likely to affect the movement of mule deer and elk. Fencing could impede the movements of antelope, mountain sheep, wild horses, and wild burros, effectively dividing management areas for these species.

General Biological Resources and Soils Measures Under the Proposed Action

- Use the measures described in Section 9.2.2 to control erosion, dust, and particulate matter and therefore to lessen the consequences for biological resources and soils from transportation activities.

- Use dust suppression measures on disturbed areas to minimize erosion and aid recovery by reducing wind erosion and supporting compaction.

- Conduct preconstruction surveys in floodplains to ensure that work would not affect important biological resources and to determine the reclamation potential of sites.

- Consider measures to relocate sensitive species in floodplains.

- If construction could threaten important biological resources in floodplains, and modification or relocation of the roads and rail line would not be reasonable, develop additional mitigation.

General Biological Resources and Soils Measures Under Consideration

- Mitigate the introduction of contaminants to soils, using methods similar to those described for surface-water impacts (see Section 9.3.3.1).

- Conduct surveys of areas along the transportation corridor selected for construction to locate areas that are potential habitats for sensitive or State-protected species before the beginning of construction activities. Avoid springs, wetlands, waters of the United States, and riparian areas where practicable.

- Reduce habitat fragmentation and barriers to animal movement by considering the needs and movement patterns of mobile species (for example, wild horses) in the design and construction of rail lines, routes, and fencing. Seek input from wildlife agencies and organizations.

- If the construction and operation of a transportation route in Nevada could not avoid springs and wetlands, minimize the amount of disturbance (to the maximum extent possible) by carefully timing construction activities; minimizing corridor widths; locating laydown, excavated rock pile, and fueling areas away from sensitive areas where practicable; and conducting any wetlands replacement activities in accordance with plans approved by the U.S. Army Corps of Engineers.

- Align and locate facilities, roadways, cleared areas, laydown areas, and similar construction activities to minimize fragmentation of habitat potentially affected by the proposed project.

- Mitigate potential soil erosion by minimizing areas of surface disturbance and using engineering practices to stabilize disturbed areas. These practices could include such measures as stormwater runoff control through the use of holding ponds, baffles, and other devices and the compacting of disturbed ground, relocated soil, or excavated material in places outside desert tortoise habitat.

- To aid recovery, strip and stockpile topsoil from disturbed areas. When the disturbed areas were no longer needed, spread the topsoil over the areas and reseed the soil using local seed sources to improve the success of vegetation reestablishment and prevent encroachment of non-native invasive species.

9.3.5 CULTURAL RESOURCES

Land clearing, excavation, and construction activities have the potential to disturb or cause the relocation of cultural artifacts. The operation of industrial facilities can degrade the value of traditional sites or uses. In addition, human activity in project areas causes concern that members of the workforce could affect cultural resource sites, especially those at buried locations or with artifacts.

Actions that DOE would take to mitigate adverse impacts to cultural resources along transportation routes include those required by law or regulation and those built into the project to reduce such impacts. In some cases, DOE cannot identify precise mitigation measures due to the limited nature of the data (for

example, construction activities could reveal previously unidentified sites). To address these cases, DOE has programmatic mitigation measures that comply with historic preservation laws and regulations in place to ensure that it would implement appropriate actions after the identification and evaluation of important cultural resources.

Cultural Resources Measures Under the Proposed Action

- Ensure that onsite employees complete cultural resource sensitivity and protection training to reduce the potential for intentional or accidental harm to sites or artifacts. The training could include descriptions of the importance of different cultural resource types, procedures to follow if resources were encountered in the field, and employment-related and legal penalties for not following the requirements.

- Continue to use the Yucca Mountain Project Native American Interaction Program, which has been in existence since 1985, to promote a government-to-government relationship with Native American tribes and concentrate on the continued protection of important cultural resources. A considerable part of this effort could continue to be directed at protecting these resources and mitigating adverse effects to the fullest extent possible. Historically, as part of this program, members of Native American tribes have made recommendations to DOE about potential adverse effects, mitigation procedures that involve required consultation with tribal governments, and direct involvement of Native Americans in proposed project activities that could affect cultural resources or values (DIRS 102043-AIWS 1998, p. 2-19). AIWS (DIRS 102043-1998, p. 4-1) suggested mitigations such as setting aside important cultural and ceremonial areas, and assisting in revegetation and reclamation activities.

- Conduct preconstruction surveys to ensure that work would not affect important archaeological resources and to determine the research potential of sites.

- If construction could threaten important archaeological resources, and modification or relocation of the roads and rail line would not be reasonable, develop additional mitigation measures.

9.3.6 OCCUPATIONAL AND PUBLIC HEALTH AND SAFETY

Over time, traffic accidents involving vehicles associated with the proposed repository would occur. The analysis indicated that fatalities and injuries from traffic accidents (nonradiological events) probably would constitute the largest impact to public health associated with the project. (See the Occupational and Public Safety and Health sections in Chapters 4 and 6.)

During the transportation of spent nuclear fuel and high-level radioactive waste, drivers and escort personnel would be routinely exposed to radiation and would receive radiological doses from this exposure. Workers and members of the public could receive doses from exposures resulting from an accident that released radionuclides.

Apart from impact findings and mitigations discussed in the EIS, Section 180(c) of the NWPA allows DOE to provide technical assistance and funds to states for training local government and Native American tribal public safety officials through whose jurisdictions DOE could plan to transport spent nuclear fuel or high-level radioactive waste. The training would cover procedures for safe routine transportation and for emergency response situations.

Occupational and Public Health and Safety Measures Under the Proposed Action

- Design task procedures to reduce the potential for accidents that could lead to radioactivity releases in the workplace environment.

Occupational and Public Health and Safety Measures Under Consideration

- Establish contract requirements to minimize worker exposure to ionizing radiation.
- Promote alternative transportation such as buses for workers to reduce automobile accidents.
- Implement a radiation protection plan for drivers and escort personnel.
- Implement accident reduction measures such as the Commercial Vehicle Safety Alliance procedures.

9.3.7 NOISE AND VIBRATION

Noise and vibration impacts could occur along a transportation corridor, depending on the scenario. Native Americans have expressed concern about noise associated with the transportation corridors and the movement of spent nuclear fuel and high-level radioactive waste to the proposed repository (DIRS 102043-AIWS 1998, p. 2-16). Impacts could result from the construction and operation of the facilities associated with transportation. There is concern that transportation activities could disrupt ceremonies that address Native American concerns for ecological health and the solitude needed for healing or prayer. Other communities could be subject to adverse noise and vibration levels, depending on the selected route and the potential to reduce such consequences. DOE expects the potential for adverse impacts from noise and vibration to be low.

Noise and Vibration Control Measures Under Consideration

- Avoid areas with sensitive receptors.
- Avoid Native American ceremonial sites.
- Consider noise and vibration intensity, time and distance, and noise canceling or interference factors when planning construction activities and facilities.
- If the transportation corridor passes through areas close to sensitive human receptors (schools, institutions, etc.), plan for noise abatement walls to reduce noise levels at specific locations.
- If the transportation corridor passes through areas close to structures and facilities that are sensitive to vibration (historic structures), plan for vibration abatement measures such as control of speed at specific locations.
- Install equipment that meets decibel limitations (see Chapter 6).
- Schedule vehicle travel through communities during daylight hours.
- Ensure that the receipt and transfer of material from railcars to heavy-haul trucks at an intermodal transfer station occurred during daylight hours.
- Impose speed limits on train or truck operations to reduce the intensity of noise and vibration in areas where there are sensitive receptors.

9.3.8 AESTHETICS

Construction along transportation routes and at facilities such as intermodal transfer stations and overnight stopping areas could reduce the quality of views in key locations. The operation of intermodal transfer stations and overnight stopping areas would require the lighting of these areas at night.

Aesthetics Measures Under the Proposed Action

- Remove or shape construction spoil piles to reflect existing contours. Keep the height of spoil piles that could not be removed or contoured to a minimum.

- Reclaim borrow areas using native vegetation.
- Plant native seedlings and other vegetation to help screen or reduce texture and color contrasts from key observation locations.
- Conduct an active misting and spraying program during construction to minimize the effects of fugitive dust.
- Reduce effects from outdoor night lighting used for intermodal transfer stations and overnight stopping areas by using measures similar to those discussed for lighting equipment above in Section 9.2.7.

9.3.9 MANAGEMENT OF WASTE AND HAZARDOUS MATERIALS

The manufacture of casks and containers could produce liquid and solid waste streams that would require disposal.

Waste and Hazardous Materials Measures Under the Proposed Action

- Design construction to include use of materials, such as depleted uranium, that could otherwise require disposal as wastes.
- Recycle lubricating and cutting oils.
- Recycle solid waste components where practicable.
- Employ ion exchange and filtration or similar methods to treat water used for ultrasonic weld testing for reuse in the manufacturing process.

REFERENCES

Note: In an effort to ensure consistency among Yucca Mountain Project documents, DOE has altered the format of the references and some of the citations in the text in this Final EIS from those in the Draft EIS. The following list contains notes where applicable for references cited differently in the Draft EIS.

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103676	Cowherd, Muleski, and Kinsey 1988	Cowherd, C.; Muleski, G.E.; and Kinsey, J.S. 1988. *Control of Open Fugitive Dust Sources, Final Report.* EPA-450/3-88-008. Research Triangle Park, North Carolina: U.S. Environmental Protection Agency. TIC: 243438.

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10

Unavoidable Adverse Impacts; Short-Term Uses and Long-Term Productivity; and Irreversible or Irretrievable Commitment of Resources

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10. UNAVOIDABLE ADVERSE IMPACTS; SHORT-TERM USES AND LONG-TERM PRODUCTIVITY; AND IRREVERSIBLE OR IRRETRIEVABLE COMMITMENT OF RESOURCES

This chapter discusses adverse impacts that would remain after the application of mitigation measures (see Chapter 9). It analyzes the relationship between short-term uses of the human environment and the maintenance and enhancement of long-term productivity, and it identifies irreversible or irretrievable commitments of resources. The chapter presents information drawn from the analysis of the Proposed Action. It summarizes and consolidates information from the impact and mitigation analyses in Chapters 4, 5, 6, and 9, and provides references to earlier chapters for readers who require more detailed information.

The chapter discusses only resource areas for which preceding analyses have identified some potential for unavoidable adverse impacts. Nevertheless, the discussions in Sections 10.1, 10.2, and 10.3 reflect an examination of all of the resource areas analyzed in this EIS.

The construction, operation and monitoring, and eventual closure of the proposed Yucca Mountain Repository and the associated transportation of spent nuclear fuel and high-level radioactive waste would have the potential to produce some environmental impacts that the U.S. Department of Energy (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.

10.1 Unavoidable Adverse Impacts

This section summarizes potential impacts associated with the proposed repository and transportation actions that would be unavoidable and adverse and that would remain after DOE implemented mitigation measures, which are discussed in Chapter 9. Some aspects and activities discussed in Section 10.1 are analyzed from different perspectives in Sections 10.2 and 10.3.

10.1.1 YUCCA MOUNTAIN REPOSITORY

This section summarizes unavoidable adverse impacts associated with the construction, operation and monitoring, closure, and long-term performance of the proposed repository.

10.1.1.1 Land Use

To develop the proposed Yucca Mountain Repository, DOE would need to obtain permanent control of land surrounding the Yucca Mountain site. DOE could obtain permanent control over the land only if Congress completed a land withdrawal action. A Congressional withdrawal would include lands already withdrawn for the Nevada Test Site and Nellis Air Force Range as well as lands under the control of the Bureau of Land Management and not currently withdrawn.

In general, the permanent withdrawal of land for the repository would prevent human use of the withdrawn lands for other purposes. Nevada Test Site activities would continue on a noninterference basis unless the Congressional land withdrawal specifically precluded them. DOE would remove mining and mineral claims from public use as they expired. Because the Yucca Mountain site has a low present resource value, is remote, and is partly withdrawn, the resultant impact would be small.

The disposal of spent nuclear fuel and high-level radioactive waste would permanently affect the availability of the subsurface area of the Yucca Mountain site and surface portions posted as off limits.

The Chapter 4 land-use discussion includes the availability of the land and the consequences of withdrawal.

10.1.1.2 Air Quality

Construction, operation and monitoring, and closure of a repository at Yucca Mountain would produce small impacts to regional air quality. Radiological impacts could occur from the release of radionuclides. The principal radionuclides released from the subsurface would be naturally occurring radon-222 and its decay products in ventilation exhaust air. There are no applicable regulatory limits for radon releases from Yucca Mountain facilities. Other impacts would come from criteria pollutants and materials such as cristobalite and erionite. Exposures of maximally exposed individuals to radionuclides and criteria pollutants would be a small fraction of applicable regulatory limits. If offsite manufacturing occurred in nonattainment areas, the manufacturing processes could detract from the ability of local governments to meet air quality goals.

10.1.1.3 Hydrology

Construction activities would temporarily restrict and minimally alter natural surface-water drainage channels. Facilities and roadways would be designed to withstand at least a 100-year flood. Therefore, after construction was complete, only flow from infrequent more-intense floods would affect those facilities and roadways. Ground-disturbing activities and the surface facilities that DOE would build would alter surface-water infiltration and runoff rates in localized areas. Given the relatively small size of the affected land in comparison to the total drainage area, drainage channels and washes would experience little difference in impacts as a result of the disturbances. DOE estimates that overall consequences from the construction of roadways and facilities would be minimal.

The proposed repository construction and operation would unavoidably involve crossing washes designated as floodplains in the vicinity of Yucca Mountain, but effects on these washes would be small.

There would be withdrawals of groundwater during construction, operations and monitoring, and closure, but they would not exceed estimates of perennial yield. Chapter 4, Section 4.1.3, provides details on the effects of repository construction, operation and monitoring, and closure on hydrology.

Analysts estimate that the placement of drip shields would prevent dripping water from reaching the waste packages for more than 10,000 years (DIRS 154659-BSC 2001, Figure 4.2.5.1, p. 4F-39. Therefore, with the potential exception of a very small number of waste packages (0 to 3) that could fail due to manufacturing defects, there would be no breaches of waste packages before 10,000 years.

If water entered a waste package, it would have to penetrate the metal cladding of the spent nuclear fuel to reach the waste. For approximately 99 percent of the commercial spent nuclear fuel, the cladding is highly corrosion-resistant metal designed to withstand the extreme temperature and radiation environment in the core of an operating nuclear reactor. Current models indicate that it would take thousands of years to corrode cladding sufficiently to allow water to reach the waste and begin to dissolve the radionuclides.

During the thousands of years required for water to reach the waste, the radioactivity of most radionuclides would decay to virtually zero. Remaining radionuclides would have to dissolve in the water to pass from a waste package. Few of the remaining radionuclides could dissolve at a meaningful rate. Thus, only long-lived water-soluble radionuclides could get out of a waste package. Long-lived water-soluble radionuclides that migrated from the waste packages would then have to move down through about 300 meters (about 1,000 feet) of rock to the groundwater and then travel about 18 kilometers (11 miles) to reach a point where they could be taken up in a well and consumed or used to irrigate crops (see Chapter 5, Sections 5.3 and 5.4).

As the long-lived water-soluble radionuclides began to move down through the rock, some would stick (or adsorb) to the minerals in the rock and be delayed in reaching the water table. After reaching the water table, radionuclides would disperse to some extent in the larger volume of groundwater beneath Yucca Mountain, and the concentrations would be diluted. Eventually, groundwater with varying concentrations of different radionuclides could reach locations in the hydrologic (groundwater) region of influence where the water could be consumed.

Of the approximately 200 different radioactive isotopes present in spent nuclear fuel and high-level radioactive waste, 26 are present in sufficient quantities and are sufficiently long-lived, soluble, mobile, and hazardous to contribute meaningfully to calculated radiation exposures.

10.1.1.4 Biological Resources and Soils

Unavoidable adverse impacts to biological resources would include the loss of small pieces of habitat totaling less than 6 square kilometers (2.5 square miles or 1,500 acres). The pieces that would be disturbed are habitat for terrestrial plant and animal species that are widespread throughout the region and typical of the Mojave and Great Basin Deserts. The death or displacement of individuals of some animal species as a result of site clearing and vehicle traffic would be unavoidable; however, changes in the regional population of any species would be undetectable.

No Federally endangered species are found on the site. The only Federally threatened species on the site is the desert tortoise (see Chapter 4, Section 4.1.4). Approximately 6 square kilometers (2.5 square miles or 1,500 acres) of desert tortoise habitat would be lost. This habitat is at the northern end of the range of the desert tortoise and is not designated critical habitat for the tortoise. The quantity of habitat that could be lost would be minimal in comparison to the range of the desert tortoise.

The U.S. Fish and Wildlife Service has issued a Biological Opinion (see Appendix O) stating reasonable and prudent measures and conditions that DOE would have to observe to protect the desert tortoise if the Proposed Action was implemented. DOE would adhere to all terms stated in the Biological Opinion, but, as the opinion acknowledges, individual tortoises could be killed inadvertently during site clearing, by vehicle traffic, or by predation from ravens. Preconstruction surveys, relocation of affected individuals, and adherence to conditions stated in the Biological Opinion would minimize, but not prevent, such deaths. Chapter 4, Section 4.1.4, discusses in detail the potential for loss of habitat or the deaths of individual members of this species. Chapter 9 (Sections 9.2.4.1 and 9.3.4.1) discusses mitigation measures to reduce potential impacts to the desert tortoise, including measures to locate facilities and roadways to avoid sensitive areas and measures to protect tortoises from construction impacts.

10.1.1.5 Cultural Resources

In the view of Native Americans, the implementation of the Proposed Action would further degrade the environmental setting. Even after closure and reclamation, the presence of the repository would, from the perspective of Native Americans, represent an irreversible impact to traditional lands.

NATIVE AMERICAN VIEW

A Native American view of facility and transportation route development, especially in remote areas such as Yucca Mountain and its surroundings, as expressed in the *American Indian Perspectives on the Yucca Mountain Site Characterization Project and the Repository Environmental Impact Statement* (DIRS 102043-AIWS 1998, pages 2-20 and 3-1), is that development of such facilities and routes inherently degrades the entire environment. This view is based on the concept that the earth, its waters, the air, and the sky are a whole and have a sacred integrity in their natural form. Chapter 4, Section 4.1.13, of this EIS presents an environmental justice discussion of this Native American perspective.

Some unavoidable adverse impacts could occur to archaeological sites and other cultural resources, although no such sites or culturally important artifacts have been found at the site of the proposed repository. There could be a loss of archaeological information due to illicit artifact collection. In addition, excavation activities could cause a loss of archaeological information. Similarly, the location of a solar power generating facility on the repository site, could affect archaeological sites. Chapter 3, Section 3.1.6, discusses the program DOE has in place to address and mitigate cultural resource impacts and issues during site characterization. DOE anticipates this program would continue through repository closure.

10.1.1.6 Socioeconomics

The construction, operation and monitoring, and closure of a repository at Yucca Mountain would result in increased employment and population, which would place increased demands on housing and public services, including schools. Nonetheless, these demands would be small in comparison to total employment, population, real disposable income, gross regional product, and public expenditures in the region of influence.

10.1.1.7 Occupational and Public Health and Safety

There would be a potential for injuries to or fatalities of workers from facility construction, including accidents and inhalation of cristobalite and erionite. Cristobalite and erionite are naturally occurring hazardous materials in the rock of Yucca Mountain. Engineering controls and training and safety programs would reduce but not eliminate the potential for injuries or fatalities to workers.

Short-term impacts during the operation and monitoring phase would present a potential for injuries or fatalities to workers from industrial accidents and exposure to radioactive materials. Engineering controls and training and safety programs would reduce but not eliminate the potential. There would also be a potential for injuries and fatalities during closure. The occupational and public health and safety discussion in Chapter 4 (Sections 4.1.7 and 4.1.8) provides details on the potential for worker injuries and fatalities. The potential for injury or death to members of the public from exposure to radioactive materials or industrial activity would be extremely small.

While there would be a potential for radioactive contamination of groundwater during the 10,000-year analysis period from materials stored at the proposed repository, there would be only a small potential for such contamination to produce long-term adverse health impacts in the surrounding region during this period, even when the potential for changing climate and seismic events is considered. Potential long-term impacts to human health from the repository in the far future would be dominated by impacts from radioactive materials dissolved or suspended in water pathways. The dose to the reasonably maximally exposed individual would depend on the distance from the repository and the uses made of the land and waters.

At the compliance point defined in Chapter 5 [36 degrees, 40 minutes, 13.6661 seconds North latitude in the predominant direction of groundwater flow (40 CFR Part 197)], the highest 95th percentile annual dose to the reasonably maximally exposed individual for the 10,000-year analysis period would be 0.0001 millirem. The highest chance of a latent cancer fatality to this hypothetical individual would be 4 in 1 billion (see Chapter 5, Section 5.4.2.1). A latent cancer fatality is a cancer fatality that could occur after and as a result of exposure to radionuclides from the repository and that would be in addition to cancer fatalities occurring from all other causes.

Expected doses and consequences to the population from exposure to radionuclides transported by groundwater from the repository were forecast for the 10,000-year analysis period. The 95th-percentile population dose over the 10,000-year period could be 0.04 person-rem over an assumed 70-year lifetime.

The estimated 95th-percentile number of latent cancer fatalities in the population during any 70-year lifetime would be 0.00002. Over the 10,000-year analysis period, the estimated number of latent cancer fatalities would be 0.0003 (see Chapter 5, Section 5.4.2.1). These consequences would be small.

DOE estimates that most waste packages would remain intact longer than 10,000 years. Current model simulations forecast that some packages would last more than 1 million years. The highest 95th-percentile peak annual dose to a hypothetical reasonably maximally exposed individual could be 620 millirem approximately 410,000 years in the future. The highest mean peak annual dose rate to a reasonably maximally exposed individual at 18 kilometers (11 miles) could be 150 millirem per year approximately 480,000 years in the future (see Chapter 5, Section 5.4.2.1). In the unlikely event of an igneous disruption of the repository, the probability-weighted peak mean annual dose resulting to an individual would be approximately 0.1 millirem.

As determined by a bounding analysis (see Appendix I, Section I.6), there would also be a potential that chromium releases could produce estimated peak concentrations during the first 10,000 years of 0.01 milligram per liter at 18 kilometers (11 miles). This value is approximately one-tenth of the Maximum Contaminant Level Goal in drinking water.

10.1.1.8 Utilities, Energy, and Materials

The construction, operation and monitoring, and closure of a repository at Yucca Mountain would result in irreversible commitments of energy (mostly electricity and petroleum products) and materials (mostly cement, steel, and copper). These commitments would not be large enough to affect national or regional supplies.

10.1.2 NATIONAL TRANSPORTATION ACTIONS

10.1.2.1 Air Quality

To determine if pollutants of concern from national transportation by truck and rail would degrade air quality in nonattainment areas outside Nevada, DOE reviewed traffic volumes in nonattainment areas (see Chapter 6, Section 6.2). From this review DOE determined that the number of shipments to Yucca Mountain would be very small in relation to normal traffic volumes in the nonattainment areas studied, and that, therefore, impacts to air quality in these areas from repository-related shipments would be very small.

10.1.2.2 Occupational and Public Health and Safety

Certain adverse impacts to workers and the public from the transportation of spent nuclear fuel and high-level radioactive waste would be unavoidable. The loading and transportation of these materials would have the potential to affect workers and the public through industrial accidents, exposure to radiation and vehicle emissions, and through traffic accidents. This EIS evaluates two transportation scenarios—one in which DOE would transport the materials mostly by legal-weight truck and the other in which it would transport the materials mostly by rail. DOE estimates that the transportation of spent nuclear fuel and high-level radioactive waste nationally, including in Nevada, in the mostly legal-weight truck scenario could cause as many as 21 fatalities among workers and the public over the 24 years of the Proposed Action. These fatalities would include fatalities in industrial accidents, traffic fatalities, latent cancer fatalities caused by exposure to radiation, and health effect fatalities caused by exposure to vehicle emissions. DOE estimates that transportation mostly by rail could cause between 8 and 14 fatalities among workers and the public, including fatalities from upgrading and maintaining highways and constructing an intermodal transfer facility or constructing a branch rail line in Nevada as well as

fatalities from operations over 24 years. These fatalities would also result from industrial accidents, vehicle crashes, radiation exposure, and exposure to vehicle emissions.

10.1.3 NEVADA TRANSPORTATION ACTIONS

This section summarizes unavoidable adverse impacts associated with the transportation of spent nuclear fuel and high-level radioactive waste and with the construction and operation of transportation facilities and routes in Nevada. Chapter 6 (Sections 6.1.2 and 6.3) provides more detailed discussions.

10.1.3.1 Land Use

Constructing and operating a new branch rail line would result in unavoidable changes to present land uses and control of the lands affected directly. The range of potentially affected uses includes grazing, wildlife habitat and management areas, mining, wilderness, Native American tribal uses, recreation, utility corridors, lands leased for oil and gas development, and military lands. Present uses of adjoining lands could also be affected to some extent. Each of the five corridors for a branch rail line encompasses a range of different land uses and surface features. If the choice was to construct a new branch rail line, the selection of a specific corridor would determine the land actually taken and the extent of impacts to land uses along that corridor. Land disturbed for a specific corridor implementing alternative could vary from 5.1 to 19.2 square kilometers (1,300 to 4,700 acres). Most land along the corridors under consideration is government administered or controlled. The Valley Modified Corridor crosses two Wilderness Study Areas. The Steiner Creek Alternate for the Carlin Corridor passes close to or encroaches on the Simpson Park Wilderness Study Area, depending on alignment. The Bonnie Claire Alternate for the Carlin and Caliente Corridors crosses lands of the Timbisha Shoshone Tribe near Scottys Junction, Nevada. The Caliente Corridor crosses a portion of the South Reveille Wilderness Study Area. The Caliente Corridor and the Caliente-Chalk Mountain Corridor pass through or encroach on the Weepa Springs Wilderness Study Area, depending on alignment.

Routes for heavy-haul or legal-weight trucks would follow existing highways and could require establishing and using access roads to obtain construction materials and additional land disturbance for road widening. Building and operating an intermodal transfer station would result in unavoidable changes of land use and ownership. The land for an intermodal transfer station could be public or private. Actual land uses lost would depend on the site and route selected. DOE expects that the total land disturbance for any implementing alternative for the construction of an intermodal transfer station and upgrades to existing highways could be as much as 3.5 square kilometers (about 860 acres). For heavy-haul truck routes originating at Caliente, an additional 0.04 square kilometer (10 acres) could be required for a midroute stop. A further 0.04 square kilometer could be required for the construction of a highway segment near Beatty, Nevada.

In some instances transportation facilities could remain in place to serve other purposes after DOE had ended use. Similarly, affected land could revert to other uses after the end of transportation activities and the removal of facilities.

10.1.3.2 Air Quality

The potential construction of the Valley Modified Alternate branch rail line or upgrades to roads to accommodate heavy-haul trucks in the Las Vegas Valley air basin, which is in nonattainment with Environmental Protection Agency standards for emissions of PM_{10} and carbon monoxide, could affect the ability of local governments to meet air quality goals.

The operation of a branch rail line or an intermodal transfer station and associated heavy-haul truck routes would lead to releases of pollutants, but these would be below thresholds of concern.

Legal-weight truck shipments through the Las Vegas Valley air basin would also emit pollutants. However, the number of legal-weight truck shipments would be less than 1 percent of all truck traffic in the area and would not contribute discernibly to sources of air pollution.

10.1.3.3 Hydrology

The construction of a branch rail line or the upgrading of roads to accommodate heavy-haul transportation in Nevada would involve the unavoidable adverse impact of altering natural surface-water drainage patterns. Any of the Nevada transportation corridors would cross a number of natural drainage channels. Upgrade activities for a route to be used by heavy-haul trucks would involve the extension of existing drainage control structures as necessary to support the road upgrades. In this case, there would be minor changes to drainage channels already altered to some extent by the original road construction. The construction of a branch rail line would require alterations to many natural drainage areas along the line. Bridges and culverts would be used as necessary to cross streams, creeks, or, most predominantly, washes of any size. These structures would be built to accommodate a 100-year flow in the channels; the resulting drainage alteration would be confined to relatively small areas. Construction could alter small drainage channels or washes more because the railway design could call for the collection of some channels to a single culvert. At the end of the period during which DOE would transport spent nuclear fuel and high-level radioactive waste to the repository, the Department could remove facilities built for transportation and land recovery could begin, or it could use the facilities for other purposes. Appendix L contains a floodplain/wetlands assessment that presents a comparison of what is known about the floodplains, springs, and riparian areas along the five alternative rail routes and at the three alternative intermodal transfer station sites with their five associated heavy-haul truck routes.

In addition, the construction of a branch rail line or upgrades to a route for heavy-haul trucks would involve the withdrawal and use of water from groundwater resources. In many areas that a branch rail line would cross, other uses or commitments of groundwater resources approach or exceed the perennial yield of the underlying groundwater basins. The Nevada State Engineer has identified these areas as Designated Groundwater Basins, which the State watches for potential groundwater depletion. DOE would apply for State water appropriations for withdrawal of groundwater from any wells it developed to construct a branch rail line or would acquire water from appropriated sources and ship the water to its construction sites.

10.1.3.4 Biological Resources and Soils

Unavoidable adverse impacts to biological resources from transportation in Nevada could occur as a result of habitat loss and the deaths of small numbers of individuals of species along transportation routes. Habitat loss would be associated with the construction of either a new rail line or an intermodal transfer station and upgrades to existing highways. This loss would occur in widely distributed land cover types, and would include the loss of a small amount of desert tortoise habitat and the deaths of a small number of tortoises. The deaths of individual members of a species as a result of construction activities or from vehicle traffic would be unlikely to produce detectable changes in the regional population of a species.

Transportation route construction or upgrades would subject disturbed soils to increased erosion for at least some of the construction phase. The recovery of these disturbed areas to predisturbance conditions would occur with the passage of time. Transportation facilities such as a branch rail line could be used for nonrepository-related purposes, potentially extending their useful life beyond the period needed for the Proposed Action. The removal of transportation facilities after the end of their useful life would assist habitat recovery.

Disturbance of habitat could lend to intrusion of invasive species. These species would compete with native species and could become dominant in areas adjacent to the routes. In addition, they could increase the risk of fire in areas adjacent to the routes.

10.1.3.5 Cultural Resources

Some unavoidable impacts could occur to archaeological sites and other resources as a result of the construction of a rail line or the upgrade of a highway to heavy-haul capability. The potential for impacts to specific resources cannot be identified before final surveys and actual construction. An agreement now in effect between DOE and the Advisory Council on Historic Preservation for repository site characterization could serve as a model for an agreement to protect archaeological sites and other resources along transportation corridors. In addition, a number of statutes provide protective frameworks (see Chapter 11). Nevertheless, there would be a potential for grading and other construction activities to degrade, cause the removal of, or alter the setting of archaeological sites or other cultural resources. Although mitigated to some extent by worker education programs, there could be some loss of archaeological information due to the illicit collection of artifacts. In addition, excavation activities could cause loss of archaeological information.

10.1.3.6 Socioeconomics

The construction of a branch rail line in Nevada or of an intermodal transfer station and upgrades to associated highways for heavy-haul trucks would result in the irreversible use of economic resources. In addition, economic activity spawned by construction and subsequent operations would affect the availability and cost of resources used for other purposes in Nevada. Increased employment and population would place increased demands on housing and public services, including schools. Nonetheless, overall socioeconomic impacts in the region of influence would be small in comparison to total employment, population, real disposable income, Gross Regional Product, and public expenditures.

10.1.3.7 Occupational and Public Health and Safety

Certain adverse impacts to workers and the public from the construction and operation of the rail and heavy-haul implementing alternatives would be unavoidable. Table 10-1 presents potential health and safety impacts to workers and the public (fatalities) during construction and operations for each implementing alternative.

Table 10-1. Unavoidable adverse impacts from rail and heavy-haul truck implementing alternatives.[a]

	Construction (worker and public fatalities)	Operations (worker and public fatalities)
Rail		
Caliente	1.6	1.5
Carlin	1.4	1.6
Caliente-Chalk Mountain	1.0	1.4
Jean	0.89	1.3
Valley Modified	0.5	1.1
Heavy-haul truck[b]		
Caliente	1.8	4.5
Caliente/Chalk Mountain	0.74	3.8
Caliente/Las Vegas	1.3	4.3
Apex/Dry Lake	0.6	3.0
Sloan/Jean	0.6	3.1

a. Source: Chapter 6, Sections 6.3.2.2 and 6.3.3.2.
b. Includes intermodal transfer station impacts.

The transportation of spent nuclear fuel and high-level radioactive waste would have the potential to affect workers and the public in Nevada through exposure to radiation and vehicle emissions and through traffic accidents. This EIS evaluates two transportation scenarios—one in which DOE would transport the materials mostly by legal-weight truck and the other in which it would transport the materials mostly by rail to Nevada and then to the repository by either heavy-haul truck or a branch rail line. DOE estimates that the transportation of spent nuclear fuel and high-level radioactive waste in the mostly legal-weight truck scenario could cause approximately 1.4 fatalities among workers and the public in Nevada as a result of exposure to radiation, vehicle emissions, and accidents over the course of 24 years. Over the same period, DOE estimates that transportation using a branch rail line in Nevada could cause up to 3.1 fatalities among workers and the public, while use of heavy-haul trucks in Nevada could result in up to 6.3 worker and public fatalities.

10.1.3.8 Aesthetics

The construction of a branch rail line in the Jean Corridor (Wilson Pass Option) would lead to a change to the aesthetic resource value of lands along the western slopes of the Spring Mountains, which the Bureau of Land Management classifies as a Class II visual resource. The construction of an intermodal transfer station near Caliente, Nevada, could affect the aesthetic value of lands in the entrance portion of the Kershaw-Ryan State Park until the station was removed.

10.1.3.9 Noise and Vibration

The long-term use of a branch rail line in any of the five rail corridors in Nevada would lead to an increase in ambient noise from periodically passing trains in areas of the State that are currently mostly uninhabited. This could affect solitude which the American Indian Writers Subgroup identified as essential for meditation and prayer. In addition, it could degrade the recreation values of the areas for individuals who seek primitive outdoor experiences. Noise from trains could be noticeable as new noise in residential areas near a potential branch rail line.

For Nevada transportation implementing alternatives that would use heavy-haul trucks, the noise from the trucks and the operation of an intermodal transfer station would be only slightly discernable above the noise of normal traffic and nearby industrial or railroad noise.

10.1.3.10 Utilities, Energy, and Materials

The construction of a branch rail line or upgrades to highways for use by heavy-haul trucks and construction of an intermodal transfer station would result in irreversible commitments of energy (mostly petroleum products) and materials (steel, concrete, and rock). These commitments would not be large enough to affect national or regional supplies.

10.1.3.11 Waste Management

The construction and operation of any of the 10 Nevada heavy-haul truck or rail implementing alternatives would generate small amounts of construction debris, sanitary solid waste, sanitary sewage, and hazardous waste. This waste would be managed by recycling, placement in permitted landfills, reuse or, in the case of sanitary sewage, onsite treatment and disposal. Waste would be managed in accordance with applicable requirements to minimize the possibility of adverse impacts to the environment. A small amount of low-level radioactive waste could be generated at an intermodal transfer station under the heavy-haul truck implementing alternative and would be disposed of in accordance with applicable regulations. The quantities of waste to be disposed of would not affect the availability of waste disposal resources for other users.

DOE would use excavated soil and rock from the construction of a branch rail line and the State of Nevada would use material from existing borrow areas and roadway excavations (highway upgrades) for fill to the extent feasible. However, some previously undisturbed areas could be covered with excavated soil and rock. To place and stabilize these materials, DOE would use approved practices that would minimize affected land areas and reduce potential impacts to biological resources and surface-water resources.

10.2 Relationship Between Short-Term Uses and Long-Term Productivity

The Proposed Action could require short-term uses of the environment that would affect long-term environmental productivity. This section describes possible consequences to long-term productivity from those short-term environmental uses.

The EIS analysis identified two distinct periods for the evaluation of the use of the environment by the Proposed Action:

- A period of 115 to 341 years for surface activities consisting of construction, operation and monitoring, and closure of the proposed repository. DOE activities during this period would include construction of facilities, receipt and emplacement of spent nuclear fuel and high-level radioactive waste, recovery of recyclable materials, ventilation of subsurface emplacement areas, decontamination, closure of surface and subsurface facilities, reclamation of land, and long-term monitoring. Sections 10.1.1.1 through 10.1.1.6 describe the unavoidable impacts that could occur during this period. This period would be the only time during which DOE would actively use the affected lands and the only time during which activities would involve the surface of the land used for the repository.

- The balance of a 10,000-year period would be for the evaluation of consequences from the disposal of spent nuclear fuel and high-level radioactive waste.

In general, transportation and disposal activities associated with the proposed repository would benefit long-term productivity by removing spent nuclear fuel and high-level radioactive waste from 72 commercial and 5 DOE sites around the country. In addition, removing these materials from existing sites would also free people and resources committed—now and in the future—to monitoring and safeguarding these materials for other potentially more productive activities. Removal could create conditions that would enable the initiation of other productive uses at the commercial and DOE sites. Finally, disposing of spent nuclear fuel and high-level radioactive waste in the proposed repository would provide a long-term global benefit by isolating the materials from concentrations of human population and human activity, thereby reducing the potential for sabotage.

10.2.1 YUCCA MOUNTAIN REPOSITORY

This section summarizes the relationship between short-term uses of land and resources and long-term land and resource productivity for the construction, operation and monitoring, closure, and long-term performance of the proposed repository. The terms "short-term" and "long-term" commonly used in National Environmental Policy Act analyses do not have a consistent duration in this section. For the analysis of impacts associated with repository activities, *short-term* refers to the time from the start of construction to the end of relevant surface and subsurface human activity, which DOE anticipates to range from 115 to 341 years. *Long-term* refers to the time between the end of relevant surface and subsurface human activity and the time when environmental resources have recovered from the potential for impacts and are again productive, or a maximum of 10,000 years. For transportation, *short-term*

refers to the time of construction or actual transportation, as appropriate. *Long-term* refers to the time from the end of the short-term period to the time of environmental recovery. *Productivity* refers to the ability of an element of the environment to generate crops, provide habitat, or otherwise serve as a medium for the creation of value.

10.2.1.1 Land Use

From the start of construction through the 10,000-year period, the construction, operation and monitoring, and closure of the proposed repository would deny other users the use of the Yucca Mountain vicinity for other purposes. Chapter 4, Section 4.1.1, discusses the long-term uses of land. Conversely, a repository at Yucca Mountain would enable consideration of other uses for the sites where spent nuclear fuel and high-level radioactive waste are being stored and the land buffering those sites. Many present storage sites are in locations that would permit a wider range of alternative uses than does Yucca Mountain.

10.2.1.2 Hydrology

The proposed repository would be in a terminal basin that is hydrologically isolated and separated from other bodies of surface and subsurface water; that is, once water enters the basin it can leave only by evapotranspiration. As explained in Section 10.1.1.3, there would be a potential for materials disposed of at the proposed Yucca Mountain Repository to reach groundwater at some time between several thousand years and several hundred thousand years. If such contamination reached groundwater in the accessible environment, and if the groundwater contamination exceeded applicable regulatory requirements, there could be an attendant loss of productivity for the affected groundwater and for surface waters in the basin that the groundwater supplied. Conversely, the disposal of spent nuclear fuel and high-level radioactive waste at Yucca Mountain would free a wide range of major and minor water bodies throughout the United States from the potential threat of radioactive contamination from the materials at the present storage sites.

10.2.1.3 Biological Resources and Soils

Short-term uses that could cause impacts to biological resources and soils would be associated with the construction, operation and monitoring, and closure of the repository; those activities could lead to long-term productivity loss in disturbed areas. This loss would be limited to less than 6.0 square kilometers (1,500 acres) of widely distributed habitats adjacent to existing disturbed areas. Biological resources would be affected directly by land disturbances. The overall impact to populations of species would be limited because the area disturbed and the number of individual animals lost would be small in relation to the regional availability.

Long-term productivity loss for soils would be limited to areas affected by land disturbances. These areas would be revegetated after the completion of closure activities. Revegetation would be accomplished through the reclamation of disturbed sites using surface soils stockpiled during construction, reseeding, and similar activities that would enhance recovery. Chapter 4, Section 4.1.4, contains more detail on productivity losses and reclamation. The disposal of spent nuclear fuel and high-level radioactive waste at Yucca Mountain would remove these materials from proximity to biota near the present storage sites across the United States.

10.2.1.4 Occupational and Public Health and Safety

A repository at Yucca Mountain would be likely to have a positive effect on the nationwide general occupational and public health because of the cessation of doses to workers at the present storage sites and because the spent nuclear fuel and high-level radioactive waste would be substantially more isolated from concentrations of people and from pathways to concentrations of people.

10.2.2 TRANSPORTATION ACTIONS

The construction of a rail line or an intermodal transfer station and improvements to existing highways, all short-term uses, could lead to a long-term loss of productivity in disturbed areas along the routes. In the context of transportation, *long-term* refers to the period of environmental recovery after the end of the construction period or the active use of a transportation route for repository purposes. A route could be used for repository purposes from 10 to approximately 30 years.

The land cover types along any route are widely distributed in the region. A loss of vegetation from a disturbed area along a route would have little effect on the regional productivity of plants and animals.

Productivity loss for soils would be limited to areas affected by land clearing and construction. These areas would not be available for revegetation and habitat for some time. Disturbed areas would recover, however, and eventually would return to predisturbance conditions, although the process of recovery would be slow in the arid environment. Chapter 6 contains more data on transportation.

The construction of a rail line, if the line were also used for nonrepository uses, could result in productivity benefits for Nevada by increasing transportation opportunities, lowering transportation costs, reducing accidents, and lowering nitrogen oxides, carbon monoxide, and other gaseous criteria pollutant emissions by diverting transportation from highway to rail.

The major long-term consequence of transporting spent nuclear fuel and high-level radioactive waste to the repository would be the permanent consolidation of these materials in an isolated location away from concentrations of people and without exposure pathways to concentrations of people.

10.3 Irreversible or Irretrievable Commitment of Resources

The Proposed Action would involve the irreversible or irretrievable commitment of land, energy, and materials. The commitment of a resource is irreversible if its primary or secondary impacts limit future options for the resource. An irretrievable commitment refers to the use or consumption of resources that are neither renewable nor recoverable for later use by future generations. Construction, operation and monitoring, and eventual closure of a repository at Yucca Mountain would result in a permanent commitment of land, groundwater, surface, subsurface, mineral, biological, soil, and air resources; materials such as steel and concrete; and consume energy in forms such as gasoline, diesel fuel, and electricity. Water use would support construction, operation and monitoring, and closure actions, and options for using groundwater could become limited if there was contamination from radionuclides. There would be an irreversible and irretrievable commitment of associated natural resource services such as uses of land and habitat productivity.

10.3.1 YUCCA MOUNTAIN REPOSITORY

The construction, operation and monitoring, closure, and long-term performance of the Yucca Mountain Repository would result in the permanent commitment of the surface and subsurface of Yucca Mountain and the permanent withdrawal of lands from public use. Because of the remote location of Yucca Mountain, the lack of present uses of the land, the terminal and isolated nature of the water basin, and the limited amounts of materials and energy required for the repository in comparison to the supply capability of the regional and national economies, the irreversible and irretrievable commitments of resources for repository-related activities would be small.

Mitigation approaches that would involve the excavation of archaeological sites to prevent degradation by construction activities would destroy the contexts of those sites and reduce the finite number of such resources in the region. DOE expects that its activities at the proposed repository would affect no more

than a minimal number of such sites. The Department would use state-of-the-art mitigation techniques on the Yucca Mountain Project.

Electric power, fossil fuels, and construction materials would be irreversibly committed to the project. Most of the steel used for the surface facilities would be recyclable and, therefore, not an irreversible or irretrievable commitment. Some copper and steel in the ramps and access mains to subsurface facilities would be recyclable, while some in the emplacement drifts would be irreversibly and irretrievably lost. Some steel, such as rebar, would be difficult to recycle. The quantity of resources consumed would be small in comparison to their national consumption or their availability to consumers in southern Nevada. These quantities are described in Chapter 4. To the extent that there is value in spent nuclear fuel or high-level radioactive waste, that value would be committed to the repository.

Aggregate would be crushed as required and mixed in concrete for the cast-in-place and precast concrete structures and liners that would be used in the repository. The amount of sand and aggregate could range from 1.2 million to 2.54 million metric tons (1.3 to 2.8 million tons). If Yucca Mountain tuff was used as the aggregate component of the subsurface concrete, the amount crushed and used as aggregate would be less than 15 percent of the total excavated from the drifts (see Chapter 4, Section 4.1.11).

Repository closure would make the energy content of uranium and plutonium in spent nuclear fuel unavailable for use by future generations.

10.3.2 TRANSPORTATION ACTIONS

The construction of a rail line or an intermodal transfer station would result in an irretrievable but not irreversible commitment of resources. Many resources could be retrieved at a later date through such actions as removing roadbeds, revegetating land, and recycling materials. Land uses would change along the selected transportation corridor during repository construction, operation and monitoring, and closure, thereby limiting or eliminating other land uses for that period. At the end of that period, however, land along the corridor could revert to public or private ownership.

Mitigation approaches involving the recovery of archaeological resources before construction activities degraded the sites would reduce the finite number of such resources in the Yucca Mountain region and destroy the context of sites. DOE would use state-of-the-art mitigation techniques during the construction of a rail corridor or an intermodal transfer station or the modification of roadways to accommodate heavy-haul trucks. Heavy-haul construction would be likely to generate only minimal impacts to cultural resources because construction would largely involve modifications to existing roads.

DOE would use about 500 to 700 million liters (132 to 185 million gallons) of fossil fuel from the nationwide supply system to transport spent nuclear fuel and high-level radioactive waste to the repository. The analysis in Chapter 6 (Sections 6.1.2.10, 6.3, 6.3.2.1, 6.3.2.2, 6.3.3.1, and 6.3.3.2), evaluates fuel use for the different transportation scenarios. The amount used would be a very small fraction of a percent of the Nation's supply over the period of fuel use.

The manufacture of casks and containers would require commitment of aluminum, chromium, copper, depleted uranium, lead, molybdenum, nickel, and steel. The required amounts of these materials, expressed as percentages of U.S. production, would be low with the exception of nickel, which would require approximately 8.2 percent of annual U.S. production.

REFERENCES

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154659	BSC 2001	BSC (Bechtel SAIC Company) 2001. *FY01 Supplemental Science and Performance Analyses, Volume 2: Performance Analyses.* TDR-MGR-PA-000001 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010724.0110.

11

Statutory and Other Applicable Requirements

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11. STATUTORY AND OTHER APPLICABLE REQUIREMENTS

The U.S. Department of Energy (DOE or the Department) has conducted site characterization activities in accordance with requirements of applicable laws and regulations and a range of permits and approvals that regulate the various aspects of the activities. The Department has successfully met environmental protection standards for its site characterization activities by developing a comprehensive approach to environmental compliance that ensures adherence to Federal and state requirements. It has implemented specific environmental compliance programs for pollution prevention, protection of cultural resources, and protection of threatened or endangered species. In its future actions involving Yucca Mountain, DOE will continue to comply with applicable Federal and state environmental requirements and with the conditions of the permits and approvals that might be required to conduct its activities, and will continue its involvement with tribal governments in accordance with Executive Orders, laws, and customs, and as based on relationships established by treaties.

This chapter identifies major requirements that could be applicable to the Proposed Action, which is to construct, operate and monitor, and eventually close a geologic repository for the disposal of spent nuclear fuel and high-level radioactive waste at Yucca Mountain. Section 11.1 lists statutory and regulatory provisions that set requirements potentially applicable to siting a monitored geologic repository. Section 11.2 summarizes statutes and regulations that set environmental protection requirements that could apply to a repository at Yucca Mountain. Section 11.3 contains a list of DOE Orders that could apply to activities related to the proposed repository. Section 11.4 contains a list of potentially applicable requirements compiled by the DOE Office of Civilian Radioactive Waste Management.

Table 11-1 lists potential new permits, licenses, and approvals that DOE could need for construction, operation, and closure of the Yucca Mountain Repository.

11.1 Statutes and Regulations Establishing or Affecting Authority To Propose, License, and Develop a Monitored Geologic Repository

Nuclear Waste Policy Act of 1982, as amended (42 U.S.C. 10101-10270)

The Nuclear Waste Policy Act, as amended in 1987 (NWPA), directs DOE to characterize and evaluate the suitability of only Yucca Mountain in southern Nevada as a potential site for a geologic repository for the disposal of spent nuclear fuel and high-level radioactive waste. After considering the suitability of the site and other information, the Secretary may then recommend approval of the site to the President. Further, the NWPA states that an environmental impact statement (EIS) must accompany any recommendation that the President approve the site for a repository. If the President recommends the Yucca Mountain Site to Congress and the designation takes effect, the NWPA provides that the Secretary of Energy must submit an application for construction authorization to the U.S. Nuclear Regulatory Commission not later than 90 days after the date on which the site designation is effective.

The NWPA directs the U.S. Environmental Protection Agency to promulgate generally applicable standards for protection of the environment from offsite releases from radioactive material in repositories. In addition, it requires the Nuclear Regulatory Commission to consider and approve or disapprove an application (if DOE submits one) for authorization to construct a repository for these materials based on Commission standards, which are to be consistent with the Environmental Protection Agency standards. In 1983, the Nuclear Regulatory Commission promulgated licensing requirements (10 CFR Part 60) that contain general criteria governing the issuance of a construction authorization and license for a geologic repository. These requirements would allow DOE to develop a repository for the receipt and disposal of spent nuclear fuel and high-level radioactive waste and would establish conditions under which DOE could receive and possess source, special nuclear, and byproduct material at a geologic repository. The

Table 11-1. Permits, licenses, and approvals needed for a monitored geologic repository.

Activity	Regulatory action	Statute or regulation	Agency(ies)
1. Disposal of spent nuclear fuel and high-level radioactive waste	Final public health and environmental protection standards	40 CFR[a] Part 197	Environmental Protection Agency
2. Repository construction, operation, and closure	Construction authorization, license to operate and monitor, and license for closure	10 CFR Part 63	Nuclear Regulatory Commission
3. Site suitability	Criteria and methodology for determining suitability of Yucca Mountain Site	10 CFR Part 963	Department of Energy
4. Repository construction, operation, and closure	Withdrawal of Land from Public Use	Future Congressional Bill needed to authorize withdrawal, 43 CFR Part 2300	Congress, Bureau of Land Management
5. Air emissions	Approvals for New Sources of Toxic Air Pollutants	40 CFR Parts 61 and 63	Environmental Protection Agency
		NAC[b] 445B.287 *et seq.*	Nevada Division of Environmental Protection
6. Air emissions	Air Quality Operating Permit	NAC 445B.287 *et seq.*	Nevada Division of Environmental Protection
7. Air emissions	National Emission Standards for Hazardous Air Pollutants Subpart H (Radionuclides)	40 CFR Part 61	Environmental Protection Agency
		10 CFR Part 20	Nuclear Regulatory Commission
	National Primary and Secondary Ambient Air Quality Standards	40 CFR Part 50	Environmental Protection Agency
8. Certification of facilities	Certification of Air and Water Pollution Control Facilities	40 CFR Part 20	Environmental Protection Agency
9. Drinking water	Water System Operating Permit	NAC 445A.070 *et seq.*	Nevada Health Division
10. Effluents	Stormwater Discharge	40 CFR Part 122	Environmental Protection Agency
		NAC 445A.070 *et seq.*	Nevada Division of Water Planning
11. Effluents	National Pollutant Discharge Elimination System	40 CFR Part 122	Environmental Protection Agency
	State Water Pollution Control Permit	NAC Chapter 445A	Nevada Division of Water Planning, Nevada Division of Environmental Protection
12. Excavation; facility construction	Cultural Resource Review Clearance, Section 106 Agreement	36 CFR Part 800	Advisory Council on Historic Preservation, State Historic Preservation Officer
13. Excavation; facility construction	Permit to Proceed (Objects of Antiquity)	36 CFR Part 296 43 CFR Parts 3 and 7	Department of the Interior
14. Excavation; facility construction	Permit for Excavation or Removal of Archaeological Resources	16 U.S.C.[c] 470 *et seq.*	Department of the Interior, affected Native American Tribes
15. Facility construction	Free-Use Permit	43 CFR Part 3620	Bureau of Land Management, Forest Service
16. Facility construction	Permit for the discharge of dredged or fill materials to Waters of the United States	Clean Water Act, Section 404	U.S. Army Corps of Engineers
17. Transportation to Facility	Right-of-way reservations	43 CFR 2800	Bureau of Land Management
18. Facility construction and operation	Endangered Species Consultation	50 CFR 402.6	Fish and Wildlife Service
19. Materials storage	Hazardous Materials Storage Permit	NAC Chapters 459 and 477	Nevada State Fire Marshal

a. CFR = Code of Federal Regulations.
b. NAC = Nevada Administrative Code.
c. U.S.C. = United States Code.

requirements in 10 CFR Part 60 do not apply to any nonrepository activities licensed under other parts of Title 10 of the Code of Federal Regulations.

Congress originally passed the Nuclear Waste Policy Act in 1982. The 1982 legislation directed the Secretary of Energy to recommend potential sites to the President for possible characterization as geologic repositories, and it directed the President to select sites for characterization. The Nuclear Waste Policy Act also required the Secretary of Energy to issue general guidelines for use in recommending potential geologic repository sites for detailed site characterization. DOE issued those guidelines in 1984 (10 CFR Part 960) and applied them when it nominated five sites as suitable for characterization and recommended characterization of three of the sites.

DOE decided to include in the general guidelines a process for evaluating the data obtained from site characterization activities to be used in determining whether a site should be recommended for the development of a geologic repository. In 1996, DOE proposed to clarify and focus its 10 CFR Part 960 guidelines (to be codified at 10 CFR Part 963), but never issued those guidelines as final. In 1999, DOE proposed further revisions to the draft 10 CFR Part 963 guidelines (64 *FR* 67054). DOE has since finalized these changes and 10 CFR Part 963 has been promulgated (66 *FR* 57297). In the Site Recommendation, if any, DOE will consider these finalized guidelines.

Section 116(c) of the NWPA establishes a procedure by which DOE can consider and, if appropriate, address a broad array of considerations. The State of Nevada or an affected unit of local government can describe impacts that are likely to result from site characterization in a report and submit it to the Secretary of Energy. Section 116 of the NWPA allows DOE to consider these impacts as a basis for DOE providing technical or financial assistance. In contrast to the National Environmental Policy Act process, a Section 116(c) determination of impact assistance is not tied to an extensive body of past precedent or regulatory interpretations. DOE has broad discretion under Section 116(c) to consider impacts that the State of Nevada or an affected unit of local government might identify.

Energy Policy Act of 1992 (42 U.S.C. 10101 *et seq.*)

In the NWPA, Congress directed the Environmental Protection Agency to establish standards to protect the general environment from offsite releases from radioactive materials in repositories. The NWPA also directed the Nuclear Regulatory Commission to issue technical requirements and criteria that it will apply in approving or disapproving any applications regarding repositories. In 1992, Congress passed the Energy Policy Act, modifying the rulemaking authorities of the Environmental Protection Agency and the Nuclear Regulatory Commission with respect to the proposed repository at Yucca Mountain. Section 801(a) of the Energy Policy Act directed the Environmental Protection Agency to (1) retain the National Academy of Sciences to make findings and recommendations on reasonable public health and safety standards for Yucca Mountain, and (2) establish Yucca Mountain-specific standards based on and consistent with the National Academy of Science's findings and recommendations. Section 801(b) of the Energy Policy Act directs the Nuclear Regulatory Commission to modify its technical requirements and criteria for geologic repositories to be consistent with the site-specific Yucca Mountain standard (40 CFR Part 197) established by the Environmental Protection Agency. Section 801(c) of the Energy Policy Act requires that DOE continue its oversight of the Yucca Mountain site after closure to prevent: (1) Unreasonable risk of breaching the repository's barriers, and (2) Increasing the exposure of individual members of the public to radiation beyond allowable limits. The National Academy of Sciences issued its findings and recommendations in a 1995 report (DIRS 100018-National Research Council 1995, all).

Environmental Radiation Protection Standards for Yucca Mountain, Nevada (40 CFR Part 197)

In response to the Energy Policy Act of 1992, the Environmental Protection Agency has established Yucca Mountain-specific environmental standards for radioactive material stored at or disposed of in the Yucca Mountain site and for disposing of radioactive material in a Yucca Mountain repository (40 CFR

Part 197; see Table 11-1, item 1). The Environmental Protection Agency provisions set public health and environmental radiation protection standards.

As part of its evaluation of the potential for public health and environmental impacts, DOE measured the short-term and long-term performance of the repository system by comparing the volume and dispersion of analyzed releases against the 40 CFR Part 197 requirements as the Nuclear Regulatory Commission has adopted those requirements. Table 11-2 provides information on the 40 CFR Part 197 standards.

The disposal standards also include limits on radionuclides and types of radiation that releases from the repository could cause in groundwater during the 10,000-year period. The standards further require DOE to calculate the peak dose to the reasonably maximally exposed individual that would occur beyond 10,000 years but within the period of geologic stability and to include the results in this EIS.

Disposal of High-Level Radioactive Wastes in a Proposed Geologic Repository at Yucca Mountain (10 CFR Part 63)

The U.S. Nuclear Regulatory Commission has established licensing regulations for disposal of spent nuclear fuel and high-level radioactive waste in the proposed geologic repository at Yucca Mountain, Nevada (10 CFR Part 63; see Table 11-1, item 2). The regulations establish site-specific technical requirements and criteria governing construction, operations and monitoring, closure, and long-term performance of the repository. If DOE submits appropriate applications, the Commission must use the requirements and criteria in 10 CFR Part 63 to determine whether to authorize the Department to construct a repository at Yucca Mountain, to license DOE to receive and possess spent nuclear fuel and high-level radioactive waste at such a repository, and to authorize DOE to close and decommission such a repository. To gain approval of a licensing application, the DOE repository design for Yucca Mountain must meet Nuclear Regulatory Commission requirements, including requirements for demonstrating compliance with the Environmental Protection Agency standards set forth at 40 CFR Part 197.

Title 10 CFR Part 63 includes the specification of overall performance objectives to protect the public health and safety during preclosure and postclosure phases of the repository. The technical criteria require that DOE demonstrate compliance with these overall performance objectives through an integrated safety analysis of preclosure operations, and through a performance assessment for long-term, postclosure performance. The criteria also address requirements for natural and engineered barriers, licensing procedures, public participation criteria, records and reporting, monitoring and testing programs, performance confirmation, quality assurance, personnel training and certification, and emergency planning. The criteria apply specifically and exclusively to the proposed repository at Yucca Mountain.

Yucca Mountain Site Suitability Guidelines (10 CFR Part 963)

The U.S. Department of Energy has set forth guidelines at 10 CFR Part 963 (see Table 11-1, item 3) to establish methods and criteria for determining the suitability of the Yucca Mountain site for the location and development of a geologic repository. The suitability determination is necessary to complete DOE's site characterization program activities required under section 113(b) of the Nuclear Waste Policy Act.

The guidelines focus on the criteria and methodology to be used for evaluating relevant geological and other related aspects of the Yucca Mountain site in assessing site suitability. The criteria and methodology are consistent with the latest scientific and analytical techniques and with the Nuclear Regulatory Commission's requirements set forth at 10 CFR Part 63 and the Environmental Protection Agency's standards established at 40 CFR Part 197. The guidelines consider the preclosure and postclosure periods, and are specific to Yucca Mountain.

Table 11-2. Title 40 CFR Part 197, Public Health and Environmental Protection Standards.

Component	Storage regulations	Disposal regulations
Individual Protection Standard[a]	150 microsieverts (15 millirem)[b]	150 microsieverts (15 millirem)[b]
Human Intrusion Standard	N/A[c]	150 microsieverts (15 millirem)[b]
Groundwater Protection Standard	N/A	• For combined radium-226 and radium-228, 5 picocuries per liter, including background radiation • For gross alpha activity (including radium-226 but excluding radon and uranium), 15 picocuries per liter, including background radiation • For combined beta- and photon-emitting radionuclides, 40 microsieverts (4 millirem) per year to the whole body or any organ, based on drinking 2 liters of water per day from the representative volume, not including background radiation
Applicable period	Construction, operation and monitoring, closure until repository is sealed	10,000 years after repository is sealed
Standards apply to	All members of the public	Reasonably maximally exposed individual[d]
Location where compliance is assessed	Anywhere in the general environment	The location where projected concentrations would be highest and that is no closer to the repository than the edge of the controlled area
Geographic scope of standards	Everywhere other than the Yucca Mountain site, the Nellis Air Force Range, and the Nevada Test Site	Everywhere outside the surface and subsurface of the controlled area[e]

a. EIS Appendix F includes a primer on potential human health effects from exposure to radionuclides.
b. Annual committed effective dose equivalent, a combination of the dose an individual could absorb during a full year and any subsequent dose over a defined period of time from radionuclides remaining within the individual as a result of the dose absorbed during the year.
c. N/A = not applicable.
d. Represents a person who resides in the accessible environment above the highest concentration of radionuclides in the plume of contamination. The reasonably maximally exposed individual approach is based on providing a sufficient level of protection to this individual so that all other persons, who would be less exposed, would also be protected.
e. The location where projected concentrations would be highest, no closer to the repository than the edge of the controlled area. The controlled area would be 300 square kilometers (120 square miles) maximum surface and subsurface area that extends in the predominant direction of groundwater flow no farther south than 36 degrees, 40 minutes, 13.6661 seconds North latitude (the present southwest corner of the Nevada Test Site), and no more than 5 kilometers (3 miles) from the repository footprint in any other direction. The controlled area would be the area restricted long term for the repository as identified by passive institutional controls DOE would implement at closure.

National Environmental Policy Act of 1969, as Amended (42 U.S.C. 4321 *et seq.*)

DOE has prepared this EIS in accordance with the provisions of the National Environmental Policy Act as implemented by Council on Environmental Quality regulations (40 CFR Parts 1500 through 1508) and DOE National Environmental Policy Act regulations (10 CFR Part 1021), and in conformance with the NWPA.

Atomic Energy Act of 1954, as Amended (42 U.S.C. 2011 *et seq.*)

The Atomic Energy Act, as amended, provides fundamental jurisdictional authority to DOE and the Nuclear Regulatory Commission over governmental and commercial use of nuclear materials. The Atomic Energy Act ensures proper management, production, possession, and use of radioactive materials. In accordance with the Atomic Energy Act, DOE has established a system of requirements that it has issued as DOE Orders.

The Atomic Energy Act gives the Nuclear Regulatory Commission specific authority to regulate the possession, transfer, storage, and disposal of nuclear materials, as well as aspects of transportation packaging design requirements for radioactive materials, including testing for packaging certification. Commission regulations applicable to the transportation of radioactive materials (10 CFR Parts 71 and 73) require that shipping casks meet specified performance criteria under both normal transport and hypothetical accident conditions.

Under the Atomic Energy Act of 1954, as amended, the Environmental Protection Agency has the authority to develop generally applicable standards for protection of the general environment from radioactive material.

Federal Land Policy and Management Act of 1976 (43 U.S.C. 1701 *et seq.*)

The Federal Land Policy and Management Act governs the use of Federal lands administered by the Bureau of Land Management, which is an agency of the U.S. Department of the Interior. Access to and use of public lands administered by the Bureau are primarily governed by the regulations regarding the establishment of rights-of-way (43 CFR Part 2800; see Table 11-1, item 17) and withdrawals of public domain land from public use (43 CFR Part 2300; see Table 11-1, item 4), as described below in this section.

Some implementing alternative branch rail lines, routes for heavy-haul trucks, and intermodal transfer station locations that could be involved in transportation of spent nuclear fuel and high-level radioactive waste to Yucca Mountain would cross or occupy land administered by the Bureau of Land Management and would require right-of-way reservations (see Table 11-1, item 17). DOE has obtained right-of-way reservations from the Bureau of Land Management and a concurrence from the U.S. Air Force for access to the Yucca Mountain vicinity for characterization activities.

To develop a monitored geologic repository at Yucca Mountain, DOE would need to obtain control of Bureau of Land Management, Air Force, and DOE lands in western Nevada. Land withdrawal is the method by which the Federal Government gives exclusive control of land it owns to a particular agency for a particular purpose. Nuclear Regulatory Commission licensing conditions for a repository include a requirement that DOE either own or have permanent control of lands for which it is seeking a repository license, and that lands used for a repository be free and clear of all encumbrances, if significant, such as (1) rights arising under the general mining laws, (2) easements or rights-of-way, and (3) all other rights arising under lease, rights of entry, deed, patent, mortgage, appropriation, prescription, or otherwise.

The Federal Land Policy and Management Act, by which the Government accomplishes most Federal land withdrawals, contains a detailed procedure for application, review, and study by the Bureau of Land Management, and decisions by the Secretary of the Interior on withdrawal and on the terms and conditions of withdrawal. Withdrawals accomplished through the Federal Land Policy and Management Act remain valid for no more than 20 years and, therefore, do not appear to meet the permanency of control required by the Nuclear Regulatory Commission.

Only Congress has the power to withdraw Federal lands permanently for the exclusive purposes of specific agencies. Through legislative action, Congress can authorize and direct a permanent withdrawal of lands such as those proposed for the Yucca Mountain Repository. In addition, Congress would determine any conditions associated with the land withdrawal. In the absence of specific direction to

another Federal agency the Bureau of Land Management would ordinarily administer details of a Congressional withdrawal, following the provisions of 43 CFR Part 2300.

Executive Order 11514, *National Environmental Policy Act, Protection and Enhancement of Environmental Quality*

Executive Order 11514 directs Federal agencies to monitor and control their activities continually to protect and enhance the quality of the environment. The Order also requires the development of procedures both to ensure the fullest practicable provision of timely public information and understanding of Federal plans and programs with potential environmental impacts, and to obtain the views of interested parties. DOE has promulgated regulations (10 CFR Part 1021, *National Environmental Policy Act Implementing Procedures*) and has issued a DOE Order (451.1A, *National Environmental Policy Act Compliance Program*) to ensure compliance with this Executive Order.

11.2 Statutes, Regulations, and Orders Regarding Environmental Protection Requirements

11.2.1 AIR QUALITY

Clean Air Act, as amended (42 U.S.C. 7401 *et seq.*)

The Clean Air Act is intended to "protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population." Section 118 of the Act requires Federal agencies such as DOE, with jurisdiction over any property or facility that might result in the discharge of air pollutants, to comply with "all Federal, state, interstate, and local requirements" related to the control and abatement of air pollution.

The Clean Air Act requires the Environmental Protection Agency to establish National Ambient Air Quality Standards to protect public health, with an adequate margin of safety, from any known or anticipated adverse effects of a regulated pollutant (42 U.S.C. 7409). It also requires the establishment of national standards of performance for new or modified stationary sources of atmospheric pollutants (42 U.S.C. 7411) and the evaluation of specific emission increases to prevent a significant deterioration in air quality (42 U.S.C. 7470). Air emission standards are established at 40 CFR Parts 50 through 99. The Clean Air Act specifically regulates emissions of hazardous air pollutants, including radionuclides, through the National Emission Standards for Hazardous Air Pollutants Program at 40 CFR Parts 61 and 63 (see Table 11-1, items 5 and 7).

Nevada Revised Statutes: Air Emission Controls, Chapter 445B

These statutes and regulations in the Nevada Administrative Code implement State and Federal Clean Air Act provisions, identify the requirements for permits for each air pollution source (unless it is specifically exempted), and identify ongoing monitoring requirements. In accordance with the Clean Air Act, DOE could have to obtain an Operating Permit from the Nevada Division of Environmental Protection for the control of gaseous, liquid, and particulate emissions associated with the construction and operation of a repository at Yucca Mountain (see Table 11-1, item 6). To ensure that its site characterization activities comply with applicable Clean Air Act and State provisions, DOE has obtained an operating permit for surface disturbances and point source emissions.

11.2.2 WATER QUALITY

Safe Drinking Water Act, as amended [42 U.S.C. 300(f) *et seq.*]

The primary objective of the Safe Drinking Water Act is to protect the quality of public water supplies, including any drinking water system at the proposed repository. This law grants the Environmental Protection Agency the authority to protect the quality of public drinking water supplies by establishing national primary drinking water regulations. In accordance with the Safe Drinking Water Act, the

Environmental Protection Agency has delegated authority for enforcement of drinking water standards to the states. Regulations (40 CFR Parts 123, 141, 145, 147, and 149) specify maximum contaminant levels, including those for radioactivity, in public water systems, which are generally defined as systems that serve at least 15 service connections or regularly serve at least 25 year-round residents.

In 1978, the Environmental Protection Agency approved the Nevada program for enforcing drinking water standards. The Nevada Health Division is responsible for enforcement of these standards. The proposed repository would include a drinking water system that obtained water from a source off the repository site, and DOE would operate the system in accordance with Nevada Health Division permitting requirements, if applicable (see Table 11-1, items 9, 10, 11, and 16).

Clean Water Act of 1977 (33 U.S.C. 1251 *et seq.*)

The purpose of the Clean Water Act, which amended the Federal Water Pollution Control Act, is to "restore and maintain the chemical, physical, and biological integrity of the Nation's water." The State of Nevada has been delegated the authority to implement and enforce most programs in the State under the Clean Water Act; exceptions include those addressed by Section 404, which is administered by the U.S. Army Corps of Engineers, as described below in this section.

The Clean Water Act prohibits the "discharge of toxic pollutants in toxic amounts" to navigable waters of the United States. Section 313 of the Act generally requires all departments and agencies of the Federal Government engaged in any activity that might result in a discharge or runoff of pollutants to surface waters to comply with Federal, state, interstate, and local requirements. Under the Clean Water Act, states generally set water quality standards, and the Environmental Protection Agency and states regulate and issue permits for point-source discharges as part of the National Pollutant Discharge Elimination System permitting program. The Environmental Protection Agency regulations for this program are codified at 40 CFR Part 122, and Nevada rules for this program are codified at Nevada Administrative Code Chapter 445A. If the construction or operation of a Yucca Mountain Project facility or associated transportation route in Nevada would result in point-source discharges, DOE could need to obtain a National Pollutant Discharge Elimination System permit from the State of Nevada Division of Environmental Protection (see Table 11-1, item 10).

Sections 401 and 405 of the Water Quality Act of 1987 added Section 402(p) to the Clean Water Act. Section 402(p) requires the Environmental Protection Agency to establish regulations for the Agency or individual states to issue permits for stormwater discharges associated with industrial activity, including construction activities that could disturb 5 or more acres (40 CFR Part 122). Nevada rules for this program are codified at Nevada Administrative Code Chapter 445A. The Agency has promulgated regulations implementing a separate stormwater permit application process.

Section 404 of the Clean Water Act gives the U.S. Army Corps of Engineers permitting authority over activities that discharge dredge or fill material into waters of the United States. DOE could need to obtain a permit from the Corps for activities associated with a repository at Yucca Mountain if those activities would discharge dredge or fill into any such waters. If the construction or modification of rail lines or highways to the repository included dredge or fill activities or other actions that would discharge dredge or fill into waters of the United States, those activities would also require Section 404 permits. DOE has obtained a Section 404 permit for site characterization-related construction activities it might conduct in Coyote Wash or its tributaries or in Fortymile Wash.

Nevada Revised Statutes: Water Controls, Chapter 445A

These statutes classify the waters of the State, establish standards for the quality of all waters in the State, and specify permitting and notification provisions for stormwater discharges and for other discharges to waters of the State in accordance with provisions of the Federal Clean Water Act. These statutes and regulations in the Nevada Administrative Code also (1) set drinking water standards, specifications for

certification, and conditions for issuance of variances and exemptions, (2) set standards and requirements for the construction of wells and other water supply systems, (3) establish the different classes of wells and aquifer exemptions, and (4) establish requirements for well operation and monitoring, plugging, and abandonment activities. Regardless of whether these provisions are applicable, DOE has obtained an Underground Injection Control Permit and a Public Water System Permit for site characterization activities at Yucca Mountain. The Underground Injection Control Permit covers tracers, pump tests, and similar activities. The Public Water System Permit establishes the terms for the provision of potable water.

The Department would install and operate the drinking water system planned for the proposed repository in accordance with Nevada Health Division standards, if applicable, and would obtain a Water System Operating Permit from the Nevada Health Division (see Table 11-1, item 9), if needed. DOE could also need to obtain a General Permit for Storm Water Discharge from the Nevada Division of Water Resources to construct and operate a repository at Yucca Mountain (see Table 11-1, item 10). Any point-source discharges to waters of the State that occurred in the course of Yucca Mountain Project activities could require a National Pollutant Discharge Elimination System permit issued under these provisions. DOE has obtained a general discharge permit from the State for effluent discharges to the ground surface during site characterization.

Nevada Revised Statutes: Adjudication of Vested Water Rights; Appropriation of Public Waters, Chapter 533; Underground Water and Wells, Chapter 534

These statutes and accompanying regulations in the Nevada Administrative Code establish permitting procedures for appropriating public waters of the State, including underground waters, for beneficial use.

DOE has obtained temporary permits for the use of underground water from several wells during site characterization.

It is the policy of the United States Government to apply for water in accordance with state laws. In 1997, DOE applied for an appropriation of water to fulfill the purpose of the NWPA, for the proposed repository in accordance with the provisions of Chapters 533 and 534 of the Nevada Revised Statutes. The Nevada State Engineer denied the DOE water appropriation applications, and DOE appealed the denial in court. The denial is being litigated. On October 15, 2001, the United States Court of Appeals for the Ninth Circuit set the matter for trial in the U.S. District Court for the State of Nevada (No. 00-17330, D.C. No. CV-00-268-RLH).

Chapter 534 of the Nevada Revised Code establishes requirements applicable to drilling, construction, and plugging of wells for extraction of underground water.

Executive Order 11988, *Floodplain Management*

This Order directs Federal agencies to establish procedures to ensure that any Federal action undertaken in a floodplain considers the potential effects of flood hazards and floodplain management and avoids floodplain impacts to the extent practicable. For its site characterization activities, DOE conducted a floodplain assessment (see Appendix L) in accordance with this Order (DIRS 103189-DOE 1992, all) and DOE implementing regulations (10 CFR Part 1022).

Compliance With Floodplain/Wetlands Environmental Review Requirements (10 CFR Part 1022)

Federal regulations (10 CFR Part 1022) establish policy and procedures for implementing Executive Order 11988, *Floodplain Management*, and for discharging DOE responsibilities regarding the consideration of floodplain/wetlands factors in DOE planning and decisionmaking. These regulations also establish DOE procedures for identifying proposed actions located in floodplains, providing opportunity for early public review of such proposed actions, preparing floodplain assessments, and

issuing statements of findings for actions in a floodplain. The rules apply to all DOE proposed floodplain actions.

If DOE determines that an action it proposes would take place wholly or partly in a floodplain, it is required to prepare a notice of floodplain involvement and a floodplain assessment containing a project description, a discussion of floodplain effects, alternatives, and mitigations. For a proposed floodplain action for which a National Environmental Policy Act document such as an environmental impact statement or an environmental assessment is required, DOE is to include the floodplain assessment in the document. For floodplain actions for which DOE does not have to prepare such a document, the Department is to issue a separate document as the floodplain assessment. After the conclusion of public comment, DOE is to reevaluate the practicability of alternatives and of mitigation measures, considering all substantive comments.

If it finds that no practicable alternative to locating in the floodplain is available, DOE must design or modify its action to minimize potential harm to and within the floodplain. For actions in a floodplain, DOE must publish a statement of findings of three pages or less containing a brief description of the proposed action, a location map, an explanation indicating the reason for locating the action in the floodplain, a list of alternatives considered, a statement indicating whether the action conforms to applicable State or local floodplain protection standards, and a brief description of steps DOE will take to minimize potential harm to or within the floodplain. For floodplain actions that require the preparation of an EIS, the Final EIS can incorporate the statement of findings. Before implementing a proposed floodplain action, DOE must endeavor to allow at least 15 days of public review of the statement of findings.

Appendix L contains a statement of findings on the potential for repository construction and operation to affect floodplains. Appendix L also contains a floodplain/wetlands assessment that examines the effects of proposed repository construction and operation and potential construction of a rail line or intermodal transfer station. The assessment includes discussion of:

1. Floodplains near Yucca Mountain (Fortymile Wash, Busted Butte Wash, Drillhole Wash, and Midway Valley Wash); there are no delineated wetlands at Yucca Mountain.

2. What is known about floodplains and areas that might have wetlands (for example, springs and riparian areas) along potential rail corridors in Nevada and at intermodal transfer station locations associated with heavy-haul truck routes. If DOE selected rail as the mode of spent nuclear fuel and high-level radioactive waste transport in Nevada, it would select one of the rail corridors, and would prepare a more detailed floodplains/wetlands assessment of the selected corridor. If DOE selected heavy-haul truck as the mode of transport for spent nuclear fuel and high-level radioactive waste in Nevada, it would select one of five heavy-haul truck routes and one of three intermodal transfer stations, and would prepare a more detailed floodplain/wetlands assessment of the selected heavy-haul truck route and the associated intermodal transfer station.

11.2.3 HAZARDOUS MATERIALS PACKAGING, TRANSPORTATION, AND STORAGE

Roles of U.S. Department of Transportation and Nuclear Regulatory Commission in Regulating the Transportation of Radioactive Materials

The U.S. Department of Transportation and Nuclear Regulatory Commission share primary responsibility for regulating safe transportation of radioactive materials in the United States. The Department of Transportation has responsibility to develop and implement transportation safety standards for hazardous materials, including radioactive materials. In Title 49 of the Code of Federal Regulations, the Department of Transportation has established standards and requirements for packaging, transporting, and handling radioactive materials for all modes of transportation, including standards for labeling, shipping papers,

placarding, loading and unloading, allowable radioactive levels, and limits for contamination of packages and vehicles, among other requirements. The regulations also specify safety requirements for vehicles and transportation operations, training for personnel who perform handling and transportation of hazardous materials, and liability insurance requirements for carriers.

The Nuclear Regulatory Commission regulates the packaging- and transportation-related operations of its licensees, including commercial shippers of radioactive materials. It sets design and performance standards for packaging (shipping casks) that carry materials with higher levels of radioactivity. The Department of Transportation, by agreement with the Nuclear Regulatory Commission, accepts the Commission standards of 10 CFR Part 71 for packaging. The Nuclear Regulatory Commission also establishes safeguards and security regulations to minimize the possibility of theft, diversion, or attack on shipments of radioactive materials (10 CFR Part 73). Title 10 of the Code of Federal Regulations details these requirements. As required by the NWPA (Section 180), carriers would make all shipments to Yucca Mountain in Nuclear Regulatory Commission-certified packages and in accordance with Commission regulations on advance notification of state and local governments. Appendix M contains a detailed discussion of regulatory responsibilities for transportation activities.

Hazardous Materials Transportation Act (49 U.S.C. 1801)

The Hazardous Materials Transportation Act gives the U.S. Department of Transportation authority to regulate the transport of hazardous materials, including radioactive materials such as those that would be transported to the proposed Yucca Mountain Repository from 72 commercial and 5 DOE sites. Department of Transportation regulations (49 CFR Parts 171 through 180) would require the identification of hazardous materials during transportation to a repository at Yucca Mountain, set forth rules for the selection of routes that carriers must use when transporting such materials, and provide guidance to states in designating preferred routes.

Emergency Planning and Community Right-to-Know Act of 1986 (42 U.S.C. 1001 *et seq.*)

Under Subtitle A of the Emergency Planning and Community Right-to-Know Act (also known as "SARA Title III"), Federal facilities, including a repository at Yucca Mountain, must provide information on hazardous and toxic chemicals to state emergency response commissions, local emergency planning committees, and the Environmental Protection Agency. The goal of providing this information is to ensure that emergency plans are sufficient to respond to unplanned releases of hazardous substances. The required information includes inventories of specific chemicals used or stored and descriptions of releases that occur from sites. This law, implemented at 40 CFR Parts 302 through 372, requires agencies to provide material safety data sheet reports, emergency and *hazardous chemical* inventory reports, and toxic chemical release reports to appropriate local, state, and Federal agencies. DOE has been complying with the provisions of the Emergency Planning and Community Right-to-Know Act and with regulations for maintaining and using inventories of chemicals for site characterization activities. If the proposed repository received a license, DOE would continue to comply with such provisions, as applicable, in storing and using chemicals for project activities.

Nevada Revised Statutes: Hazardous Materials, Chapter 459

A Nevada Hazardous Materials Storage Permit could be required to store hazardous materials in quantities greater than those specified in the Uniform Fire Code. To receive such a permit, if sought, DOE would submit an application to the Nevada State Fire Marshal (Nevada Revised Statutes, Chapter 477) that describes its plans for the storage of hazardous materials in excess of specified quantities (see Table 11-1, item 19). If permit renewal was sought each year, DOE would have to submit an annual report to the State Fire Marshal that complied with the reporting requirements of the Federal Emergency Planning and Community-Right-to-Know Act, Sections 302, 311, and 312. Regardless of whether these provisions are applicable, DOE has obtained a permit from the State Fire Marshal for the storage of flammable materials during site characterization activities.

Nuclear Regulatory Commission Radioactive Materials Packaging and Transportation Regulations (10 CFR Parts 71 and 73)

Under 10 CFR Part 71, the Nuclear Regulatory Commission regulates the packaging and transport of spent nuclear fuel for its licensees, which include commercial shippers of radioactive material and the DOE Office of Civilian Radioactive Waste Management. In addition, under an agreement with the U.S. Department of Transportation, the Commission sets the standards for packages containing Type B quantities of radioactive materials, including high-level radioactive waste and spent nuclear fuel. Type B packages are designed and built to retain their radioactive contents in both normal and accident conditions.

The demonstration of compliance with these requirements applies a combination of simple calculational methods, computer modeling techniques, and physical testing to the design features of the package. An applicant presents the results of the analyses and tests to the Nuclear Regulatory Commission in a Safety Analysis Report for Packaging, which the Commission, after review, approves by issuing a Certificate of Compliance. This certificate would be required for the use of a package (cask) to ship spent nuclear fuel or high-level radioactive waste to the repository.

The regulations at 10 CFR Part 73 govern safeguards and physical security during the transit of shipments of spent nuclear fuel. These regulations specify requirements for vehicles, carrier personnel, communications, notification of state governors, escorts, and route planning for such shipments.

Department of Transportation Hazardous Materials Packaging and Transportation Regulations (49 CFR Subchapter C – Hazardous Materials Regulations, Parts 171 Through 180)

The Department of Transportation regulates the shipments of hazardous materials, including spent nuclear fuel and high-level radioactive waste, in interstate and intrastate commerce by land, air, and navigable water. As outlined in a 1979 Memorandum of Understanding with the Nuclear Regulatory Commission (44 *FR* 38690, July 2, 1979), the Department of Transportation specifically regulates carriers of spent nuclear fuel and the conditions of transport, such as routing, handling and storage, and vehicle and driver requirements. It also regulates the labeling, classification, and marking of transportation packages for radioactive materials.

Department of Transportation regulations include requirements for carriers, drivers, vehicles, routing, packaging, labeling, marking, placarding of vehicles, shipping papers, training, and emergency response. The requirements specify the maximum dose rate associated with radioactive material shipments and the maximum allowable levels of radioactive surface contamination on packages and vehicles.

The public highway routing regulations of the Department of Transportation are prescribed in 49 CFR Part 397. The objectives of the regulations are to reduce the impacts of transporting highway route-controlled quantities of radioactive materials to establish consistent and uniform requirements for route selection, and to identify the role of state and local governments in the routing. The requirements at 49 CFR 173.403(l) contain a complete definition of *Highway Route-Controlled Quantities of Radioactive Material.*

Shipping casks transported by legal-weight trucks typically would contain about 300,000 curies of radionuclides, and rail casks typically would contain larger quantities. These regulations attempt to reduce potential hazards by requiring the use of routes that avoid populous areas and minimize travel times. At present, the Department of Transportation does not regulate the routing of rail shipments of radioactive materials. Department of Transportation regulations also include requirements to protect the health and safety of transportation workers.

11.2.4 CONTROL OF POLLUTION

Pollution Prevention Act of 1990 (42 U.S.C. 13101 *et seq.*)

The Pollution Prevention Act of 1990 establishes a national policy for waste management and pollution control that focuses first on source reduction, then on environmentally safe recycling, treatment, and disposal. DOE requires each of its sites to establish specific goals to reduce the generation of waste. If the Department built and operated a repository at the Yucca Mountain site, it would implement an appropriate pollution prevention plan. DOE has implemented a pollution prevention plan for site characterization activities. DOE would update this plan to include construction, operation and monitoring, and closure activities if the repository received a license.

Comprehensive Environmental Response, Compensation, and Liability Act, as amended (42 U.S.C. 9601 *et seq.*)

The Comprehensive Environmental Response, Compensation, and Liability Act, as amended by the Superfund Amendments and Reauthorization Act, authorizes the Environmental Protection Agency to require responsible site owners, operators, arrangers, and transporters to clean up releases of hazardous substances, including certain radioactive substances. Under this Act, the Environmental Protection Agency would have the authority to regulate hazardous substances, including certain radioactive materials, at the Yucca Mountain Repository in the event of a release or a "substantial threat of a release" of those materials from the repository. Releases greater than reportable quantities would be reported to the National Response Center.

Standards for Protection Against Radiation (10 CFR Part 20)

The purpose of 10 CFR Part 20 is to provide standards and procedures for protection against radiation. Provisions of 10 CFR Part 20 address repository occupational dose limits, public dose limits, survey and monitoring procedures, exposure control in restricted areas, respiratory protection and controls, precautionary procedures, and related topics.

Low-Level Radioactive Waste Policy Amendments Act of 1985 (P.L. 99-240)

Under the Low-Level Radioactive Waste Policy Amendments Act of 1985 (P.L. 99-240), DOE is responsible for disposal of any low-level waste generated by operations at the proposed Yucca Mountain Repository. Such waste would be considered DOE-owned and -generated waste.

On February 25, 2000, DOE issued a Record of Decision (65 *FR* 10061) to establish regional low-level waste disposal at the Hanford Site and Nevada Test Site that would be available to all DOE sites. DOE would ensure that Yucca Mountain is an approved generator in accordance with the requirements of Nevada Test Site waste acceptance criteria prior to disposal of any low-level radioactive waste at the Test Site generated from Yucca Mountain Repository operations.

Resource Conservation and Recovery Act, as amended (42 U.S.C. 6901 *et seq.*)

The treatment, storage, and disposal of hazardous and nonhazardous waste is regulated in accordance with the provisions of the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act and the Hazardous and Solid Waste Amendments of 1984, and applicable state laws.

Environmental Protection Agency regulations implementing the hazardous waste portions of the Resource Conservation and Recovery Act define hazardous wastes and specify requirements for their transportation, handling, treatment, storage, and disposal (40 CFR Parts 260 through 272). In addition, under current Civilian Radioactive Waste system requirements, DOE could not accept hazardous waste for disposal at Yucca Mountain. Before shipping to Yucca Mountain, DOE would treat materials that contained hazardous components to eliminate the hazardous waste characteristics. Before shipping materials containing hazardous components listed under Subpart D of Part 261 or applicable state requirements, DOE would process any necessary delisting petitions with the appropriate regulatory

authorities. If the activities at Yucca Mountain generated hazardous or mixed waste, the Department would not dispose of such waste on the site and would not treat such waste in a manner that required Resource Conservation and Recovery Act permitting, and would not store such waste on the site for more than 90 days. DOE does not expect to need a Resource Conservation and Recovery Act permit for its activities at the proposed repository.

Noise Control Act of 1972, as amended (42 U.S.C. 4901 *et seq.*)

Section 4 of the Noise Control Act directs Federal agencies to carry out programs in their jurisdictions "to the fullest extent within their authority" and in a manner that furthers a national policy of promoting an environment free from noise that jeopardizes health and welfare. This law provides requirements related to noise that would be generated by construction, operation, or closure activities associated with the Proposed Action at Yucca Mountain.

Nevada Revised Statutes: Sanitation, Chapter 444

These statutes and regulations in the Nevada Administrative Code establish the standards, permits, and requirements for septic tanks and other sewage disposal systems for single-family dwellings, communities, and commercial buildings. The construction and operation of a sanitary sewage collection system at Yucca Mountain could require the State of Nevada to approve DOE designs and to issue a permit. In connection with site characterization activities, DOE operates a septic system that the State has permitted under these provisions.

These statutes and regulations also set forth the definitions, methods of disposal, special requirements for solid waste collection and transportation standards, and classification of landfills. Onsite disposal of solid waste from a repository at Yucca Mountain could require that DOE obtain an appropriate permit for these activities.

In compliance with the Resource Conservation and Recovery Act, the Environmental Protection Agency has authorized the State of Nevada to regulate the management and disposal of solid, hazardous, and mixed wastes in the State. The Nevada Division of Environmental Protection or an equivalent solid waste management authority would regulate the onsite disposal of nonhazardous solid wastes generated by activities associated with the proposed repository. DOE would manage such waste in accordance with applicable laws and regulations.

Nevada Administrative Code Chapter 444 contains regulations that provide for fees, variances, and permits, and has adopted Environmental Protection Agency regulations (40 CFR Parts 2, 124, and 260 through 270) as part of the code. The regulations could affect any hazardous or mixed waste generated, treated, or stored onsite by activities associated with a proposed repository at Yucca Mountain. DOE would ship any generated hazardous or mixed wastes off the site within 90 days for treatment, storage, and disposal.

Executive Order 12088, *Federal Compliance with Pollution Control Standards*

Executive Order 12088, as amended by Executive Order 12580, *Superfund Implementation Control Standards*, generally directs Federal agencies to comply with applicable administrative and procedural pollution control standards established by, but not limited to, the Clean Air Act, the Noise Control Act, the Clean Water Act, the Safe Drinking Water Act, the Toxic Substances Control Act, and the Resource Conservation and Recovery Act. Compliance with these orders, as applicable, would be required for a range of DOE activities associated with a proposed repository at Yucca Mountain.

Executive Order 12856, *Right to Know Laws and Pollution Prevention Requirements*

This Order directs Federal agencies to reduce and report toxic chemicals entering any waste stream; improve emergency planning, response, and accident notification; and encourage the use of clean technologies and testing of innovative prevention technologies. In addition, the Order states that Federal

agencies are persons for purposes of the Emergency Planning and Community Right-to-Know Act (SARA Title III), which requires agencies to meet the requirements of the Act. Compliance with these orders, as applicable, would be required for a range of DOE activities associated with a proposed repository at Yucca Mountain.

11.2.5 CULTURAL RESOURCES

National Historic Preservation Act, as amended (16 U.S.C. 470 *et seq.*)

The National Historic Preservation Act provides for the placement of sites with significant national historic value on the *National Register of Historic Places.* It requires no permits or certifications. DOE would evaluate activities associated with a repository at Yucca Mountain to determine if they would affect historic resources. If required after this evaluation, the Department would consult with the Advisory Council on Historic Preservation and the Nevada State Historic Preservation Officer. Such consultations generally result in the development of an agreement that includes stipulations to be followed to minimize or mitigate potential adverse impacts to a historic resource (see Table 11-1, item 12).

DOE has entered into a programmatic agreement with the Advisory Council on Historic Preservation for implementation of the National Historic Preservation Act for site characterization activities. This agreement requires DOE to consult and interact with Native Americans during site characterization. In compliance with the agreement provisions, Native American representatives from the Southern Paiute, Western Shoshone, and Owens Valley Paiute and Shoshone Tribes have reviewed Yucca Mountain activities on the site twice each year. These reviews have been followed by discussions between Native American representatives and DOE personnel, submittal of comments by the Native American representatives, and responses to the comments by DOE.

Archaeological Resources Protection Act, as amended (16 U.S.C. 470aa *et seq.*)

The Archaeological Resources Protection Act requires a permit for excavation or removal of archaeological resources from publicly held or Native American lands (see Table 11-1, item 14). Excavations must further archaeological knowledge in the public interest, and the resources removed are to remain the property of the United States. If a resource is found on land owned by a Native American tribe, the tribe must give its consent before a permit is issued, and the permit must contain terms or conditions requested by the tribe. Requirements of the Archaeological Resources Protection Act would apply to any Yucca Mountain Project excavation activities that resulted in identification of archaeological resources.

American Indian Religious Freedom Act of 1978 (42 U.S.C. 1996)

The American Indian Religious Freedom Act reaffirms Native American religious freedom under the First Amendment and establishes policy to protect and preserve the inherent and constitutional right of Native Americans to believe, express, and exercise their traditional religions. This law ensures the protection of sacred locations and access of Native Americans to those sacred locations and traditional resources that are integral to the practice of their religions. Further, it establishes requirements that would apply to Native American sacred locations, traditional resources, or traditional religious practices potentially affected by the construction and operation of a repository at Yucca Mountain.

Native American Graves Protection and Repatriation Act of 1990 (25 U.S.C. 3001)

The Native American Graves Protection and Repatriation Act directs the Secretary of the Interior to guide the repatriation of Federal archaeological collections and collections that are culturally affiliated with Native American tribes and held by museums that receive Federal funding. Major actions to be taken under this law include (1) the establishment of a review committee with monitoring and policymaking responsibilities, (2) the development of regulations for repatriation, including procedures for identifying lineal descent or cultural affiliation needed for claims, (3) the oversight of museum programs designed to

meet the inventory requirements and deadlines of this law, and (4) the development of procedures to handle unexpected discoveries of graves or grave goods during activities on Federal or tribal land. The provisions of the Act would be invoked if any excavations associated with a repository at Yucca Mountain led to unexpected discoveries of Native American graves or grave artifacts. DOE and the Southern Paiute, Western Shoshone, and Owens Valley Paiute and Shoshone Tribes have entered an agreement to address the potential applicability of the Native American Graves Protection and Repatriation Act to artifacts collected during site characterization activities at Yucca Mountain.

Antiquities Act (16 U.S.C. 431 *et seq.*)

The Antiquities Act protects historic and prehistoric ruins, monuments, and objects of antiquity (including paleontological resources) on lands owned or controlled by the Federal Government. If historic or prehistoric ruins or objects were found during the construction or operation of facilities associated with a repository at Yucca Mountain, DOE would have to determine if adverse effects to these ruins or objects would occur. If adverse effects would occur, the Secretary of the Interior would have to grant permission to proceed with the activity (36 CFR Part 296 and 43 CFR Parts 3 and 7) (see Table 11-1, item 13).

Executive Order 13007, *Indian Sacred Sites*

This Order directs Federal agencies, to the extent permitted by law and not inconsistent with agency missions, to avoid adverse effects to sacred sites and to provide access to those sites to Native Americans for religious practices. The Order directs agencies to plan projects to provide protection of and access to sacred sites to the extent compatible with the project.

Executive Order 13175, *Consultation and Coordination with Indian Tribal Governments*

This Order directs Federal agencies to establish regular and meaningful consultation and collaboration with tribal governments in the development of Federal policies that have tribal implications, to strengthen United States government-to-government relationships with Indian tribes, and to reduce the imposition of unfunded mandates on tribal governments.

11.2.6 ENVIRONMENTAL JUSTICE

Executive Order 12898, *Environmental Justice*

This Order directs Federal agencies, to the extent practicable, to make the achievement of environmental justice part of their mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority and low-income populations in the United States and its territories and possessions. The order provides that the Federal agency responsibilities it establishes are to apply equally to Native American programs.

11.2.7 ECOLOGY AND HABITAT

Endangered Species Act, as amended (16 U.S.C. 1531 *et seq.*)

The Endangered Species Act provides a program for the conservation of threatened and endangered species and the ecosystems on which those species rely. If a proposed action could affect threatened or endangered species or their habitat, the Federal agency must assess the potential impacts and develop measures to minimize those impacts. The agency then must consult formally with the Fish and Wildlife Service (part of the U.S. Department of the Interior) and the National Marine Fisheries Service (part of the Department of Commerce), as required under Section 7 of the Act. The outcome of this consultation would be a biological opinion by the Fish and Wildlife Service or the National Marine Fisheries Service that stated whether the proposed action would jeopardize the continued existence of the species under consideration. If there is a non-jeopardy opinion, but some individuals are killed incidentally as a result of the proposed action, the Services can determine that such losses are not prohibited as long as measures

outlined by the Services are followed. Regulations implementing the Endangered Species Act are codified at 50 CFR Parts 15 and 402.

There are no known endangered species on the Yucca Mountain site. The desert tortoise is the only threatened species found on the site. The Fish and Wildlife Service previously issued a biological opinion stating that site characterization activities at Yucca Mountain would not jeopardize the continued existence of the desert tortoise (DIRS 104618-Buchanan 1997, p. 16).

The U.S. Fish and Wildlife Service has issued a Biological Opinion (50 CFR 402.6; see Table 11-1, item 18) establishing reasonable and prudent meaures and terms and conditions to ensure that constructing, operating and monitoring, and eventually closing a repository at Yucca Mountain would not jeopardize the continued existence of the desert tortoise (see Appendix O). If the repository was approved, DOE would comply with all provisions of the Biological Opinion, including the reasonable and prudent measures and their implementing terms and conditions. DOE would fulfill the requirements of the Endangered Species Act, as appropriate, with regard to transportation impacts before making a final determination on a transportation route.

Fish and Wildlife Coordination Act, as amended (16 U.S.C. 661, 48 Stat. 401)

The Fish and Wildlife Coordination Act promotes more effectual planning and cooperation between Federal, state, public, and private agencies for the conservation and rehabilitation of the Nation's fish and wildlife and authorizes the Department of the Interior to provide assistance.

Migratory Bird Treaty Act, as amended (16 U.S.C. 703 *et seq.*)

The purpose of the Migratory Bird Treaty Act is to protect birds that have common migration patterns between the United States and Canada, Mexico, Japan, and Russia. It regulates the take and harvest of migratory birds. The Fish and Wildlife Service will review this EIS to determine whether the activities analyzed would comply with the requirements of the Migratory Bird Treaty Act. Studies indicate that no requirements of this Act are applicable to the Yucca Mountain Project.

Bald and Golden Eagle Protection Act, as amended (16 U.S.C. 668-668d)

The Bald and Golden Eagle Protection Act makes it unlawful to take, pursue, molest, or disturb bald (American) and golden eagles, their nests, or their eggs anywhere in the United States (Section 668, 668c). The Department of the Interior regulates activities that might adversely affect bald and golden eagles. The Fish and Wildlife Service will review this EIS to determine whether the activities analyzed in this EIS would comply with the Bald and Golden Eagle Protection Act. DOE has established a program to ensure compliance with this law during site characterization activities.

National Wildlife Refuge System Administration Act of 1966 (16 U.S.C. 668dd)

The National Wildlife Refuge System Administration Act provides guidelines for the administration and management of lands in the system, including "wildlife refuges, areas for the protection and conservation of fish and wildlife that are threatened with extinction, wildlife ranges, game ranges, wildlife management areas, or waterfowl production areas." If use of lands for transportation corridors and facilities such as a rail line or intermodal transfer station associated with a repository at Yucca Mountain could affect lands in the system, DOE would consult with the Fish and Wildlife Service. Regulations implementing the Act are codified at 50 CFR Parts 25 and 27 through 29. The Fish and Wildlife Service will review this EIS to determine if the Proposed Action would comply with the Act. It is DOE policy to place transportation corridors and facilities to avoid existing wildlife refuges.

Nevada Revised Statutes: Protection and Preservation of Timbered Lands, Trees, and Flora, Chapter 527

These provisions broadly protect the indigenous flora of the State of Nevada. If the State determines that a species or subspecies of native flora is threatened with extinction, that species or subspecies is to be placed on the State list of fully protected species. In general, no member of the species or subspecies may be taken or destroyed unless an authorized State official issues a special permit. Activities associated with a repository at Yucca Mountain arguably could affect such species and could require special permits.

Nevada Revised Statutes: Hunting, Fishing, and Trapping; Miscellaneous Protective Measures, Chapter 503; Nevada Administrative Code, Chapter 503: Sections 010-104, General Provisions

These provisions specify procedures for the classification and protection of wildlife. If the State determines that an animal species is threatened with extinction, the species is to be placed on the State list of fully protected species. In general, no member of the species may be taken or destroyed unless the Nevada Division of Wildlife issues a special permit. Activities associated with a repository at Yucca Mountain arguably could affect such species and could require special permits. Regardless of whether these provisions are applicable, DOE has obtained a permit for site characterization activities from the State of Nevada.

Executive Order 11990, *Protection of Wetlands*

This order directs Federal agencies to avoid new construction in wetlands unless there is no practicable alternative and unless the proposed action includes all practicable measures to minimize harm to wetlands that might result from such use. DOE requirements for compliance with wetlands activity review procedures are codified at 10 CFR Part 1022.

Executive Order 13112, *Invasive Species*

This order directs Federal agencies to act to prevent the introduction of or to monitor and control invasive (non-native) species, to provide for restoration of native species, to conduct research, to promote educational activities, and to exercise care in taking actions that could promote the introduction or spread of invasive species. If a repository were constructed at Yucca Mountain, DOE would comply with provisions of this Executive Order as part of construction, operation and monitoring, and closure activities.

Executive Order 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds*

This Order requires Federal agencies to avoid or minimize the negative impacts of their actions on migratory birds, and to take active steps to protect birds and their habitats. The Order directs each Federal agency taking actions having or likely to have a negative impact on migratory bird populations to work with the U.S. Fish and Wildlife Service to develop an agreement to conserve those birds. The Order directs agencies to avoid or minimize impacts to migratory bird populations, take reasonable steps that include restoring and enhancing habitat, prevent or abate pollution affecting birds, and incorporate migratory bird conservation into agency planning processes whenever possible. The Order also requires environmental analyses of Federal actions to evaluate effects of those actions on migratory birds, to control the spread and establishment in the wild of exotic animals and plants that could harm migratory birds and their habitats, and either to provide advance notice of actions that could result in the take of migratory birds or to report annually to the U.S. Fish and Wildlife Service on the numbers of each species taken during the conduct of agency actions. If a repository was constructed at Yucca Mountain, DOE would comply with provisions of this Executive Order as part of construction, operation and monitoring, and closure activities.

11.2.8 USE OF LAND AND WATER BODIES

Coastal Zone Management Act (16 U.S.C. 1451 *et seq.*)

The purpose of the Coastal Zone Management Act is to preserve, protect, develop, restore, and enhance the resources of the Nation's coastal zone. Resources include wetlands, floodplains, estuaries, beaches, dunes, barrier islands, coral reefs, and fish and wildlife and their habitat. This law provides for (1) management to minimize the loss of life and property caused by improper development and by the destruction of natural protective features such as beaches, dunes, wetlands, and barrier islands, and (2) improvement, safeguarding, and restoration of the quality of coastal waters, and for protection of existing uses of those waters. The Coastal Zone Management Act requires priority consideration to coastal-dependent uses and orderly processes for siting major facilities related to national defense, energy, fisheries development, recreation, ports and transportation, and the location of new commercial and industrial developments in or adjacent to areas where such development already exists.

The operation of a repository at Yucca Mountain could require the use of barges for transportation of spent nuclear fuel along portions of routes from some storage facilities. In addition, rail corridors, roads, and bridges from some storage facilities could require repair or enhancement before they could support shipment of spent nuclear fuel. DOE would ensure that its activities are consistent with state-specific coastal zone management plans promulgated in accordance with this Act, if applicable. The regulations promulgated under the Act are codified at 15 CFR Part 930.

Rivers and Harbors Act (33 U.S.C. 401 *et seq.*)

The transportation of spent nuclear fuel and high-level radioactive waste could require the construction or modification of road or rail bridges that span navigable waters. The Rivers and Harbors Act prevents the alteration or modification of the course, location, condition, or capacity of any channel of any navigable water of the United States without a permit from the U.S. Army Corps of Engineers. If DOE assumed responsibility for such construction or modifications, it would need to obtain a permit from the U.S. Army Corps of Engineers. Regulations implementing this Act are codified at 33 CFR Part 323.

National Forest Organic Administrative Act (16 U.S.C. 521)

The National Forest Organic Administrative Act establishes the functions and responsibilities of the Forest Service, an agency of the U.S. Department of Agriculture. The Forest Service would be requested to approve the construction of rail lines and roads in Nevada that would be associated with the operation of a repository at Yucca Mountain and that could cross land administered by the Service (16 U.S.C. 1600, 1611 to 1614).

National Forest Management Act of 1976

The National Forest Management Act establishes decision planning and management practices for forests. This law could affect any proposed construction of rail lines or roads associated with the construction or operation of a repository at Yucca Mountain that could cross National Forest lands.

Materials Act of 1947 (30 U.S.C. 601-603)

The Materials Act authorizes land management agencies, such as the Bureau of Land Management and the Forest Service, to make common varieties of sand, stone, and gravel from public lands available to Federal and state agencies under a Free Use Permit (see Table 11-1, item 15). Regulations implementing the Materials Act are codified at 43 CFR Part 3620. DOE has received three free use permits from the Bureau of Land Management to obtain gravel for site characterization activities in a manner compliant with the Materials Act.

Taylor Grazing Act (43 U.S.C. 315-316)

The Taylor Grazing Act establishes the processes by which the Bureau of Land Management grants and administers grazing rights. If a decision is made to construct and operate a repository, a new rail line, or a

new road on a Bureau of Land Management grazing allotment, DOE would have to acquire a right-of-way grant across the allotment or a withdrawal of the allotment. Regulations implementing the Taylor Grazing Act are codified at 43 CFR Part 4100.

Farmland Protection Policy Act (7 U.S.C. 4201 *et seq.*)

The Farmland Protection Policy Act seeks to minimize the extent to which Federal programs contribute to the unnecessary and irreversible conversion of farmlands to nonagricultural uses. Compliance with this law requires concurrence from the Natural Resources Conservation Service of the U.S. Department of Agriculture that proposed activities would not affect farmlands. DOE has completed a consultation with the Natural Resources Conservation Service that determined that a repository at Yucca Mountain would not affect prime or unique farmlands. This EIS assesses the potential construction of a rail line, new roads, or an intermodal transfer station in Nevada to determine if that construction could affect such lands. Regulations implementing the Farmland Protection Policy Act are codified at 7 CFR Part 658.

11.3 Department of Energy Orders

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. 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. Table 11-3 lists DOE Orders potentially relevant to the Civilian Radioactive Waste Management Program.

The Nuclear Regulatory Commission is authorized to license the proposed Yucca Mountain repository. Some DOE Orders overlap or duplicate Nuclear Regulatory Commission repository licensing regulations in whole or in part. Recognizing this, the Department issued DOE HQ Order 250.1, *Civilian Radioactive Waste Management Facilities – Exemption from Departmental Directives.* This Order exempts geologic repository design, construction, operation, and decommissioning from compliance with the provisions of DOE Orders that overlap or duplicate Commission requirements related to radiation protection, nuclear safety (including quality assurance), and safeguard and security of nuclear material. The exemption would apply only to portions of a repository project for which DOE sought a Nuclear Regulatory Commission license. DOE Orders would continue to establish requirements for other activities associated with a repository that fall outside the scope of this exemption, for example in the area of computer security (Order 1360.28).

Through DOE Order 440.1A, *Worker Protection Management for DOE Federal and Contractor Employees,* the Department has prescribed the Occupational Safety and Health Act standards that contractors are to meet in their work at government-owned, contractor-operated facilities.

A monitored geologic repository at Yucca Mountain would be a nonreactor nuclear facility. DOE Orders 5480.21, *Unreviewed Safety Questions,* 5480.22, *Technical Safety Requirements,* and 5480.23, *Nuclear Safety Analysis Reports,* ordinarily apply to nonreactor nuclear facilities. Because DOE Order 250.1 gives precedence to Nuclear Regulatory Commission rules, DOE Orders 5480.21, 5480.22, and 5480.23, for example, probably would not apply to the repository.

11.4 Potentially Applicable Federal Regulations

Sections 11.2.1 through 11.2.8 and Section 11.3 identify major laws, regulations, and DOE Orders potentially applicable to the construction, operation and monitoring, and closure of a monitored geologic repository. Table 11-4 lists other potentially applicable regulations and orders.

Table 11-3. DOE Orders potentially relevant to the Civilian Radioactive Waste Management Program (page 1 of 2).

Order	Subject	Description
151.1	Comprehensive Emergency Management System	Establishes requirements for emergency planning, preparedness, response, recovery, and readiness assurance activities and describes the approach for effectively integrating these activities under a comprehensive, all-emergency concept.
231.1	Environment, Safety and Health Reporting	Establishes the requirements and procedures for reporting information with environmental protection, safety, or health protection significance for DOE operations.
232.1	Occurrence Reporting and Processing of Operations Information	Establishes the requirements for reporting and processing occurrences related to safety, health, security, property, operations, and the environment, up to and including emergencies.
250.1	Civilian Radioactive Waste Management Facilities – Exemption from Departmental Directives	Establishes the relationship between DOE directives and Nuclear Regulatory Commission regulations for the Yucca Mountain Project.
420.1A	Facility Safety	Establishes facility safety requirements related to nuclear safety design, criticality safety, fire protection, and natural phenomena hazards mitigation.
425.1	Facility Startup and Restart	Establishes procedures to be followed when a facility is taken from a nonoperational to an operational state.
430.1	Life Cycle Asset Management	Establishes procedures to be followed in all phases of the management of DOE facilities.
435.1	Radioactive Waste Management	Establishes policies and guidelines by which DOE manages radioactive waste, waste byproducts, and radioactively contaminated surplus facilities.
440.1A	Worker Protection Management for DOE Federal and Contractor Employees	Establishes a comprehensive worker protection program that ensures that DOE and its contractor employees have an effective worker protection program that will reduce or prevent injuries, illnesses, and accidental losses by providing DOE, Federal, and contractor workers with a safe and healthful workplace.
451.1B	National Environmental Policy Act Compliance Program	Establishes DOE internal requirements and responsibilities for implementing the National Environmental Policy Act of 1969, as amended, the Council on Environmental Quality regulations implementing the procedural provisions of the Act (40 CFR Part 1500 *et seq.*), and the DOE procedures that implement it (10 CFR Part 1021).
460.1A	Packaging and Transportation Safety	Establishes requirements and assigns responsibilities for the safe transport of hazardous materials, hazardous substances, hazardous wastes, and radioactive materials.
462.1	Departmental Materials Transportation and Packaging Management	Establishes supplemental policies and requirements for materials transportation and packaging operations.
1300.2A	Department of Energy Technical Standards Program	Establishes policy, assigns responsibility, and provides requirements for development and application of technical standards in DOE facilities, programs, and projects; provides for participation in non-Government standards bodies and for establishment of a DOE Technical Standards Program; and assigns responsibility for the management of the program.

Table 11-3. DOE Orders potentially relevant to the Civilian Radioactive Waste Management Program (page 2 of 2).

Order	Subject	Description
1360.2B	Unclassified Computer Security Program	Establishes requirements, policies, responsibilities, and procedures for developing, implementing, and sustaining a DOE unclassified computer security program.
3790.1B	Federal Employee Occupational Safety and Health Program	Establishes requirements and procedures to ensure that occupational safety and health standards prescribed pursuant to the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974, and the DOE Organization Act of 1977 provide occupational safety and health protection for DOE contractor employees in Government-owned contractor-operated facilities.
5400.1	General Environmental Protection Program	Establishes environmental protection program requirements, authorities, and responsibilities for DOE operations to ensure compliance with applicable Federal, state, and local environmental protection laws and regulations and with internal DOE policies.
5400.5	Radiation Protection of the Public and the Environment	Establishes standards and requirements for operation of DOE and DOE contractors with respect to protection of members of the public and the environment against undue risk from radiation.
5480.19	Conduct of Operations Requirements for DOE Facilities	Provides requirements and guidelines for DOE elements to use in developing directives, plans, and procedures related to the conduct of operations at DOE facilities.
5484.1	Environmental Protection, Safety, and Health Protection Information Reporting Requirements	Establishes the requirements and procedures for the investigation of occurrences having environmental protection, safety, or health protection significance, and for efficient environmental monitoring of DOE operations.
5610.14	Transportation Safeguards System Program Operations	Establishes DOE policies for and implementation of the management and operation of the Transportation Safeguards System program.
5632.1C	Protection and Control of Safeguards and Security Interests	Establishes policy, responsibilities, and authorities for the protection and control of safeguards and security interests (for example, special nuclear material, vital equipment, classified matter, property, facilities, and unclassified irradiated reactor fuel in transit).
5633.3B	Control and Accountability of Nuclear Materials	Prescribes the minimum DOE requirements and procedures for control and accountability of nuclear materials at DOE-owned and -leased facilities and DOE-owned nuclear materials at facilities that are exempt from licensing by the Nuclear Regulatory Commission. Would apply to materials destined for a repository before the materials reached the repository.

Table 11-4. Other potentially applicable Federal regulations, orders, standards, and memoranda (page 1 of 3).

Document Number	Title[a]
Code of Federal Regulations	
10 CFR Part 2	Rules of Practice for Domestic Licensing Proceedings and Issuance of Orders
10 CFR Part 19	Notices, Instructions and Reports to Workers: Inspection and Investigations
10 CFR Part 40	Domestic Licensing of Source Material
10 CFR Part 51	Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions
10 CFR Part 75	Safeguards on Nuclear Material-Implementation of US/IAEA Agreement
10 CFR Part 100	Reactor Site Criteria
10 CFR Part 707	Workplace Substance Abuse Programs at DOE Sites
10 CFR Part 830	Nuclear Safety Management
10 CFR Part 835	Occupational Radiation Protection
10 CFR Part 1021	National Environmental Policy Act Implementing Procedures
10 CFR Part 1022	Compliance with Floodplain/Wetlands Environmental Review Requirements
29 CFR Part 1926	Safety and Health Regulations for Construction
29 CFR Part 1960	Basic Program Elements for Federal Employee Occupational Safety and Health Programs and Related Matters
30 CFR Part 57	Safety and Health Standards, Underground Metal and Nonmetal Mines
33 CFR Part 323	Permits for Discharges of Dredged or Fill Material into Waters of the United States
33 CFR Chapter I	Coast Guard Department of Transportation (Parts 1-199)
36 CFR Part 296	Permits to Proceed (Objects of Antiquity)
36 CFR Part 800	Protection of Historic and Cultural Properties
40 CFR Part 50	National Primary and Secondary Ambient Air Quality Standards
40 CFR Part 60	Standards of Performance for New Stationary Sources
40 CFR Part 61	National Emission Standards for Hazardous Air Pollutants
40 CFR Part 63	National Emission Standards for Hazardous Air Pollutants for Source Categories
40 CFR Part 122	EPA Administered Permit Programs: The National Pollutant Discharge Elimination System
40 CFR Part 125	Criteria and Standards for the National Pollutant Discharge Elimination System
40 CFR Part 133	Secondary Treatment Regulation
40 CFR Part 136	Guidelines Establishing Test Procedures for the Analysis of Pollutants
40 CFR Part 141	National Primary Drinking Water Regulations
40 CFR Part 142	National Primary Drinking Water Regulations Implementation
40 CFR Part 143	National Secondary Drinking Water Regulations
40 CFR Part 246	Source Separation for Materials Recovery Guidelines
40 CFR Part 257	Criteria for Classification of Solid Waste Disposal Facilities and Practices
40 CFR Part 260	Hazardous Waste Management System: General
40 CFR Part 261	Identification and Listing of Hazardous Waste
40 CFR Part 262	Standards Applicable to Generators of Hazardous Waste
40 CFR Part 263	Standards Applicable to Transporters of Hazardous Waste
40 CFR Part 264	Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR Part 265	Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR Part 268	Land Disposal Restrictions
40 CFR Part 280	Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks
40 CFR Part 503	Standards for the Use or Disposal of Sewage Sludge
40 CFR Part 747	Metalworking Fluids
40 CFR Part 761	Polychlorinated Biphenyls Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions
40 CFR Parts 1500 to 1508	Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act

Table 11-4. Other potentially applicable Federal regulations, orders, standards, and memoranda (page 2 of 3).

Document Number	Title[a]
Code of Federal Regulations (continued)	
41 CFR Part 101	Federal Property Management Regulations
43 CFR Parts 3 and 7	Preservation of Antiquities, Protection of Archaeological Resources
43 CFR Part 2300	Land Withdrawal
43 CFR Part 3620	Free Use Permit
43 CFR Part 4100	Grazing Administration, Exclusive of Alaska
49 CFR Part 40	Procedures for Transportation Workplace Drug Testing Programs
49 CFR Part 171	General Information, Regulations and Definitions
49 CFR Part 172	Hazardous Materials Table, Special Provisions, Hazardous Materials Communications Requirements and Emergency Response Information Requirements
49 CFR Part 173	Shippers – General Requirements for Shipments and Packagings
49 CFR Part 174	Carriage by Rail
49 CFR Part 176	Carriage by Vessel
49 CFR Part 177	Carriage by Public Highway
49 CFR Part 178	Shipping Container Specifications
49 CFR Part 180	Continuing Qualification and Maintenance of Packagings
49 CFR Part 392	Driving of Motor Vehicles
49 CFR Part 393	Parts and Accessories Necessary for Safe Operation
49 CFR Part 395	Hours of Service for Drivers
50 CFR Part 17	Endangered and Threatened Wildlife and Plants
50 CFR Part 400	Endangered Species Act
50 CFR Part 402	Interagency Cooperation – Endangered Species Act of 1973, as Amended
Executive Orders	
Executive Order 11514	National Environmental Policy Act, Protection and Enhancement of Environmental Quality
Executive Order 11988	Floodplain Management
Executive Order 11990	Protection of Wetlands
Executive Order 12856	Right to Know Laws and Pollution Prevention Requirements
Executive Order 12898	Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations
Executive Order 13007	Indian Sacred Sites
Executive Order 13084	Consultation and Coordination with Indian Tribal Governments
Executive Order 13132	Federalism
Other documents, orders and directives	
AAR Rule 91	1993 Field Manual of Association of American Railroads Interchange Rules (AAR Interchange Rule 91, Weight Limitations)
BLM Manual, Sec. 9113	Bureau of Land Management Manual, Road Standards
DOE Order 430.1	Life Cycle Asset Management
DOE Order 3790.1	Federal Employees Occupational Safety and Health Program
DOE Order 5480.4	Environmental Protection, Safety, and Health Protection Standards
DOE Order 5632.1	Protection Program Operation
DOE/EA-0179	Environmental Assessment Waste Form Selection for Savannah River HLW
DOE/EH-0256T	DOE Radiological Control Manual
DOE/RW-0184	Characteristics of Potential Repository Wastes, Volumes 1-4
DOE/RW-0194P	Records Management Policies and Requirements
DOE/RW-0328P	Acceptance Priority Ranking
DOE/RW-0333P	OCRWM Quality Assurance Requirements and Description
DOE/RW-0457	1995 Acceptance Priority Ranking and Annual Capacity Report
DOE-STD-1020	Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities
DOE-STD-1021	Natural Phenomena Hazards Performance Categorization Criteria for Structures, Systems and Components
DOE-STD-1022	Natural Phenomena Hazards Site Characterization Criteria

Table 11-4. Other potentially applicable Federal regulations, orders, standards, and memoranda (page 3 of 3).

Document Number	Title[a]
Other documents, orders and directives (continued)	
DOE-STD-1023	Natural Phenomena Hazards Assessment Criteria (Draft)
DOE-STD-1024	Guidelines for Use of Probabilistic Seismic Hazard Curves at Department of Energy Sites
DOE-STD-1062	Ergonomic and Human Factors Design Criteria[b]
Fed-STD-795	Uniform Federal Accessibility Standards
GSA-FSS-W-A-450/1-17	General Service Administration Interim Federal Specification
MOA DP/RW	Policy for Shipping Defense High-Level Waste (DHLW) to a Civilian Radioactive Waste Repository
MOA RW/NS	Nuclear Safety Requirement
MOU DOE/DOL	Mining Safety
NRC RG 1.13	Spent Fuel Storage Facility Design Basis
NRC RG 1.76	Design Basis Tornado for Nuclear Power Plants
NRC RG 8.8	Information Relevant to Ensuring That Occupational Radiation Exposure at Nuclear Power Stations Will Be As Low As Is Reasonably Achievable
NRC RG 8.10	Operating Philosophy for Maintaining Occupational Radiation Exposure As Low As Is Reasonably Achievable
NUREG 0700	Guidelines for Control Room Design Reviews
NUREG 0856	Final Technical Position on Documentation of Computer Codes for High-Level Waste Management
Presidential Memo (04/30/85)	Dispose of Defense Waste in a Commercial Repository

a. IAEA = International Atomic Energy Agency; EPA = Environmental Protection Agency; HLW = high-level radioactive waste; OCRWM = Office of Civilian Radioactive Waste Management.

b. This standard is complete, but has not been formally published at this time. However, it is included here as a source because it consists of a compilation of requirements from accepted sources. Those sources include standards from the Code of Federal Regulations, Nuclear Regulatory Commission regulations, and military, American National Standards Institute, National Aeronautics and Space Administration, and Electric Power Research Institute standards, as well as recognized design handbooks and guides that govern standard engineering practice.

REFERENCES

104618 Buchanan 1997 — Buchanan, C.C. 1997. "Final Biological Opinion for Reinitiation of Formal Consultation for Yucca Mountain Site Characterization Studies." Letter from C.C. Buchanan (Department of the Interior) to W. Dixon (DOE/YMSCO), July 23, 1997, File No. 1-5-96-F-307R. ACC: MOL.19980302.0368.

103189 DOE 1992 — DOE (U.S. Department of Energy) 1992. *Environmental Assessment for the Shipment of Low Enriched Uranium Billets to the United Kingdom from the Hanford Site, Richland, Washington.* DOE/EA-0787. Richland, Washington: U.S. Department of Energy. ACC: MOL.20010730.0389.

100018 National Research Council 1995 — National Research Council 1995. *Technical Bases for Yucca Mountain Standards.* Washington, D.C.: National Academy Press. TIC: 217588.

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References

12. REFERENCES

Chapter 12 of the Draft Environmental Impact Statement (EIS) listed all of the references cited in Chapters 1 through 11 of that document. For this Final EIS, the U.S. Department of Energy (DOE or the Department) has put a list of references at the end of each chapter that is specific to that chapter. DOE feels that this makes it easier for the reader to find the complete citations relevant to each chapter. Information regarding the availability of these references can be found in the DOE Reading Rooms (as listed in Appendix D) or on the internet at the Yucca Mountain Project website at *http://www.ymp.gov*.

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Preparers, Contributors, and Reviewers

13. PREPARERS, CONTRIBUTORS, AND REVIEWERS

13.1 Preparers and Contributors

This chapter lists the individuals who filled primary roles in the preparation of this final environmental impact statement (EIS). Jane R. Summerson of the U.S. Department of Energy (DOE) Yucca Mountain Project Office directed the preparation of the EIS. Primary support and assistance to DOE was provided by the EIS Preparation Team, led by Joseph W. Rivers, Jr., of Jason Technologies Corporation; other members of the team included Tetra Tech NUS Inc., Battelle, and Dade Moeller & Associates. Judith A. Shipman coordinated the work of the Jason Technologies Corporation production team (Elisa Aguilar, Dalene Glanz, Laura Hall, Virginia Hutchins, Robin Klein, Evelyn Mayfield, Aaron McKinnon, and Janet McCreary). Dawn Siekerman supervised the EIS recordkeeping and reference support team (Marcia Gershin, Angelica Marquez, and Jessi Pagel). Glenn Caprio, assisted by Barbara Rhoads, provided scheduling support. Cynthia Langdale and Kathy Grebstad, under the supervision of Diane Morton, ensured EIS revision control accuracy.

DOE provided direction to the EIS Preparation Team, which was responsible for developing the analytical methodology and alternatives, coordinating the work tasks, performing the impact analyses, and producing the document. DOE was responsible for data quality, the scope and content of the EIS, and issue resolution and direction.

In addition, the Management and Operating Contractor to the DOE Yucca Mountain Site Characterization Office (Bechtel SAIC Corporation and its subcontractors) assisted in the preparation of supporting documentation and information for the EIS, as did Sandia, Argonne, and Oak Ridge National Laboratories. These organizations worked closely with the EIS Preparation Team under DOE direction.

DOE independently evaluated all supporting information and documentation prepared by these organizations. Further, DOE retained the responsibility for determining the appropriateness and adequacy of incorporating any data, analyses, and results of other work performed by these organizations in the EIS. The EIS Preparation Team was responsible for integrating such work into the EIS.

As required by Federal regulations (40 CFR 1506.5c), Jason Technologies Corporation and its subcontractors have signed NEPA Disclosure Statements in relation to the work they performed on this EIS. These statements appear at the end of this chapter.

Name	Education	Experience	Responsibility
U.S. Department of Energy			
Jane R. Summerson	Ph.D., Geology, 1991 M.S., Geobiology, 1985 M.A., Anthropology, 1978 B.A., Anthropology, 1977	11 years – waste management projects with the DOE Office of Civilian Radioactive Waste Management	Document Manager
Robin L. Sweeney	Ph.D. student, Environmental Science and Public Policy M.S., Geosciences, 1987 B.S., Biological Sciences, 1980	22 years – hazardous and nuclear waste field; waste management, RCRA/CERCLA facility assessments, sampling and monitoring, project/program management, laboratory research	Senior Technical Specialist; NEPA Compliance Officer

Name	Education	Experience	Responsibility
Joseph D. Ziegler	B.S., Engineering (Nuclear), 1975	26 years – nuclear engineering, nuclear safety, environmental assessment, and project management; Federal and commercial nuclear projects	Senior Technical Advisor
M. Jozette Booth	B.S., Business Administration	18 years – transportation and policy analysis, communications and public participation, intergovernmental and Native American consultations	Technical lead for transportation and American Indian Programs
Wendy R. Dixon	Postgraduate studies, Geology and Environmental Science M.B.A., Business B.A., Sociology	21 years – management of nuclear-related projects; 14 years – regulatory compliance and field management; 6 years – safety and health	Senior Advisor for Environmental Policy
Kenneth J. Skipper	B.S., Geology, 1984	19 years – geotechnical/ environmental project management; Federal civil works projects; planning, construction, operations, and performance monitoring	Document Manager until March 2001
Final EIS Preparation Team			
Joseph W. Rivers, Jr. Jason Technologies Corporation	B.S., Mechanical Engineering, 1982	19 years – commercial and DOE nuclear projects; design, systems engineering, safety analysis, and regulatory compliance	Project Manager
David R. Wayman Jason Technologies Corporation	M.B.A., Business Administration, 1988 B.S., Construction Technology, 1980	20 years – commercial and DOE projects; construction engineering, nuclear safety analysis, environment compliance and permitting	Deputy Project Manager; Lead, Comment-Response Document
Diane E. Morton Jason Technologies Corporation	B.S., Chemical Engineering, 1979	21 years – DOE nuclear and environmental projects; project/program management, assessments, planning	Document Manager
John O. Shipman Jason Technologies Corporation	B.A., English Literature, 1966	35 years – NEPA documentation, technical writing and editing, publications management; 10 years – public participation	Document Production Manager, Editor; Comment-Response Document

Name	Education	Experience	Responsibility
Dawn Siekerman Jason Technologies Corporation	B.S., Biology, 1985	16 years – 3 years NEPA document preparation, 6 years environmental compliance/mixed waste project coordination/ quality assurance, 7 years inorganic chemistry	Records/Data Manager
Roseanne Aaberg Battelle – Pacific Northwest National Laboratories	B.S., Chemical Engineering, 1976	24 years – geological analysis; 11 years – environmental health physics	Air quality
Thomas Anderson Battelle Memorial Institute	B.S., Botany, 1973	28 years – preparation of DOE NEPA documents	Transportation
Pixie Baxter Tetra Tech NUS Inc.	M.B.A., Economics, 1981 B.A., Art History	20 years – multidisciplinary economic and business experience including 15 years as Economics College faculty member	Lead analyst, socioeconomics
William J. Berry Jason Technologies Corporation	Ph.D., Entomology, 1988 M.S., Biology, 1983 B.S., Biology, 1981	12 years – NEPA documents, ecological risk assessments, and habitat management plans	Lead analyst, biological resources
Ralph E. Best Jason Technologies Corporation	M.B.A., 1981 M.S., Electrical Engineering, 1970 B.S., Engineering Physics, 1964	36 years – energy, transportation, and environmental technology	Lead analyst, transportation
Carol Cole Jason Technologies Corporation	B.S., Experimental Psychology, 1967	20 years – NEPA documents, communications, public participation, media planning	Comment-Response Document
William J. Craig Dade Moeller & Associates	M.S., Planning, 1977 B.S., Forestry, 1972	22 years – environmental project management, nuclear fuel planning and analyses, natural resource management, and nuclear powerplant siting and relicensing	Comment-Response Document
David Crowl Jason Technologies Corporation	B.A., Computer Science, 1985	16 years – editing and document production	Editor

Name	Education	Experience	Responsibility
Keith D. Davis, PE Jason Technologies Corporation	M.S., Civil and Environmental Engineering, 1976 B.S., Civil Engineering, 1973	25 years – civil and environmental engineering; waste management; facility permitting and closure; site investigations, feasibility studies, and remedial action planning; 8 years – NEPA documentation	Hydrology; soils
Peter R. Davis Jason Technologies Corporation	Oak Ridge School of Reactor Technology, 1962 B.S. Physics, 1961	38 years – nuclear reactor and nuclear facility safety analysis and risk assessment	Lead analyst, accidents, inventory
Ted B. Doerr Jason Technologies Corporation	Ph.D., Wildlife and Fisheries Sciences, 1988 M.S., Range Science, 1980 B.S., Wildlife and Fisheries Sciences, 1977	19 years – NEPA implementation, ecology, environmental and ecological risk assessments, mitigation development, and regulatory compliance	Project Manager, Draft EIS
Sara A. Doersam Jason Technologies Corporation	B.A., Psychology, 1982	9 years – editing and publishing; 14 years – health administration	Editor
Paul W. Eslinger Battelle – Pacific Northwest National Laboratories	Ph.D., Statistics, 1983 M.A., Mathematics, 1978 B.S., Mathematics, 1976	18 years – environmental risk and human and ecological risk analysis	Long-term performance analysis
Suzanne Fiscus Jason Technologies Corporation	B.S., Mechanical Engineering, 1987	12 years - DOE nuclear projects; safety analysis, design and testing, waste characterization	Offsite manufacturing of disposal containers, shipping casks, drip shields, emplacement pallets, and related components
Philip C. Fulmer Dade Moeller & Associates	Ph.D., Nuclear Engineering, 1993 M.S., Health Physics, 1990 B.S., Health Physics, 1989	7 years – preparation of NEPA documents; 12 years – radiation protection, internal radiation dosimetry, external radiation dosimetry	Lead analyst, cumulative impacts
Gary Gunter Tetra Tech NUS Inc	B.S., Geology, 1984	5 years – preparation of NEPA documents; 13 years – assessments, remedial action	Lead analyst, land use; aesthetics

Name	Education	Experience	Responsibility
Ernest C. Harr, Jr. Jason Technologies Corporation	B.S., Zoology/Chemistry, 1977	12 years – preparation of NEPA documents; acted as DOE EM Headquarters NEPA Compliance Officer; reviewed many DOE waste management NEPA documents.	Deputy Project Manager, Draft EIS; Project Manager, 1999-2000
Mary N. Hoganson Tetra Tech NUS Inc.	M.S., Biology, 1989 B.S., Biology, 1984	14 years – waste management and waste minimization; 6 years – NEPA document preparation	Lead analyst, waste management and hazardous materials
Richard H. Holder Jason Technologies Corporation	M.B.A., Business Administration, 1986 M.S., Electrical Engineering, 1970 B.S., Electrical Engineering, 1966	33 years – team and line management for nuclear utility, industrial, and overseas projects	Proposed Action, alternatives, summary of findings and comparison
R. Kingsley House, PE Jason Technologies Corporation	M.S., Engineering Science/Nuclear Option, 1963 B.S., Mechanical Engineering, 1960 Nevada Registration No. 13062, 1997	40 years – nuclear and non-nuclear facility design, construction, testing, and operation; hazards analysis, safety analysis, and environmental impact analysis	Lead analyst, utilities, energy, materials, and site services; offsite manufacturing of disposal containers, shipping casks, drip shields, waste package supports, and related components
Tracy A. Ikenberry, CHP Dade Moeller & Associates	M.S., Radiology & Radiation Biology, 1982 B.A., Biology, 1979	19 years - environmental and occupational radiation protection; 7 years - NEPA document management and technical analysis	Lead analyst, short-term repository impacts, air quality; human health and safety
David H. Lester Jason Technologies Corporation	Ph.D., Chemical Engineering, 1969 M.S., Chemical Engineering, 1966 B.Che., Chemical Engineering, 1964	28 years – hazardous and nuclear waste management; nuclear Safety Analysis Reports, hazards analysis of waste storage operations, risk assessment of low-level nuclear waste burial operations, groundwater contamination transport modeling, performance assessment of high-level nuclear waste systems, design of treatment systems, design and analysis of high-level waste packages, and soil remediation studies	Lead Analyst, long-term performance

Name	Education	Experience	Responsibility
Steven Maheras Battelle Memorial Institute	Ph.D., Health Physics, 1988 M.S., Health Physics, 1985 B.S., Zoology, 1982 Certified Health Physicist, 1992	13 years – transportation risk assessment and radiological assessment; environmental and occupational radiation protection	Transportation
Thomas McSweeney Battelle Memorial Institute	Ph.D., Chemical Engineering, 1967 M.A., Mathematics, 1964 M.S., Chemical Engineering, 1961 B.S., Chemical Engineering, 1960	34 years – risk and safety analysis; 14 years – transportation risk analysis	Transportation
William E. Nichols Battelle – Pacific Northwest National Laboratories	M.S., Civil Engineering, 1990 B.S., Agricultural Engineering, 1987	12 years – subsurface flow and transport modeling and model development, environmental dispersion modeling and model development, probabilistic risk assessment, total systems modeling for geologic radioactive waste disposal evaluation, and NEPA documents	Long-term performance analysis
Paul R. Nickens Battelle – Pacific Northwest National Laboratories	Ph.D., Anthropology, 1977 M.A., Anthropology, 1974 B.A., Anthropology, 1969	25 years – cultural resource management and Native American consultation	Cultural resources
Donna L. Osborne Jason Technologies Corporation	20 years experience	20 years – technical editing, document production and coordination; 2 years – NEPA documentation	Editor
W. Kent Ostler Jason Technologies Corporation	Ph.D., Plant Ecology, 1979 M.S., Botany, 1976 B.S., Botany, 1974	22 years – plant ecology and arid land reclamation; identification of techniques to mitigate human impacts on biotic communities; surveys and research on endangered and threatened species; mitigation strategies for recovery of species	Biological resources

Name	Education	Experience	Responsibility
Ted M. Poston Battelle – Pacific Northwest National Laboratories	M.S., Fisheries, 1978 B.A., Biology,1973	19 years – noise analysis; 26 years – environmental research and toxicology; 24 years – NEPA experience	Lead analyst, noise and ground vibration
Eugene M. Rollins Dade Moeller & Associates	M.S.P.H., Health Physics, 1976 B.S., Nuclear Engineering, 1973	25 years – technical and management experience in health physics and risk assessments related to the nuclear fuel cycle	Lead analyst, No-Action Alternative
Steven B. Ross Battelle Memorial Institute	M.S., Nuclear Engineering, 1987 B.S., Nuclear Engineering, 1985	16 years – safety analysis, risk assessment, transportation, regulatory analysis, and fire risk assessment	Transportation
Dillard B. Shipler Battelle Memorial Institute	M.S., Major in Physics, 1967 B.S., Major in Science & Math, 1957 Certified Health Physicist, 1983	40 years – environment, safety, and health protection; occupational health and safety; radiation protection; high-level waste management; risk assessment; regulatory compliance; NEPA; systems engineering; and project/program management.	Transportation; Comment-Response Document
Judith A. Shipman Jason Technologies Corporation	A.A., General Studies, 1991	26 years – NEPA documentation, document production coordination, editing	Production Coordinator, Editor; Comment-Response Document
Sandra Snyder Battelle Memorial Institute	M.S.P.H., Radiological Hygiene, 1991 B.S., Environmental Resource Management, 1986	10 years – assessment of environmental and occupational exposure to radionuclides and chemicals	Air quality
Dennis Strenge Battelle Memorial Institute	M.S., Chemical Engineering, 1968 B.S., Chemical Engineering	33 years – environment exposure analysis and dosimetry for accidental and chronic releases of radionuclides and chemicals	Accidents
Lucinda Low Swartz Battelle Memorial Institute	J.D., 1979 B.A., Political Science and Administrative Studies, 1976	21 years – environmental law and regulation, specializing in NEPA compliance	Summary

Name	Education	Experience	Responsibility
John E. von Reis Jason Technologies Corporation	J.D., 1969 B.A., English (Prelegal), 1966	28 years – energy, environmental, resource and regulatory issues	Lead analyst, purpose and need, regulatory requirements, mitigation, unavoidable adverse impacts, environmental justice
Dee H. Walker Jason Technologies Corporation	Ph.D., Chemical Engineering, 1963 M.S., Chemical Engineering, 1962 Oak Ridge School of Reactor Technology, 1954 B.S., Chemical Engineering, 1953	48 years – nuclear engineering; 11 years – effects of radiological releases on humans and the environment	Health and safety
Jeffrey L. Weiler Jason Technologies Corporation	M.S., Resource Economics/ Environmental Management, 1974 B.A., Political Science, 1970	28 years – management of large interdisciplinary project teams; interagency coordination; stakeholder involvement; NEPA compliance	Document Manager, Draft EIS; Comment-Response Document
Ruth Weiner Jason Technologies Corporation	Ph.D., Chemistry, 1962 M.S., Chemistry, 1959 M.S., Physics, 1957 B.S., Physics, 1956	14 years – risk assessment of airborne pollutants and transportation risks, decision analysis; 25 years – environmental impact assessment; 35 years – professor of chemistry and environmental studies; 15 years – radioactive waste disposal, radioactive waste policy and regulation	Transportation
Thomas J. Winnard Battelle Memorial Institute	B.S., Geology, 1984	12 years – information systems	Transportation

13.2 Reviewers

The DOE Yucca Mountain Project Office incorporated input into the preparation of this EIS from a number of other DOE offices that reviewed the document while it was under development. These included the Offices of Environmental Management, Naval Reactors, Nuclear Energy, Materials Disposition, the National Spent Fuel Program, and the National High-Level Waste Program. The DOE Yucca Mountain Site Characterization Office, Nevada Operations Office, Idaho National Engineering and Environmental Laboratory, Hanford Site, and Savannah River Site also participated in the reviews of this EIS. In addition, personnel on assignment to the Yucca Mountain Project Office from the U.S. Department of the Interior Bureau of Reclamation provided technical review and other support, as did personnel from the DOE Office of Civilian Radioactive Waste Management Technical Support Services Contractor (Booz-Allen & Hamilton and its subcontractors).

QUALIFICATION CRITERION NO. 1

NEPA DISCLOSURE STATEMENT FOR
PREPARATION OF THE
ENVIRONMENTAL IMPACT STATEMENT FOR A GEOLOGIC REPOSITORY FOR THE DISPOSAL OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE AT YUCCA MOUNTAIN, NYE COUNTY, NEVADA

CEQ Regulations at 40 CFR 1506.5(c), which have been adopted by the DOE (10 CFR 1021), require contractors who will prepare and EIS to execute a disclosure specifying that they have no financial or other interest in the outcome of the project. The term "financial interest or other interest in the outcome of the project" for purpose of this disclosure is defined in the March 23, 1981, guidance "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations", 46 FR 18026-18038 at Question 17a and b.

"Financial or other interest in the outcome of the project" includes "any financial benefit such as a promise of future construction or design work in the project, as well as indirect benefits the contractor is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients)". See 46 FR 18026-18031.

In accordance with these requirements, the offeror and the proposed subcontractors hereby certify as follows. (check either (a) or (b) and list financial or other interest if (b) is checked)

(a) ☑ Contractor has no financial or other interest in the outcome of the project.

(b) ☐ Offeror and any proposed subcontractor have the following financial or other interest in the outcome of the project and hereby agree to divest themselves of such interest prior to award of this contract.

Financial or Other Interest

1.

2.

3.

Certified By:

Signature

James S. Holm

Name (Printed)

Director of Contracts

Title

Jason Associates Corporation

Company

June 7, 1999

Date

QUALIFICATION CRITERION NO. 1

NEPA DISCLOSURE STATEMENT FOR PREPARATION OF THE ENVIRONMENTAL IMPACT STATEMENT FOR A GEOLOGIC REPOSITORY FOR THE DISPOSAL OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE AT YUCCA MOUNTAIN, NYE COUNTY, NEVADA

CEQ Regulations at 40 CFR 1506.5c, which have been adopted by the DOE (10 CFR 1021), require contractors who will prepare an EIS to execute a disclosure specifying that they have no financial or other interest in the outcome of the project. The term "financial interest or other interest in the outcome of the project" for purposes of this disclosure is defined in the March 23, 1981, guidance "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations", 46 FR 18026-18038 at Question 17a and b.

"Financial or other interest in the outcome of the project" includes "any financial benefit such as a promise of future construction or design work in the project, as well as indirect benefits the contractor is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients)". See 46 FR 18026-18031.

In accordance with these requirements, the offeror and the proposed subcontractors hereby certify as follows: (check either (a) or (b) and list financial or other interest if (b) is checked).

(a) ☑ Contractor has no financial or other interest in the outcome of the project.

(b) ☐ Offeror and any proposed subcontractor have the following financial or other interest in the outcome of the project and hereby agree to divest themselves of such interest prior to award of this contract.

Financial or Other Interest

1.

2.

3.

Certified by:

Signature

Janet M. Mandel
Name (Printed)

Manager, Contract Operations
Title

Tetra Tech NUS, Inc.
Company

June 4, 1999
Date

QUALIFICATION CRITERION NO. 1

NEPA DISCLOSURE STATEMENT FOR
PREPARATION OF THE
ENVIRONMENTAL IMPACT STATEMENT FOR A GEOLOGIC REPOSITORY FOR THE DISPOSAL OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE AT YUCCA MOUNTAIN, NYE COUNTY, NEVADA

CEQ Regulations at 40 CFR 1506.5(c), which have been adopted by the DOE (10 CFR 1021), require contractors who will prepare and EIS to execute a disclosure specifying that they have no financial or other interest in the outcome of the project. The term "financial interest or other interest in the outcome of the project" for purpose of this disclosure is defined in the March 23, 1981, guidance "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations", 46 FR 18026-18038 at Question 17a and b.

"Financial or other interest in the outcome of the project" includes "any financial benefit such as a promise of future construction or design work in the project, as well as indirect benefits the contractor is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients)". See 46 FR 18026-18031.

In accordance with these requirements, the offeror and the proposed subcontractors hereby certify as follows. (check either (a) or (b) and list financial or other interest if (b) is checked)

(a) ☒ Contractor has no financial or other interest in the outcome of the project.

(b) ☐ Offeror and any proposed subcontractor have the following financial or other interest in the outcome of the project and hereby agree to divest themselves of such interest prior to award of this contract.

Financial or Other Interest

1.

2.

3.

Certified By:

Signature

RALPH K. HENRICKS
Name (Printed)

CONTRACTING OFFICER
Title

BATTELLE MEMORIAL INSTITUTE
COLUMBUS OPERATIONS
Company

June 7, 1999
Date

QUALIFICATION CRITERION NO. 1

NEPA DISCLOSURE STATEMENT FOR
PREPARATION OF THE
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

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Financial or Other Interest

1.

2.

3.

Certified By:

Signature

Matthew P. Moeller
Name (Printed)

Vice President
Title

Dade Moeller & Assoc.
Company

June 4, 1999
Date

14

Glossary

14. GLOSSARY

(Note: A number of the terms in the Glossary emphasize their project-specific relationship to the Yucca Mountain Repository EIS. Words in *italics* refer to other words in the glossary.)

10,000-year peak of the mean annual dose
For this EIS, the largest annual *dose* analyzed within the first 10,000 years. See *peak of the mean annual dose (post-10,000 years).*

100-year flood
A flood event of such magnitude that it occurs, on average, every 100 years; this equates to a 1-percent chance of its occurring in a given year.

500-year flood
A flood event of such magnitude that it occurs, on average, every 500 years; this equates to a 0.2-percent chance of its occurring in a given year.

A-weighted decibel scale
See *decibel, A-weighted.*

accessible environment
For this EIS, all points on Earth outside the surface and subsurface area controlled over the long term for the repository, including the atmosphere above the *controlled area.*

accident
An unplanned sequence of events that results in undesirable consequences. Examples in this EIS include an inadvertent release of *radioactive* or hazardous materials from their containers or *confinement* to the *environment*; vehicular accidents during the transportation of highly radioactive materials; and industrial accidents that could affect workers in the facilities.

acre-foot
The volume of water required to cover 1 acre to a depth of 1 foot (about 1,200 cubic meters or 330,000 gallons).

actinide
Any one of a series of chemically similar elements of *atomic numbers* 89 (actinium) through 103 (lawrencium). All actinides are *radioactive.*

active institutional control
Continued Federal control of the Yucca Mountain Repository site including access control, maintenance, monitoring, and surveillance of facilities and waste. See *institutional control.*

aerosol
A suspension of tiny, *colloid*-size particles or liquid droplets in air. Fog and smoke are common examples of aerosols.

affected environment
For an EIS, a description of the existing *environment* (that is, site description) covering information that relates directly to the scope of the *Proposed Action*, the *No-Action Alternative*, and the *implementing alternatives* being analyzed; in other words, the information necessary to assess or understand the *impacts*. This description must contain enough detail to support the

impact analysis. The information must highlight "environmentally sensitive resources," if present; these include floodplains and wetlands, *threatened* and *endangered species*, prime and unique agricultural lands, and property of historic, archaeological, or architectural significance.

aging

Retaining *commercial spent nuclear fuel* on the surface at the proposed repository for future emplacement in an underground *drift*. DOE could retain the spent nuclear fuel in either wet or dry storage. If the Department used dry storage, it would place the spent nuclear fuel in a storage module licensed by the Nuclear Regulatory Commission.

affected unit of local government

The unit local government with jurisdiction over the site of a repository or a monitored retrievable storage facility. This term may, at the discretion of the Secretary of Energy, include units of local government that are contiguous with such unit. For the proposed, Yucca mountain Repository, the affected units of local government are Nye County, which has jurisdiction over the repository site and counties contiguous to Nye county (that is, Clark, Lincoln, White Pine, Eureka, Lander, Churchill, Mineral, and Esmeralda Counties in Nevada and Inyo County in California).

air lock

A chamber or room in which air pressure can be regulated, usually between two regions of unequal pressure. The isolation air locks each consist of two *bulkheads* with doors that open and close in sequence.

air quality

A measure of the concentrations of pollutants, measured individually, in the air.

ALARA

See *as low as reasonably achievable.*

alcove

A small excavation (room) off the main tunnel of a repository used for scientific study or for installing equipment.

alien species

With respect to a particular ecosystem, any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem.

alignment

As used in the transportation analysis in this EIS, the location of a rail line in a *corridor.*

alkali flat

A level area or plain in an *arid* or semiarid region encrusted with alkali salts that become concentrated by evaporation and poor drainage. *Cap.* (Alkali Flat): An example of such terrain, approximately 25 miles south of the location in Amargosa Valley formerly known as Lathrop Wells along the Amargosa River.

alkalinity

Acid-neutralizing capacity of a substance. High alkalinity conditions can promote metal *corrosion.*

Alloy-22

A *corrosion*-resistant, high-nickel alloy used for the outer shell of the *disposal container/waste package*, and for the parts of the emplacement pallet that would contact the waste package.

alluvial fan

A low, outspread, relatively flat to gently sloping mass of loose rock material, shaped like an open fan or a segment of a cone, deposited by a stream where it issues from a narrow mountain valley on a plain or broad valley.

alluvium

Sedimentary material deposited by flowing water.

alpha particle

A positively charged particle ejected spontaneously from the *nuclei* of some *radioactive* elements. It is identical to a helium nucleus and has a mass number of 4 and an electrostatic charge of +2. It has low penetrating power and a short range (a few centimeters in air). See *ionizing radiation.*

alternate

As used in the transportation analysis in this EIS, a variation of a rail corridor segment to mitigate a potential adverse environmental or engineering factor. See *variation*, *option*, *corridor.*

alternative

One of two or more actions, processes, or propositions from which a *decisionmaker* will determine the course to be followed. The *National Environmental Policy Act*, as amended, states that in preparing an EIS, an agency "shall ... (s)tudy, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources" [42 U.S.C. 4321, Title I, Section 102 (E)]. The regulations of the Council on Environmental Quality that implement the National Environmental Policy Act indicate that the alternatives section in an EIS is "the heart of the environmental impact statement" (40 CFR 1502.14), and include rules for presenting the alternatives, including no action, and their estimated impacts.

This EIS has two alternatives: the *Proposed Action* under which DOE would construct, operate and monitor, and eventually close a *monitored geologic repository* for the *disposal* of *spent nuclear fuel* and *high-level radioactive waste* at Yucca Mountain, and the *No-Action Alternative* under which DOE would end *site characterization* activities at Yucca Mountain, and spent nuclear fuel and high-level radioactive waste at commercial storage sites and DOE facilities would continue to accumulate. The *Nuclear Waste Policy Act* states that this EIS does not have to discuss alternatives to geologic disposal or alternative sites to Yucca Mountain; DOE included the analysis of the No-Action Alternative to provide a basis for comparison with the Proposed Action. See *implementing alternative.*

DOE will base its decision on whether the repository program should proceed toward a site recommendation for Yucca Mountain in part on the Final EIS.

Amargosa Desert

The basin area lying south of Beatty, Nevada, and extending southeast some 80 kilometers (50 miles) to the area of Alkali Flat in California. The unincorporated Town of Amargosa Valley, Nevada, lies in the central portion of Amargosa Desert. Amargosa Desert is also the name of

hydrographic area number 230 which is part of the Death Valley Groundwater Region; both are designations used by the State of Nevada in its water planning and appropriations efforts. The boundaries of the Amargosa Desert hydrographic area closely resemble those of the geographic area.

Amargosa River

The main drainage system of the *Amargosa Desert*. The Amargosa River drainage basin originates in the Pahute Mesa-Timber Mountain area north of Yucca Mountain and includes the main tributary systems of *Beatty Wash* and *Fortymile Wash*. The river, which is frequently dry along much of its length, flows southeastward through the Amargosa Desert and ends in the internal drainage system of Death Valley.

ambient

(1) Undisturbed, natural conditions such as ambient temperature caused by climate or natural *subsurface* thermal gradients. (2) Surrounding conditions.

ambient air

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

ambient air quality standards

Standards established on a Federal or state level that define the limits for airborne concentrations of designated *criteria pollutants* [nitrogen dioxide, *sulfur dioxide*, *carbon monoxide*, *particulate matter* with aerodynamic diameters less than 10 microns (PM_{10}), *ozone*, and lead] to protect public health with an adequate margin of safety (primary standards) and to protect public welfare, including plant and animal life, visibility, and materials (secondary standards). See *criteria pollutants.*

analyzed land withdrawal area

See *land withdrawal area.*

aquifer

A *subsurface* saturated rock unit (formation, group of formations, or part of a formation) of sufficient *permeability* to transmit *groundwater* and yield usable quantities of water to wells and springs.

aquitard

A rock unit or layer or layer that stores water and allows it to move only at a very slow rate.

areal mass loading

As used in *thermal loading* calculations, the amount of *heavy metal* (usually expressed in metric tons of uranium or equivalent) emplaced per unit area in the proposed repository.

arid

(1) Areas where mean annual evaporation exceeds mean annual precipitation; (2) having insufficient rainfall to support agriculture; (3) the hyper-arid zone (arid index 0.03) comprises dryland areas without vegetation with the exception of a few scattered shrubs. Annual rainfall is low, rarely exceeding 100 millimeters (4 inches). In the arid zone (arid index 0.03-0.20), the native vegetation is sparse, being comprised of annual and perennial grasses and other herbaceous vegetation, and shrubs and small trees. There is high rainfall variability, with annual amounts ranging between 100 and 300 millimeters (4 and 12 inches).

as low as reasonably achievable
A process that applies a graded approach to reducing *dose* levels to workers and the public, and releases of *radioactive* materials to the *environment*. The goal of this process, often referred to as ALARA, is not merely to reduce doses, but to reduce them to levels that are as low are reasonable achievable.

assembly
See *fuel assembly*.

atmospheric dispersion
Movement of a *contaminant* as a result of the cumulative effect of the wind patterns and random motions of the air.

atomic mass
The mass of a neutral atom, based on a relative scale, usually expressed in atomic mass units. See *atomic weight*.

atomic number
The number of protons in an atom's nucleus.

atomic weight
The relative mass of an atom based on a scale in which a specific carbon atom (carbon-12) is assigned a mass value of 12. Also known as relative *atomic mass*.

autolytic criticality
A transient *criticality* in which the usual mechanisms that tend to shut down a criticality are delayed until a high *fission* rate is achieved.

backfill
The general fill that is placed in the excavated areas of an underground facility. Backfill for the proposed repository could be *tuff* or other material.

background radiation
Radiation from cosmic sources, naturally occurring *radioactive* materials such as granite, and global fallout from nuclear testing.

Bare Mountain
An upfaulted mountain block that bounds the west side of *Crater Flat*.

barrier
Any material, structure, or condition (as a thermal barrier) that prevents or substantially delays the movement of water or *radionuclides*. See *natural barrier*.

basalt
A dark gray to black, dense to fine-grained *igneous* rock.

baseline
Documentation of current conditions so that changes can be identified.

Beatty Wash
A tributary drainage to the *Amargosa River*; drains the west and north sides of the Yucca Mountain area.

berm
A mound or wall of earth.

beta particle
A negatively charged *electron* or positively charged positron emitted from a *nucleus* during decay. Beta decay usually refers to a radioactive transformation of a nuclide by electron emission, in which the atomic number increases by 1 and the mass number remains unchanged. In positron emission, the atomic number decreases by 1 and the mass number remains unchanged. See *ionizing radiation.*

biosphere
The ecosystem of the Earth and the living *organisms* inhabiting it.

blending
See *fuel blending.*

block-bounding fault
A high-angle, normal fault with relatively large displacement that bounds one or both sides of the fault-block mountains typical of the Basin and Range province.

boiling-water reactor (BWR)
A *nuclear reactor* that uses boiling water to produce steam to drive a turbine.

borehole
For this EIS, a hole drilled for purposes of collecting *site characterization* data or for supplying water.

borosilicate glass
High-level radioactive waste matrix material in which boron takes the place of the lime used in ordinary glass mixtures.

borrow areas
Areas outside the rail corridor where construction personnel could obtain materials to be used in the establishment of a stable platform (subgrade) for the rail track. Aggregate crushing operations could occur in these areas.

buffer cars
Railcars in front of or in back of those carrying *spent nuclear fuel* and *high-level radioactive waste* to provide additional distance to possibly occupied railcars or to railcars carrying hazardous materials other than *radioactive* materials. Federal regulations require the separation of a railcar carrying spent nuclear fuel and high-level radioactive waste from a locomotive, occupied caboose, carload of undeveloped film, or railcar carrying another class of hazardous material by at least one buffer car. These could be DOE railcars or, in the case of general freight service, commercial railcars.

bulkhead

A wall or embankment in a mine or tunnel that protects against earthslide, fire, water, or gas.

burnup

A measure of *nuclear reactor* fuel consumption expressed either as the percentage of fuel atoms that have undergone *fission* or as the amount of energy produced per unit weight of fuel.

caldera

An enlarged volcanic crater formed by explosion or collapse of the original crater.

cancer

A malignant tumor of potentially unlimited growth, capable of invading surrounding tissue or spreading to other parts of the body.

candidate species

Species for which the U.S. Fish and Wildlife Service has enough substantive information on biological status and threats to support proposals to list them as threatened or endangered under the Endangered Species Act. Listing is anticipated but has been precluded temporarily by other listing activities.

canister

An unshielded metal container used as: (1) a pour mold in which molten vitrified *high-level radioactive waste* can solidify and cool; (2) the container in which DOE and electric utilities place intact *spent nuclear fuel*, loose rods, or nonfuel components for shipping or storage; or (3) in general, a container used to provide radionuclide *confinement*. Canisters are used in combination with specialized overpacks that provide structural support, shielding or confinement for storage, transportation, and *emplacement*. Overpacks used for transportation are usually referred to as transportation *casks*; those used for emplacement in a repository are referred to as *waste packages*.

capillary barrier

A contact in the *unsaturated zone* between a *geologic* unit containing relatively small-diameter openings and a unit containing relatively large-diameter openings across which water does not flow.

carbon monoxide

A colorless, odorless, poisonous gas produced by incomplete fossil-fuel combustion; one of the six pollutants for which there is a national *ambient air quality standard.*

carbon steel

A steel that is tough but malleable and contains a small percentage of carbon. The inner *barrier* of *waste packages* is composed of carbon steel.

carcinogen

An agent capable of producing or inducing *cancer*.

carcinogenic

Capable of producing or inducing *cancer*.

cask

(1) A heavily shielded container that meets applicable regulatory requirements used to ship *spent nuclear fuel* or *high-level radioactive waste*; (2) a heavily shielded container used by DOE and utilities for the *dry storage* of spent nuclear fuel; usable only for storage, not for transportation to or *emplacement* in a repository.

chain reaction

A process in which some of the *neutrons* released in one *fission* event cause other fission events that in turn release *neutrons.*

characterization

Activities in the laboratory or the field undertaken to establish the geologic conditions and the ranges of the parameters of a candidate site relevant to the location of a repository. These activities include borings, surface excavations, excavations of exploratory shafts, limited *subsurface* lateral excavations and borings, and *in situ* testing to evaluate the suitability of a candidate site for the location of a repository, but do not include preliminary borings and geophysical testing to assess if *site characterization* should be undertaken.

Civilian Radioactive Waste Management System

The organizational system of the DOE Office of Civilian Radioactive Waste Management; it is the composite of the sites and all facilities, systems, equipment, materials, information, activities, and personnel required to perform the activities necessary to manage *radioactive* waste *disposal.*

cladding

The metallic outer sheath of a fuel element generally made of stainless steel or a *zirconium alloy.* It is intended to isolate the fuel element from the external *environment.*

clastic

Describing a rock or sediment composed mainly of broken fragments of preexisting minerals or rocks that have been transported from their places of origin.

climate states

Representations of climate conditions. Six different climate states are used to represent changes in climate over the periods of interest: Interglacial Climate (the same as present-day), Glacial-Transition (also known as Intermedial Climate), Intermediate/Monsoon Climate, Glacial Climate Stage 8/10, Glacial Climate Stage 6/16, and Glacial Climate Stage 4.

closure

See *repository phases.*

co-disposal

A packaging method for *disposal* of *radioactive* waste in which two types of waste, such as *commercial spent nuclear fuel* and defense *high-level radioactive waste*, are combined in *disposal containers.* Co-disposal takes advantage of otherwise unused space in disposal containers and is more cost-effective than other methods to limit the reactivity of individual *waste packages.*

collective dose

See *population dose.*

colloid

Small particles in the size range of 10^{-9} to 10^{-6} meters that are suspended in a solvent. Naturally occurring colloids in *groundwater* arise from clay minerals.

colluvium

Loose earth material that has accumulated at the base of a hill, through the action of gravity.

commercial spent nuclear fuel

Commercial nuclear fuel rods that have been removed from *reactor* use. See *spent nuclear fuel* and *DOE spent nuclear fuel.*

conceptual model

A set of *qualitative* assumptions used to describe a system or subsystem for a given purpose. Assumptions for the model should be compatible with one another and fit the existing data within the context of the given purpose of the model.

confinement

As it pertains to *radioactivity*, the retention of *radioactive* material within some specified bounds. Confinement differs from containment in that there is no absolute physical *barrier* in the former.

construction

See *repository phases.*

construction/demolition debris

Discarded solid wastes resulting from the construction, remodeling, repair, and demolition of structures, road building, and land clearing that are inert or unlikely to create an environmental hazard or threaten the health of the general public. Such debris from repository construction would include materials such as soil, rock, masonry materials, and lumber.

construction support areas

Areas along the rail route that could be used as temporary residences for construction crews, material and equipment storage areas, and concrete production areas. Such camps probably would be for the construction of routes far from population centers.

contaminant

A substance that contaminates (pollutes) air, soil, or water. Also, a hazardous substance that does not occur naturally or that occurs at levels greater than those that occur naturally in the surrounding *environment.*

contaminant flux

Movement of a *contaminant* across a surface boundary per unit time (for example, *curies* per year; milligrams per year).

contamination

The intrusion of undesirable elements (unwanted physical, chemical, biological, or radiological substances, or matter that has an adverse effect) to air, water, or land.

controlled area

The area restricted for the long term for the repository, as identified by passive institutional controls DOE would install at *closure.* The controlled area is 300 square kilometers (about 120

square miles) maximum surface and subsurface area that extends in the predominant direction of groundwater flow no farther south than 36 degrees, 40 minutes, 13.6661 seconds north latitude (the present southwest corner of the Nevada Test Site), and no more than 5 kilometers (3 miles) from the repository footprint in any other direction. (See 40 CFR 197.12.)

convection

(1) Thermally driven *groundwater* flow or a heat-transfer mechanism for a gas phase. The bulk motion of a flowing fluid (gas or liquid) in the presence of a gravitational field, caused by temperature differences that, in turn, cause different areas of the fluid to have different densities (for example, warmer is less dense). (2) One of the processes that moves solutes in *groundwater*.

corridor

As used in the transportation analysis in this EIS, a strip of land, approximately 400 meters (0.25 mile) wide, that encompasses one of several possible routes through which DOE could build a branch rail line to transport *spent nuclear fuel*, *high-level radioactive waste*, and other material to and from the proposed Yucca Mountain Repository.

corrosion

The process of dissolving or wearing away gradually, especially by chemical action.

corrosion-resistant material

Disposal container material, such as Alloy-22, that oxidizes slowly in a corrosive environment.

cosmic radiation

A variety of high-energy particles including protons that bombard the Earth from outer space. They are more intense at higher altitudes than at sea level where the Earth's atmosphere is most dense and provides the greatest protection.

cosmogenic radionuclides

Radioactive nuclides generated when the upper atmosphere interacts with many of the cosmic radiations. Common cosmogenic radionuclides include carbon-14, tritium, and beryllium-7.

Crater Flat

A north-trending, 6- to 11-kilometer (4- to 7-mile)-wide area west of Yucca Mountain; bounded by *Bare Mountain* on the west and Yucca Mountain on the east.

credible event/credible accident

An event or *accident* scenario that the design of the *geologic repository* considers reasonably foreseeable with a possibility of at least 1 in 10 million.

criteria pollutants

Six common pollutants (*ozone*, *carbon monoxide*, *particulates*, *sulfur dioxide*, lead, and nitrogen dioxide) known to be hazardous to human health and environment and for which the U.S. Environmental Protection Agency sets National Ambient Air Quality Standards under the Clean Air Act. See *toxic air pollutants*.

criticality

The condition in which nuclear fuel sustains a *chain reaction*. It occurs when the number of neutrons present in one generation cycle equals the number generated in the previous cycle.

criticality control

Set of measures taken to maintain nuclear materials, including *spent nuclear fuel*, in a *subcritical* condition during storage, transportation, and *disposal*, so no self-sustaining nuclear *chain reaction* can occur. Subcriticality is maintained by loading spent nuclear fuel in specific configurations that meet requirements related to fuel age, enrichment, and reduction in nuclear fuel reactivity through *burnup*.

cross drift

An approximately 2,800-meter (9,200-foot)-long *drift* excavated to provide researchers new opportunities to study the geologic profile of the rock in the proposed repository area beneath Yucca Mountain. Researchers will conduct a new battery of tests in the cross drift as part of ongoing studies to determine if Yucca Mountain would be a suitable host for a deep *monitored geologic repository* for *spent nuclear fuel* and *high-level radioactive waste*. The cross drift begins inside the *Exploratory Studies Facility* approximately 2,000 meters (6,600 feet) from the northern entrance and cuts through the entire stratigraphic section of the potential Upper Block emplacement area.

crud

The *radionuclide* contribution from activated *corrosion* products deposited on the surfaces of *fuel assemblies* during reactor operations.

cumulative impact

The *impact* on the *environment* that results from the incremental impact(s) of an action when added to other past, present, and reasonably foreseeable future actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

curie

A unit of *radioactivity* equal to 37 billion *disintegrations* per second.

decay (radioactive)

The process in which one radionuclide spontaneously transforms into one or more different radionuclides called decay products.

decibel (dB)

A standard unit for measuring sound-pressure levels based on a reference sound pressure of 0.0002 dyne per square centimeter. This is the smallest sound a human can hear.

decibel, A-weighted (dBA)

A measurement of sound approximating the sensitivity of the human ear and used to characterize the intensity or loudness of sound.

decisionmaker

The group or individual responsible for making a decision on constructing and operating a *monitored geologic repository* for the disposal of *spent nuclear fuel* and *high-level radioactive waste* at Yucca Mountain.

decommissioning

The process of removing from service a facility in which nuclear materials are handled. It usually involves decontaminating the facility so that it may be dismantled or dedicated to other purposes.

decontamination

A process that removes, destroys, or neutralizes chemical, biological, or radiological contamination from a person, object, or area.

dedicated freight rail service

A train that handles only one commodity (in this case, *spent nuclear fuel* or *high-level radioactive waste*); this separate train with its own crew would limit switching between trains of the railcars carrying these materials.

defense-in-depth

(1) A design strategy based on a system of multiple, independent, and redundant *barriers*, designed to ensure that failure in any one barrier does not result in failure of the entire system. (2) The term used to describe a system of multiple barriers that mitigate *uncertainties* in conditions, processes, and events.

deformation

A change in the shape and size of a body.

design alternative

A fundamentally different conceptual design for a repository, which could stand alone as the License Application repository design concept.

design-basis event

Naturally or humanly induced events that are reasonably likely to occur one or more times before permanent closure of the *geologic repository's* operations area; in addition, any other natural or human-induced event that is unlikely, but is sufficiently credible to warrant consideration, taking into account the potential for significant radiological impacts on public health and safety.

design enhancement

An engineered *barrier* system feature that DOE is considering for possible inclusion in the design for the Yucca Mountain Repository. Design enhancements are not considered to be essential to the successful performance of the repository. The EIS analysis of the *Proposed Action* will not include design enhancements, but will identify them as possible means of *mitigation*. If a design enhancement is added to the reference design in time for inclusion in the EIS, it will be evaluated as part of the Proposed Action design.

deterministic

A single calculation using only a single value for each of the model parameters. A deterministic system is governed by definite rules of system behavior leading to cause and effect relationships and predictability. Deterministic calculations do not account for *uncertainty* in the physical relationships or parameter values.

dip-slip fault

A fault in which the relative displacement is along the direction of dip of the fault plane. If the block above the fault has moved downward it is a *normal fault*; upward movement indicates a *reverse fault*.

direct impact

Effect that results solely from the construction or operation of a proposed action without intermediate steps or processes. Examples include habitat destruction, soil disturbance, air emissions, and water use.

discretization

The process of dividing geometry into smaller pieces (finite elements) to prepare for analysis. For example, for the EIS analysis DOE divided the broad volume of the *unsaturated zone* beneath the proposed repository into smaller portions, each of which has its own set of characteristics, to model water flow and potential transport of *radionuclides* from the repository to the *saturated zone*.

disintegration

Any transformation of a *nucleus*, whether spontaneous or induced by *irradiation*, in which the nucleus emits one or more particles or *photons*.

disposable canister

A metal vessel for commercial or DOE *spent nuclear fuel* assemblies or solidified *high-level radioactive waste* with specialized overpacks to enable storage, transportation, and *emplacement* in a repository.

disposal

The *emplacement* in a repository of *high-level radioactive waste*, *spent nuclear fuel*, or other highly *radioactive* material with no foreseeable intent of recovery, whether or not such emplacement permits the recovery of such waste, and the *isolation* of such waste from the *accessible environment*.

disposal container

The vessel consisting of the *barrier* materials and internal components in which the canistered or uncanistered waste form would be placed. The disposal container would include the container barriers or shells, spacing structures or baskets, shielding integral to the container, packing contained within the container, and other absorbent materials designed to be placed internal to the container or immediately surrounding the disposal container (that is, attached to the outer surface of the container). The filled, sealed, and tested disposal container is referred to as the *waste package*, which would be emplaced in the repository.

disproportionately high and adverse environmental impacts

An environmental *impact* that is unacceptable or above generally accepted norms; these would include economic impacts of the *Proposed Action*. A disproportionately high impact is one (or the risk of one) to a *low-income population* or *minority population* that significantly exceeds the impact to the general population. In assessing cultural and aesthetic impacts, agencies consider impacts that would have unique effects on geographically dislocated or dispersed low-income or minority populations.

disproportionately high and adverse human health effects

Effects that occur when *impacts* to a *minority population* or *low-income population* from exposure to an environmental hazard significantly exceed the impacts to the general population and, where available, to an appropriate comparison group.

disruptive event

An unexpected event which, in the case of the repository, includes *human intrusion*, volcanic activity, *seismic* activity, and nuclear *criticality*. Disruptive events have two possible effects: (1) direct release of *radioactivity* to the surface, or (2) alteration of the expected behavior of the system.

dissolution

Molecular dispersion of a solid in a liquid.

distribution

As used in analyses of long-term performance, a range of values and probabilities associated with each value (or subrange of values) within the range. This can be in the form of a mathematical function or a table of values. *See normal distribution.*

DOE spent nuclear fuel

Radioactive waste created by defense activities that consists of more than 250 different waste forms. The major contributor to this waste form is the N-Reactor fuel currently stored at the Hanford Site. This waste form also includes 65 MTHM of *naval spent nuclear fuel.*

dose

The amount of radioactive energy taken into (absorbed by) living tissues.

dose equivalent

(1) The number (corrected for background) zero and above that is recorded as representing an individual's *dose* from external *radiation* sources or internally deposited *radioactive* materials; (2) the product of the absorbed dose in *rads* and a quality factor; (3) the product of the absorbed dose, the quality factor, and any other modifying factor. The dose equivalent quantity is used for comparing the biological effectiveness of different kinds of radiation (based on the quality of radiation and its spatial distribution in the body) on a common scale; it is expressed in *rem.*

dose rate

The *dose* per unit time.

dose risk

The product of a radiation dose and the probability of its occurrence.

drift

From mining terminology, a horizontal underground passage. Includes excavations for *emplacement* (emplacement drifts) and access (access mains).

drip shield

A corrosion-resistant engineered *barrier* that would be placed above the *waste package* to prevent seepage water from directly contacting the waste packages for thousands of years. The drip shield would also offer protection to the waste package from rockfall.

dry storage

Storage of *spent nuclear fuel* without immersing the fuel in water for cooling or shielding; it involves the encapsulation of spent fuel in a steel cylinder that might be in a concrete or massive steel *cask* or structure.

dual-purpose canister

A metal vessel suitable for storing (in a storage facility) and shipping (in a shipping cask) commercial *spent nuclear fuel* assemblies. At the repository, dual-purpose canisters would be removed from the shipping cask and opened. The *spent nuclear fuel* assemblies would be removed from the canister and placed in a *disposal container* or in the fuel pool to accomodate *blending*. The opened canister would be recycled or disposed of offsite as low-level *radioactive* waste.

earthquake

A series of elastic waves in the crust of the Earth caused by abrupt movement easing strains built up along *geologic* faults or by volcanic action and resulting in movement of the Earth's surface.

electron

A stable elementary particle that is the negatively charged constituent of ordinary matter.

emplacement

The placement and positioning of *waste packages* in the repository emplacement *drifts*.

endangered species

A species that is in danger of extinction throughout all or a significant part of its range; a formal listing of the U.S. Fish and Wildlife Service under the Endangered Species Act.

Energy Policy Act of 1992 (Public Law 102-486, 106 Stat. 2776)

Legislation that amends the *Nuclear Waste Policy Act* by directing (1) the Environmental Protection Agency to set site-specific public health and safety radiation protection standards from Yucca Mountain, and (2) the Nuclear Regulatory Commission to modify its technical requirements and licensing criteria to be consistent with the Environmental Protection Agency site-specific standards.

engineered barrier system

The designed, or engineered, components of the underground facility, including the *waste packages* and other engineered *barriers*.

enhanced design alternative

A combination (or variation) of one or more design alternatives and design features.

environment

(1) Includes water, air, and land and all plants and humans and other animals living therein, and the interrelationship existing among these. (2) The sum of all external conditions affecting the life, development, and survival of an *organism*.

environmental impact statement (EIS)

A detailed written statement which describes:

> "...the environmental impact of the proposed action; any adverse environmental effects which cannot be avoided should the proposal be implemented; alternatives to the proposed action (although the Nuclear Waste Policy Act, as amended, precludes consideration of certain alternatives); the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity; and any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented."

Preparation of an EIS requires a public process that includes public meetings, reviews, and comments, as well as agency responses to the public comments.

environmental justice

The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.

environmental monitoring

The process of sampling and analyzing environmental media in and around a facility to (1) confirm compliance with performance objectives and (2) detect *contamination* entering the *environment* to facilitate timely remedial action.

environmental resource areas

Areas examined for potential environmental impacts as part of the *National Environmental Policy Act* analysis process. Examples include air quality, hydrology, and biological resources.

ephemeral

Used in this EIS in reference to a nonpermanent stream or other body of water.

equilibrium

The state of a chemical system in which the phases do not undergo any spontaneous change in properties or proportions with time; a dynamic balance.

erionite

A natural fibrous *zeolite* in the rocks at Yucca Mountain that is listed as a known human carcinogen by recognized international agencies such as the International Agency for Research on Cancer.

escort cars

Railcars in which escort personnel would travel on trains carrying *spent nuclear fuel* or *high-level radioactive waste*.

evapotranspiration

The combined processes of evaporation and plant *transpiration* that remove water from the soil and return it to the air.

Exploratory Studies Facility

An underground laboratory at Yucca Mountain that includes an 8-kilometer (5-mile) main loop (tunnel), a 3-kilometer (2-mile) *cross drift*, and a research *alcove* system constructed for

performing underground studies during *site characterization*. The data collected will contribute toward determining the suitability of the Yucca Mountain site as a repository. Some or all of the facility could be incorporated into the proposed repository.

exposure (to radiation)

The incidence of *radiation* on living or inanimate material by accident or intent. Background exposure is the exposure to natural *ionizing radiation*. Occupational exposure is the exposure to ionizing radiation that occurs during a person's working hours. Population exposure is the exposure to a number of persons who inhabit an area.

exposure pathway

The course a chemical or physical agent takes from the source to the exposed *organism*; describes a unique mechanism by which an individual or population can become exposed to chemical or physical agents at or originating from a release site. Each exposure pathway includes a source or a release from a source, an exposure point, and an exposure route.

far-field

The area of the geosphere and *biosphere* far enough away from the repository that, when numerically modeled, releases from the repository are represented as a homogeneous, single-source effect.

fault

A *fracture* or a fracture zone in crustal rocks along which there has been movement of the fracture's two sides relative to one another, so that what were once parts of one continuous rock stratum or vein are now separated.

Fiscal Year

A 12-month period to which a jurisdiction's annual budget applies and at the end of which its financial position and the results of its operations are determined. For example, the Fiscal Year for Clark and Nye Counties, the Cities of Las Vegas and North Las Vegas, the Towns of Tonopah and Pahrump, and the Clark County and Nye County School Districts runs from July 1 through the following June 30; the Federal Fiscal Year runs from October 1 through the following September 30.

fission

The splitting of a *nucleus* into at least two other nuclei, resulting in the release of two or three *neutrons* and a relatively large amount of energy.

fission products

Radioactive or nonradioactive atoms produced by the *fission* of heavy atoms, such as uranium.

flexible design

As used in this EIS, the repository design and operating modes presented in the *Yucca Mountain Science and Engineering Report: Technical Information Supporting Site Recommendation Consideration*. See *higher-temperature repository operating mode* and *lower-temperature repository operating mode*.

floodplain

The lowlands adjoining inland and coastal waters and relatively flat areas and floodprone areas of offshore islands including, at a minimum, that area inundated by a 1 percent or greater chance flood in any given year. The base floodplain is defined as the 100-year (1.0-percent) floodplain. The critical action floodplain is defined as the 500-year (0.2-percent) floodplain.

Fortymile Wash

A major tributary to the *Amargosa River*; drains *Jackass Flats* to the east of Yucca Mountain; usually dry along most of its length.

fracture

A general term for any break in a rock, whether or not it causes displacement, caused by mechanical failure from stress. Fractures include cracks, joints, and *faults*. Fractures can act as pathways for rapid *groundwater* movement.

fuel assembly

A number of fuel elements held together by structural materials, used in a *nuclear reactor*. Sometimes called a fuel bundle.

fuel blending

The process of loading low-heat-output waste with high-heat-output waste in a *waste package* to balance its total heat output. This process would apply only to *commercial spent nuclear fuel*.

fugitive dust

Particulate matter composed of soil; can include emissions from haul roads, wind erosion of exposed soil surfaces, and other activities in which soil is removed or redistributed.

fugitive emissions

Emissions released directly into the *atmosphere* that could not reasonably pass through a stack, chimney, vent, or other functionally equivalent opening.

GENII

A *deterministic* computer software code that evaluates *dose* from the migration of radionuclides introduced into the *accessible environment*, or *biosphere*, that may eventually affect humans through ingestion, inhalation, or direct *radiation*. It is used to develop biosphere dose conversion factors.

gamma ray

The most penetrating type of radiant nuclear energy. It does not contain particles and can be stopped by dense materials such as concrete or lead. *See ionizing radiation.*

general freight rail service

Railroad line service that uses trains that move railcars, each of which might contain a different commodity. Railcars carrying *spent nuclear fuel* or *high-level radioactive waste* could be switched (in railyards or on sidings) successively from one general freight train to another as they traveled from the commercial and DOE locations to Nevada.

geologic

Of or related to a natural process acting as a dynamic physical force on the Earth (faulting, erosion, mountain building resulting in rock formations, etc.).

geologic repository

A system for disposing of *radioactive* waste in excavated *geologic* media, including surface and *subsurface* areas of operation, and the adjacent part of the geologic setting that provides *isolation* of the radioactive waste in the *controlled area.*

Great Basin

A subprovince of the Basin and Range province, generally characterized by north-trending mountain ranges and intervening basins, stretching from eastern Oregon to southern California.

Greater-Than-Class-C waste

Low-level nuclear waste generated by the commercial sector that exceeds U.S. Nuclear Regulatory Commission concentration limits for Class-C low-level waste, as specified in 10 CFR Part 61. DOE is responsible for disposing of this type of waste from its nondefense programs.

Gross Regional Product

The dollar value of all final goods and services produced in a given year in a specific region (such as the *region of influence*).

ground support

The system (rock bolts with wire mesh, steel structures, cast or precast concrete sections) used to line the main and emplacement *drifts* to minimize rock or earth falling into the drifts.

ground vibration

The rapid linear motion of a compression wave in the ground caused by a single or repeated force or impact to the ground as in the action of a pile driver or a tire hitting a bump or pothole in a road.

groundwater

Water contained in pores or fractures in either the *unsaturated zone* or *saturated zone* below ground level.

habitat

Area in which a plant or animal lives and reproduces.

half-life (radiological)

The time in which half the atoms of a *radioactive* substance decay to another nuclear form. Half-lives range from millionths of a second to billions of years depending on the stability of the nuclei.

hazardous chemical

As defined under the Occupational Safety and Health Act and the Community Right-to-Know Act, a chemical that is a physical or health hazard.

hazardous pollutant

Hazardous chemical that can cause serious health and environmental hazards, and listed on the Federal list of hazardous air pollutants (42 U.S.C. 7412). See *toxic air pollutants.*

hazardous waste

Waste designated as hazardous by Environmental Protection Agency or State of Nevada regulations. Hazardous waste, defined under the Resource Conservation and Recovery Act, is

waste that poses a potential hazard to human health or the environment when improperly treated, stored, or disposed of. Hazardous wastes appear on special Environmental Protection Agency lists or possess at least one of the following characteristics: ignitability, corrosivity, toxicity, or reactivity. Hazardous waste streams from the repository could include certain used rags and wipes contaminated with solvents. (Note: The proposed Yucca Mountain Repository would not accept hazardous waste, either solid or liquid, and DOE would dispose of all repository-generated hazardous waste at offsite facilities.)

heavy-haul truck

An overweight, overdimension vehicle that must have permits from state highway authorities to use public highways; a vehicle DOE would use on public highways to move *spent nuclear fuel* or *high-level radioactive waste shipping casks* designed for a railcar.

heavy metal

All uranium, plutonium, and thorium used or generated in a manmade *nuclear reactor.*

high-efficiency particulate air filter

A filter with an efficiency of at least 99.95 percent that separates particles from an air exhaust stream before the air is released to the atmosphere.

higher-temperature repository operating mode

The *flexible design* would maintain the repository host rock temperatures below the boiling point of water [96°C (205°F) at the elevation of the repository] during the preclosure period with continuous ventilation of the *emplacement drifts.* After mechanical ventilation was discontinued at closure, host rock temperatures would increase above the boiling point of water, and moisture around the emplacement drifts would evaporate and be driven away from the drifts as water vapor. A boiling zone would develop around each emplacement drift, but it would not extend all the way across the *pillars.* This mode would allow percolation of moisture downward past the *emplacement horizon* through central portions of the rock pillars between the drifts. See *lower-temperature repository operating mode.*

high-level radioactive waste

(1) The highly *radioactive* material that resulted from the reprocessing of *spent nuclear fuel,* including liquid waste produced directly in reprocessing, and any solid material derived from such liquid waste that contains *fission* products in sufficient concentrations. (NOTE: DOE would vitrify liquid *high-level radioactive waste* before shipping it to the repository.) (2) Other highly radioactive material that the Nuclear Regulatory Commission, consistent with existing law, determines by rule requires permanent *isolation.*

Highway Route-Controlled Quantities of Radioactive Material

Thresholds for certain quantities of *radioactive* materials above which shipments are subject to specific routing controls that apply to the highway carrier. These thresholds are defined by U.S. Department of Transportation regulations (49 CFR Part 177). (49 CFR Part 397 Subpart D defines routing requirements.)

horizon

See *repository horizon.*

human intrusion

The inadvertent disturbance of a *disposal* system by the activities of humans that could result in release of *radioactive* waste. 40 CFR Part 191 Subpart B requires that *performance assessments* consider the possibility of human intrusion.

hydrogeology

A study that encompasses the interrelationships of *geologic* materials and processes involving water.

hydrographic area

In reference to Nevada *groundwater*, divisions of the State into groundwater basins and sub-basins based primarily on topographic features such as mountains and valleys. The State uses the map of hydrographic areas as the basis for water planning, management, and administration. (Because they are based heavily on topographic features, hydrographic area boundaries sometimes differ from groundwater basin designations developed from studies of inferred or measured groundwater flow patterns.)

hydrology

(1) The study of water characteristics, especially the movement of water. (2) The study of water, involving aspects of geology, oceanography, and meteorology.

igneous

(1) A type of rock formed from a molten, or partially molten, material. (2) An activity related to the formation and movement of molten rock either in the *subsurface* (plutonic) or on the surface (volcanic).

impact

For an EIS, the positive or negative effect of an action (past, present, or future) on the natural *environment* (land use, air quality, water resources, geological resources, ecological resources, aesthetic and scenic resources) and the human environment (infrastructure, economics, social, and cultural).

impact limiters

Devices attached to rail and truck *shipping casks* that would help absorb impact energy in the event of a collision.

implementing alternative

An action or proposition by DOE necessary to implement the *Proposed Action* and to enable the estimation of the range of reasonably foreseeable *impacts* of that action or proposition.

- The implementing rail/intermodal alternatives for Nevada transportation are the five corridors for a new rail spur:
  - Caliente
  - Carlin
  - Caliente-Chalk Mountain
  - Jean
  - Valley Modified

- The five *intermodal transfer station*/heavy-haul route combinations:
  - Caliente intermodal transfer station, Caliente route
  - Caliente intermodal transfer station, Caliente-Chalk Mountain route
  - Caliente intermodal transfer station, Caliente-Las Vegas route
  - Sloan/Jean intermodal transfer station, Sloan/Jean route
  - Apex/Dry Lake intermodal transfer station, Apex/Dry Lake route

DOE decisions on implementing alternatives will be made when they are ripe for decisionmaking, which might occur after a decision to construct and operate the Yucca Mountain Repository.

inadvertent intrusion

The unintended disturbance of a *disposal* facility or its immediate *environment* by a future occupant that could result in a loss of *containment* of the waste or *exposure* of people.

incident-free transportation

Routine transportation in which cargo travels from origin to destination without being involved in an *accident*.

indirect impact

An effect that is related to but removed from a proposed action by an intermediate step or process. Examples include surface-water quality changes resulting from soil erosion at construction sites, and reductions in productivity resulting from changes in soil temperature.

industrial wastewater

Liquid wastes from industrial processes that do not include sanitary sewage. Repository industrial wastewater would include water used for dust suppression and process water from building heating, ventilation, and air conditioning systems.

inert

Lacking active thermal, chemical, or biological properties. An inert atmosphere is incapable of supporting combustion.

infiltration

The process of water entering the soil at the ground surface and the ensuing movement downward. Infiltration becomes *percolation* when water has moved below the depth at which it can return to the atmosphere by evaporation or *evapotranspiration*.

infrastructure

Basic facilities, services, and installations needed for the functioning of a community or society, such as transportation and communication systems. These include surface and *subsurface* facilities (for example, service drifts, transporters, electric power supplies, waste handling buildings, administrative facilities).

in situ

In its natural position or place. The phrase distinguishes in-place experiments, conducted in the field or underground facility, from those conducted in the laboratory.

institutional control

Monitoring and maintenance of storage facilities to ensure that radiological releases to the *environment* and *radiation* doses to workers and the public remain within Federal limits and DOE

Order requirements. *Active institutional control* would require the presence of humans to safeguard and maintain the site; passive institutional control would include such devices as permanent markers and land records to warn future generations of dangers.

intermodal transfer station

A facility at the juncture of rail and road transportation used to transfer *shipping casks* containing *spent nuclear fuel* and *high-level radioactive waste* from rail to truck and empty casks from truck to rail.

intermodal transfer station candidate area

Area near one or more existing main rail lines that DOE is considering for the location of an *intermodal transfer station.*

intrablock fault

A relatively minor fault that lies between the major north-trending, block-bounding faults. Also called subsidiary fault.

intrusive sound

A new sound that, either because of its loudness in relation to the local *ambient* sound level, or because of such characteristics as tone content, impulsive or unexpected nature, or high information content, is annoying or detracts from the usual ambiance of the receptor location. See *noise.*

invasive species

An *alien species* whose introduction does or is likely to cause economic or environmental harm or harm to human health.

invert

The structure constructed in a *drift* to provide the floor of that drift. In an *emplacement* drift, ballast in the invert would serve as a *barrier* to migration of *radionuclides* that escaped from breached *waste packages.*

involved worker

A worker who would be directly involved in the activities related to facility construction and operations, including excavation activities; receipt, handling, packaging, and *emplacement* of waste materials; and *monitoring* of the condition and performance of the *waste packages.* See *noninvolved worker.*

ion

(1) An atom that contains excess *electrons* or is deficient in electrons, causing it to be chemically active. (2) An electron not associated with a *nucleus.*

ionizing radiation

(1) *Alpha particles*, *beta particles*, *gamma rays*, *X-rays*, *neutrons*, high-speed *electrons*, high-speed *protons*, and other particles capable of producing *ions.* (2) Any radiation capable of displacing electrons from an atom or molecule, thereby producing ions.

irradiation

Exposure to *radiation.*

isolation

Inhibiting the transport of *radioactive* material so that the amounts and concentrations of this material entering the *accessible environment* stay within prescribed limits.

isotope

One of two or more atomic *nuclei* with the same number of *protons* (that is, the same *atomic number*) but with a different number of *neutrons* (that is, a different *atomic weight*). For example, uranium-235 and uranium-238 are both isotopes of uranium.

Jackass Flats

A broad asymmetric basin 8 to 10 kilometers (5 to 6 miles) wide and 20 kilometers (12 miles) long that is east of Yucca Mountain and is drained by *Fortymile Wash.*

juvenile failure

Premature failure of a *waste package* because of material imperfections or damage by rockfall during *emplacement.*

land withdrawal area

An area of Federal property set aside for the exclusive use of a Federal agency. For the analyses in this EIS, DOE used an assumed land withdrawal area of 600 square kilometers, or 150,000 acres.

Las Vegas Valley shear zone

A major right-lateral strike-slip zone of faulting.

latent cancer fatality

A death resulting from *cancer* that has been caused by exposure to *ionizing radiation.* For exposures that result in cancers, the generally accepted assumption is that there is a latent period between the time an exposure occurs and the time a cancer becomes active.

legal-weight truck

A truck with a gross vehicle weight (both truck and cargo weight) of less than 36,300 kilograms (80,000 pounds), the loaded weight limit for commercial vehicles operated on public highways without special state-issued permits. In addition, the dimensions, axle spacing, and, if applicable, axle loads of these vehicles must be within Federal and state regulations.

License Application

An application to the Nuclear Regulatory Commission to construct a *geologic repository* for the disposal of *spent nuclear fuel* and *high-level radioactive waste.* The application would be considered by the Nuclear Regulatory Commission in any decision whether to grant DOE authorization to begin constructing a repository.

line-loading repository design

A waste *emplacement* design in which *waste packages* would be spaced closely enough along the axis of the *drift* such that the heat source could be assumed to be continuous in long-term performance analyses.

linear thermal load

Heat output per unit length of the emplacement *drift*; expressed in kilowatts per meter.

lithology

The study and description of the general, gross physical characteristics of a rock, especially sedimentary *clastics*, including color, grain size, and composition.

lost workday cases

Incidents that result in injuries that cause the loss of work time.

lower-temperature repository operating mode

The *flexible design* would have the ability to hold repository host rock temperatures below the boiling point of water [96°C (205°F) at the elevation of the repository] after closure by a combination of methods such as increasing the continuous ventilation period, aging the fuel prior to *emplacement*, and increasing the spacing between emplaced waste packages. The mode ranges include conditions under which the drift rock wall temperatures would be below the boiling point of water, and conditions under which the waste package surface temperature would not exceed 85°C (185°F). To bound the impact analysis, DOE considered conditions under which the rock wall temperatures would be above the boiling point of water, and conditions under which waste package surface temperatures would not exceed 85°C. See *higher-temperature repository operating mode*.

low-income population

One in which 20 percent or more of the persons in the population live in poverty, as reported by the Bureau of the Census in accordance with Office of Management and Budget requirements.

low-level radioactive waste

Radioactive waste that is not classified as *high-level radioactive waste*, *transuranic waste*, or byproduct tailings containing uranium or thorium from processed ore. Usually generated by hospitals, research laboratories, and certain industries.

maintenance

Activities during the repository operation and monitoring phase including maintenance of *subsurface* monitoring and instrumentation systems and utilities (compressed air, water supply, fire water, wastewater system, power supply, and lights), maintenance of the main ventilation fan installations and surface facilities related to underground activities, and site security. Maintenance also preserves the capability to retrieve emplaced *waste packages*. See *repository phases*.

matrix (geology)

The solid, but porous, portion of rock.

maximally exposed individual

A hypothetical individual whose location and habits result in the highest total radiological or chemical exposure (and thus *dose*) from a particular source for all exposure routes (for example, inhalation, ingestion, direct exposure). The EIS analyses used the concept of the maximally exposed individual to evaluate potential short-term impacts to individuals around the repository and from transportation (and for some aspects of the *No-Action Alternative*). The EIS analyses used the concept of the maximally exposed individual to evaluate potential short-term impacts to individuals around the repository and from transportation (and for some aspects of the No-Action Alternative. For potential impacts to individuals from long-term repository performance, see *receptor*.

Maximum Contaminant Level

Under the Safe Drinking Water Act, the maximum permissible concentrations of specific constituents in drinking water that is delivered to any user of a public water system that serves 15 or more connections and 25 or more people; the standards established as maximum contaminant levels consider the feasibility and cost of attaining the standard.

maximum reasonably foreseeable accident

An accident characterized by extremes of mechanical (impact) forces, heat (fire), and other conditions that would lead to the highest foreseeable consequences. In general, accidents with conditions that have a chance of occurring more often than 1 in 10 million in a year are considered to be reasonably foreseeable.

metamorphic

Rock in which the original mineralogy, texture, or composition has changed due to the effects of pressure, temperature, or the gain or loss of chemical components.

metric tons of heavy metal (MTHM)

Quantities of *spent nuclear fuel* without the inclusion of other materials such as *cladding* (the tubes containing the fuel) and structural materials. A metric ton is 1,000 kilograms (1.1 tons or 2,200 pounds). Uranium and other metals in spent nuclear fuel (such as thorium and plutonium) are called *heavy metals* because they are extremely dense; that is, they have high weights per unit volume.

millirad

One one-thousandth (0.001) of a *rad.*

millirem

One one-thousandth (0.001) of a *rem.*

minority population

A community in which the percent of the population of a racial or ethnic minority is 10 points higher than the percent found in the population as a whole.

mitigation

Actions and decisions that (1) avoid *impacts* altogether by not taking a certain action or parts of an action, (2) minimize impacts by limiting the degree or magnitude of an action, (3) rectify the impact by repairing, rehabilitating, or restoring the *affected environment*, (4) reduce or eliminate the impact over time by preservation and maintenance operations during the life of the action, or (5) compensate for an impact by replacing or providing substitute resources or *environments.*

mixed-oxide fuel

A mixture of uranium oxide and plutonium oxide that could be used to power commercial nuclear reactors.

monitored geologic repository

A system, requiring licensing by the U.S. Nuclear Regulatory Commission, intended or used for the permanent underground *disposal* of *radioactive* waste (including *spent nuclear fuel*). A *geologic repository* includes (1) the geologic repository operations area, and (2) the geologic setting in the *controlled area* that provides *isolation* of the radioactive waste. The repository would be monitored between *emplacement* of the last *waste package* and closure.

monitoring

Activities during the repository operation and monitoring phase including the surveillance and testing of *waste packages* and the repository for *performance confirmation*. See *repository phases*.

National Environmental Policy Act, as amended (NEPA; 42 U.S.C. 4321 *et seq.*)

The Federal statute that is the national charter for protection of the *environment*. The Act is implemented by procedures issued by the Council on Environmental Quality and DOE.

native species

With respect to a particular ecosystem, a species that, other than as a result of an introduction, historically occurred or currently occurs in that ecosystem.

natural barrier

The physical components of the geologic *environment* that individually and collectively act to limit the movement of water or radionuclides. See *barrier*.

natural system

A host rock suitable for repository construction and waste *emplacement* and the surrounding rock formations. It includes *natural barriers* that provide *containment* and *isolation* by limiting radionuclide transport through the geohydrologic *environment* to the *biosphere* and provide conditions that will minimize the potential for *human intrusion* in the future.

natural ventilation

Ventilation driven by a difference in density between the air columns in connected *shafts* or ramps. The density difference is generally caused by a difference in air temperature between the shafts, which results in a pressure differential that induces the air flow. This phenomenon, which is common in underground mines, can be enhanced by differences in elevation between the intake and exhaust locations. In relation to this EIS, the repository would be unique in that, due to the heat output of the emplaced waste, the exhaust air temperature would virtually always be higher than the intake temperature. The heat supplied by the waste and the difference in elevation between the intake and exhaust shaft portals would mean that there would always be a pressure differential, and that it would always be positive (that is, it would induce flow from the intakes to the exhausts).

naval spent nuclear fuel

Spent nuclear fuel discharged from reactors in surface ships, submarines, and training reactors operated by the U.S. Navy.

near-field

The area of and conditions in the repository including the *drifts* and *waste packages* and the rock immediately surrounding the drifts. The region around the repository where the natural hydrogeologic system would be significantly impacted by the excavation of the repository and the *emplacement* of waste.

neutron

An atomic particle with no charge and an atomic mass of 1; a component of all atoms except hydrogen; frequently released as *radiation*.

neutron absorber

A material (such as boron or gadolinium) that absorbs neutrons. Used in *nuclear reactors*, transportation *casks*, and *waste packages* to control neutron activity and prevent criticality.

nitrogen oxides

Gases formed in great part from atmospheric nitrogen and oxygen when combustion occurs under conditions of high temperature and high pressure; a major air pollutant. Two primary nitrogen oxides, nitric oxide (NO) and nitrogen dioxide (NO_2), are important airborne *contaminants*. Nitric oxide combines with atmospheric oxygen to produce nitrogen dioxide. Both nitric oxide and nitrogen dioxide can, in high concentration, cause lung cancer. Nitrogen dioxide is a *criteria pollutant*.

No-Action Alternative

The *Nuclear Waste Policy Act* states that this EIS does not have to discuss *alternatives* to geologic disposal or alternative sites to Yucca Mountain; DOE included the analysis of the No-Action Alternative to provide a basis for comparison with the *Proposed Action*. For this EIS, under the No-Action Alternative DOE would end *site characterization* activities at Yucca Mountain and continue to accumulate *spent nuclear fuel* and *high-level radioactive waste* at commercial storage sites and DOE facilities. See *alternative*.

noble gas

Any of a group of rare gases that include helium, neon, argon, krypton, xenon, and radon and that exhibit great chemical stability and extremely low reaction rates; also called *inert* gas. Xenon and radon exhibit extremely low reaction rates.

noise

Any sound that is undesirable because it interferes with speech and hearing; if intense enough, it can damage hearing.

nominal scenario

Long-term performance of the proposed repository using the Proposed Action modeled inventory, undisturbed by volcanic activity or human intrusion, but including seismic activity.

nonattainment area

An area that does not meet the *ambient air quality standard* for one or more criteria pollutants. Further designations (for example, serious, moderate) describe the magnitude of the nonattainment.

noninvolved worker

A worker who would perform managerial, technical, supervisory, or administrative activities but would not be directly involved in construction, excavation, or operations activities. See *involved worker*.

normal distribution

As used in analyses of long-term performance, a special type of symmetrical distribution known in the science of statistics as the Gaussian Distribution and commonly known as the "bell-shaped curve." *See distribution.*

normal fault

A fault in which the relative displacement is along the direction of dip of the fault plane (*dip-slip fault*) where the block above the fault has moved downward in relation to the block below the fault. See *reverse fault*.

nuclear radiation

Radiation that emanates from an unstable atomic *nucleus*.

nuclear reactor

A device in which a nuclear *fission chain reaction* can be initiated, sustained, and controlled to generate heat or to produce useful radiation.

nuclear waste

Unusable by-products of nuclear power generation, nuclear weapons production, and research, including *spent nuclear fuel, high-level radioactive waste*.

Nuclear Waste Policy Act (NWPA; 42 U.S.C. 10101 *et seq.*)

The Federal statute, originally enacted in 1982 (Public Law 97-425; 96 Stat. 2201), that established the Office of Civilian Radioactive Waste Management and defines its mission to develop a Federal system for the management and geologic disposal of *commercial spent nuclear fuel* and other *high-level radioactive wastes*, as appropriate. The Act also specifies other Federal responsibilities for nuclear waste management, establishes the Nuclear Waste Fund to cover the cost of geologic *disposal*, authorizes interim storage under certain circumstances, and defines interactions between Federal agencies and the states, local governments, and Native American tribes. The Act was substantially amended in 1987 (see *Nuclear Waste Policy Act Amendments of 1987*) and 1992 (see *Energy Policy Act of 1992*).

Nuclear Waste Policy Act Amendments of 1987 (Public Law 100-203; 101 Stat. 1330)

Legislation that amended the *Nuclear Waste Policy Act* to limit repository *site characterization* activities to Yucca Mountain, Nevada; establish the Office of Nuclear Waste Negotiator to seek a state or Native American tribe willing to host a repository or monitored retrievable storage facility; create the *Nuclear Waste Technical Review Board*; and increase state and local government participation in the waste management program.

Nuclear Waste Technical Review Board

An independent body established within the executive branch, created by the *Nuclear Waste Policy Amendments Act of 1987* to evaluate the technical and scientific validity of activities undertaken by the U.S. Department of Energy, including *site characterization* activities and activities relating to the packaging or transportation of *high-level radioactive waste* or *spent nuclear fuel*. Members of this Board are appointed by the President from a list prepared by the National Academy of Sciences.

nucleus

The central, positively charged, dense portion of an atom. Also known as atomic nucleus.

nuclide

An atomic *nucleus* specified by its *atomic weight*, *atomic number*, and energy state; a radionuclide is a *radioactive* nuclide.

oblique-slip fault

A *fault* that combines some purely horizontal motion (*strike-slip fault*) with some along the direction of the dip of the fault plane (*dip-slip fault*).

offsite

Physically not in a repository-related area managed by DOE.

onsite

Physically in an area managed by DOE where access can be limited for any reason. The site boundary encompasses *controlled areas*. The site comprises the various Operations Areas and the areas between and immediately surrounding them.

operational storage

A storage capacity DOE could use to collect material shipped to the repository before (or after) its insertion in *waste packages* and *emplacement* in the repository.

operation and monitoring

See *repository phases*.

option

As used in the transportation analysis in this EIS, a variation based on a determination that the location of a rail *corridor* segment is essentially equivalent to that of another option considering environmental and engineering factors. See *variation*, *alternate*, *corridor*.

organism

An individual constituted to carry on the activities of life by means of organs separate but mutually dependent; a living being.

overburden

Geologic material of any nature, consolidated or unconsolidated, that overlies a deposit of useful materials. As used by the Yucca Mountain Project, this is geologic material overlying the *repository block*.

overweight, overdimension truck

Semi- and tandem tractor-trailer trucks with gross weights over 80,000 pounds that must obtain permits from state highway authorities to use public highways.

ozone (O_3)

The triatomic form of oxygen; in the *stratosphere*, ozone protects the Earth from the Sun's *ultraviolet radiation*, but in lower levels of the atmosphere it is an air pollutant.

Paleozoic Era

A geologic era extending from the end of the Precambrian to the beginning of the Mesozoic, dating from about 600 to 230 million years ago.

particulate matter

Fine liquid or solid particles such as dust, smoke, mist, fumes, or smog, found in air or emissions. See PM_{10}.

pathway

A potential route by which radionuclides might reach the *accessible environment* and pose a threat to humans.

peak of the mean annual dose (post-10,000 years)

For this EIS, the maximum of the mean annual *dose* analyzed for the 1-million-year postclosure period. Because the dose would decline after this peak, this would be the peak for all time after closure. See *10,000-year peak of the mean annual dose.*

pediment

A planar sloping rock surface forming a ramp to a front of a mountain range in an arid region. It might be covered locally by a thin *alluvium.*

perched water

A *saturated zone* condition that is not continuous with the *water table*, because there is an impervious or semipervious layer underlying the perched zone or a *fault* zone that creates a *barrier* to water movement and perches water. See *permeable.*

percolation

The passage of a liquid through a porous substance. In rock or soil it is the movement of water through the interstices and pores under hydrostatic pressure and the influence of gravity. The downward or lateral flow of water that becomes net *infiltration* in the *unsaturated zone.*

perennial yield

The amount of usable water from a *groundwater* aquifer that can be economically withdrawn and consumed each year for an indefinite period. It cannot exceed the natural recharge to that aquifer and ultimately is limited to the maximum amount of discharge that can be used for beneficial use.

performance assessment

An analysis that estimates the potential behavior of a system or system component under a given set of conditions. Performance assessments include estimates of the effects of *uncertainties* in data and modeling. See *Total System Performance Assessment.*

performance confirmation

The program of tests, experiments, and analyses conducted to evaluate the accuracy and adequacy of the information used to determine with reasonable assurance that the performance objectives for the period after *permanent closure* will be met.

permanent closure

Final sealing of *shafts* and *boreholes* of the underground facility, including the installation of permanent monuments to mark the location and boundaries of the repository.

permeable

Pervious; a permeable rock is a rock, either porous or cracked, that allows water to soak into and pass through it freely.

permeability

In general terms, the capacity of such mediums as rock, sediment, and soil to transmit liquid or gas. Permeability depends on the substance transmitted (oil, air, water, etc.) and on the size and shape of the pores, joints, and fractures in the medium and the manner in which they

interconnect. "Hydraulic conductivity" is equivalent to "permeability" in technical discussions relating to *groundwater*.

person-rem

A unit used to measure the *radiation* exposure to an entire group and to compare the effects of different amounts of radiation on groups of people; it is the product of the average *dose equivalent* (in *rem*) to a given organ or tissue multiplied by the number of persons in the population of interest.

pH

A number indicating the acidity or alkalinity of a solution. A pH of 7 indicates a neutral solution. Lower pH values indicate more acidic solutions while higher pH values indicate alkaline solutions.

photon

A massless particle, the quantum of an electromagnetic field, carrying energy, momentum, and angular momentum.

photovoltaic

Capable of generating a voltage as a result of exposure to *radiation*. Solar power generation systems use photovoltaic energy from the sun's radiation to produce electricity.

picocurie

One one-trillionth (1×10^{-12}) of a *curie*.

pillar

The rock section between adjacent *emplacement drifts*.

PM_{10}

All *particulate matter* in the air with an aerodynamic diameter less than or equal to a nominal 10 micrometers (0.0004 inch). Particles less than this diameter are small enough to be breathable and could be deposited in lungs.

polycyclic volcanism

Multiple cycles of volcanic activity, as in describing a cinder cone that resulted from numerous volcanic events separated by significant intervals of time (as opposed to a cone generated by a single event or a tightly grouped series of events).

population dose

A summation of the radiation doses received by individuals in an exposed population; equivalent to *collective dose*; expressed in *person-rem*.

portal

Surface entrance to a mine, particularly in a *drift* or tunnel. The North and South Portals are the two primary entrances to the *subsurface* facilities.

postclosure controlled area

See *controlled area*.

preferred route

A public highway route that satisfies the requirements of U.S. Department of Transportation regulations (49 CFR Part 397, Subpart D) to be acceptable for shipments of *Highway Route-Controlled Quantities of Radioactive Material.*

pressurized-water reactor (PWR)

A nuclear power *reactor* that uses water under pressure as a coolant. The water boiled to generate steam is in a separate system.

prime farmland

Land that has the best combination of physical and chemical characteristics for producing food, feed, fiber, forage, oilseed, and other agricultural crops with minimum inputs of fuel, fertilizer, pesticides, and labor, and without intolerable soil erosion.

probabilistic

(1) Based on or subject to *probability*. (2) Involving a variable factor, such as temperature or porosity. At each instance of time, the factor may take on any of the values of a specified set with a certain probability. Data from a probabilistic process is an ordered set of observations, each of which is one item in a probability distribution.

probability

The relative frequency at which an event can occur in a defined period. Statistical probability is about what actually happens in the real world and can be verified by observation or sampling. Knowing the exact probability of an event is usually limited by the inability to know, or compile the complete set of, all possible outcomes over time or space. Probability is measured on a scale of 0 (event will *not* occur) to 1 (event *will* occur).

probable maximum flood

The hypothetical flood (peak discharge, volume, and hydrographic shape) that is considered to be the most severe reasonably possible, based on comprehensive hydrometeorological application of probable maximum precipitation and other hydrologic factors, such as sequential storms and snowmelts, that are favorable for maximum flood runoff.

proposed action

The activity proposed to accomplish a Federal agency's purpose and need. An EIS analyzes the environmental *impacts* of the Proposed Action. A proposed action includes the project and its related support activities (preconstruction, construction, and operation, along with postoperational requirements). The Proposed Action in this EIS is the construction, operation and monitoring, and eventual closure of a *monitored geologic repository* for *spent nuclear fuel* and *high-level radioactive waste* at Yucca Mountain in Nevada (see *repository phases*).

proton

An elementary particle that is the positively charged component of ordinary matter and, together with the *neutron*, is a building block of all atomic *nuclei*.

pyroclastic

Of or relating to individual particles or fragments of *clastic* rock material of any size formed by volcanic explosion or ejected from a volcanic vent.

qualitative

With regard to a variable, a parameter, or data, an expression or description of an aspect in terms of non-numeric qualities or attributes. See *quantitative*.

quantitative

A numeric expression of a variable. See *qualitative*.

rad

The unit of measure of absorbed *radiation* dose in terms of energy. One rad is equal to an absorbed *dose* of 100 ergs per gram. (In the metric system of measurements, an erg is a unit of energy. One foot-pound is equal to 13,560,000 ergs.)

radiation

The emitted particles or *photons* from the *nuclei* of *radioactive* atoms. Some elements are naturally radioactive; others are induced to become radioactive by *irradiation* in a *reactor*. Naturally occurring radiation is indistinguishable from induced radiation.

radioactive

Emitting *radioactivity*.

radioactive decay

The process in which one *radionuclide* spontaneously transforms into one or more different radionuclides, which are called decay products.

radioactivity

The property possessed by some elements (for example, uranium) of spontaneously emitting alpha, beta, or *gamma rays* by the *disintegration* of atomic *nuclei*.

radiologically controlled area

An area of the surface repository enclosed by security fences, control gates, lighting, and detection systems established to prevent the spread of radiological contamination. The area would include the facilities and transportation systems required to receive and ship rail and truck waste shipments, prepare *shipping casks* for handling, and load *waste forms* into disposal containers for *emplacement* in the repository. It would also include the facility and systems required to treat and package site-generated *low-level radioactive waste* for offsite disposal.

radionuclide

See *nuclide*.

rail classification yard

A railroad switching yard where railcars arriving in inbound freight trains are classified and reassembled according to their routing to make up outbound freight trains.

rail route

Route from point of origin to the repository.

reactor

See *nuclear reactor*.

release fraction

The fraction of each *isotope* in *spent nuclear fuel* or *high-level radioactive waste* that could be released from a containment in an *accident*.

real disposable income

The dollar income, including the value of transfer payments, available to individuals after taxes have been paid; also referred to as *real disposable personal income*.

reasonably maximally exposed individual

See *receptor*.

receptor

A hypothetical person who is exposed to environmental contaminants (in this case *radionuclides*) in such a way—by a combination of factors including location, lifestyle, dietary habits, etc.—that this individual is representative of the *exposure* of the general population. DOE used this hypothetical individual to evaluate long-term repository performance. The receptor represents the "Reasonably Maximally Exposed Individual (RMEI)" defined in 40 CFR Part 197. The Draft EIS defined the receptor slightly differently and called this hypothetical person the *maximally exposed individual,* which is still used for evaluating short-term impacts.

recharge

The movement of water from an *unsaturated zone* to a *saturated zone*.

recordable cases

Occupational injuries or occupation-related illnesses that result in (1) a fatality, regardless of the time between the injury or the onset of the illness and death, (2) lost workday cases (nonfatal), and (3) the transfer of a worker to another job, termination of employment, medical treatment, loss of consciousness, or restriction of motion during work activities.

Record of Decision

A document that provides a concise public record of a decision made by a government agency.

region of influence

The physical area that bounds the environmental, sociologic, economic, or cultural features of interest for the purpose of analysis.

rem

A unit of *dose equivalent.*

remediation

Action taken to permanently remedy a release or threatened release of a hazardous substance to the *environment*, instead of or in addition to removal.

repository

See *geologic repository.*

repository block

The portion of rock in Yucca Mountain that would house the repository, if the site was suitable.

repository horizon

The area within the *repository block* where *emplacement drifts* would be excavated. Also called emplacement horizon.

repository phases

The development of a monitored geologic repository at Yucca Mountain, if approved, would have three phases, as follows:

- *Construction:* Activities during this phase would include preparing the site, constructing surface waste handling and support facilities, excavating and equipping a portion of the repository *subsurface* for initial waste *emplacement*, and conducting initial verification testing of components and systems.

- *Operation and monitoring:* Repository operations activities would include waste receipt, repackaging, and emplacement in the repository; continuing subsurface development for waste *emplacement; monitoring; and maintenance*. Monitoring would begin with the initial emplacement of waste in the repository and would end at repository closure. In addition, the maintenance of repository facilities would continue until the closure of the repository. See *monitoring*, *maintenance*.

- *Closure:* The closure of the *subsurface* repository facilities would include the removal and salvage of equipment and materials; filling of the main *drifts*, access ramps, and ventilation shafts; and sealing of openings, including ventilation shafts, access ramps, and *boreholes*. Surface closure activities would include the construction of monuments to mark the repository location, *decommissioning* and demolition of facilities, and restoration of the site to its approximate condition before the construction of the repository facilities.

respirable fraction

The fraction of *aerosol* released in an *accident* that consists of particles or droplets having aerodynamic effective diameters of 10 microns (about 4 millionths of an inch) or less.

retrieval

The act of removing *radioactive* waste from the underground location at which the waste had been previously emplaced for disposal. Retrieval would be a contingency action, performed only if *monitoring* indicated that the waste needed to be retrieved in order to protect the public health and safety or the environment or to recover resources from *spent nuclear fuel*.

reverse fault

A *fault* in which the relative displacement is along the direction of the dip of the fault plane (*dip-slip fault*), and in which the block above the fault has moved upward in relation to the block below the fault.

riparian

Of, on, or pertaining to the bank of a river or stream, or of a pond or small lake.

riprap

Broken stones or chunks of concrete used as foundation material or in embankments to control water flow or prevent erosion.

risk

The product of the probability that an undesirable event will occur multiplied by the consequences of the undesirable event.

safe haven

Designated safe parking locations along transportation routes.

sanitary and industrial solid waste

Solid waste that is neither hazardous nor radioactive. Sanitary waste streams include paper, glass, and discarded office material. State of Nevada waste regulations identify this waste stream as household waste.

sanitary waste

Domestic wastewater from toilets, sinks, showers, kitchens, and floor drains from restrooms, change rooms, and food preparation and storage areas.

saturated zone

The area below the *water table* where all spaces (*fractures* and rock pores) are completely filled with water.

scenario

A specific set of actions, activities, and assumptions. Scenarios are identified and analyzed to enable the estimation of the range of environmental impacts associated with the *Proposed Action* and the *No-Action Alternative*. The environmental impacts identified from these scenarios provide environmental information to support Departmental decisions about the *alternatives* and *implementing alternatives*.

scoria

Bubbly, glassy lava rock of basaltic composition that originated as hot, welded materials ejected from a volcano. Small fragments are called "cinders."

seismic

Pertaining to, characteristic of, or produced by *earthquakes* or earth vibrations.

seismicity

A seismic event or activity such as an *earthquake* or earth tremor; *seismic* action.

sensitive structures

Buildings or structures, usually old and of cultural value, or facilities that house vibration-sensitive equipment, that could be susceptible to ground vibrations, activities, or conditions causing *ground vibrations*.

shaft

For the Yucca Mountain Repository, an excavation or vertical passage of limited area, compared to its depth, used to ventilate underground facilities.

shielding

Any material that provides *radiation* protection.

shipment

The movement of a properly prepared (loaded, unloaded, or empty) *cask* from one site to another and associated activities to ensure compliance with applicable regulations.

shipping cask

A heavily shielded massive container that meets regulatory requirements for shipping *spent nuclear fuel* or *high-level radioactive waste*. See *cask*.

single-purpose (storage or transportation) cask

A heavily shielded massive container for the dry storage of *spent nuclear fuel*; it is usable for either storage or transportation but not for *emplacement* in a repository. See *cask*.

site boundary

The boundary of the land withdrawal area used for analytical purposes in this EIS. See *land withdrawal area*.

site characterization

Activities associated with the determination of the suitability of the Yucca Mountain site as a *monitored geologic repository*. DOE constructed the *Exploratory Studies Facility* to support the following activities related to the determination of site suitability, including surface facilities and *subsurface* ramps and *drifts*:

- Gather and evaluate surface and subsurface site data
- Predict the performance of the repository
- Prepare the repository design
- Assess the performance of the system against the required Code of Federal Regulations and program performance criteria

Some of the exploratory surface and subsurface facilities would be enhanced during the repository construction phase (see *repository phases*); others would be removed, demolished, or relocated, as necessary. Data gathering associated with site characterization would end with any Site Recommendation decision.

site-generated waste

Waste or wastewater generated at the *monitored geologic repository* and related transportation facilities.

Site Recommendation

A recommendation by the Secretary of Energy to the President that the Yucca Mountain site be approved for development as the Nation's first *spent nuclear fuel* and *high-level radioactive waste* repository.

soil recovery

The return of disturbed land to a relatively stable condition with a form and productivity similar to that which existed before any disturbance.

sound barrier

Natural or artificial structures that block or interfere with the propagation of sound; examples include terrain features and manmade structures (buildings, walls, etc.).

source term

Types and amounts of radionuclides that are the source of a potential release of *radioactivity*.

Spaghetti Bowl

As used in this EIS, the intersection of Interstate Highway 15 and U.S. Highway 93/95 in Las Vegas, Nevada.

spalling

(1) Flaking off of corrosion products from the metal *substrate* as it undergoes corrosion. The layer of corroded material thickens. The spalling could be caused by an expansive action of the corrosion products because they occupy a greater volume than the uncorroded metal substrate. (2) Flaking, chipping, or cracking at the opening of a *borehole*, *shaft*, or other rock excavation.

Special-Performance-Assessment-Required (SPAR) wastes

Low-level radioactive wastes generated in DOE production reactors, research reactors, reprocessing facilities, and research and development activities that exceed the Nuclear Regulatory Commission Class C shallow-land burial disposal limits.

spent nuclear fuel

Fuel that has been withdrawn from a *nuclear reactor* following *irradiation*, the component elements of which have not been separated by reprocessing. For this project, this refers to (1) intact, nondefective *fuel assemblies*, (2) failed fuel assemblies in canisters, (3) fuel assemblies in canisters, (4) consolidated fuel rods in canisters, (5) nonfuel assembly hardware inserted in *pressurized-water reactor* fuel assemblies, (6) fuel channels attached to *boiling-water reactor* fuel assemblies, and (7) nonfuel assembly hardware and structural parts of assemblies resulting from consolidation in *canisters*.

spoils areas

Areas outside the rail corridor for the deposition of excavated materials from rail line development.

stakeholder

A person or organization with an interest in or affected by DOE actions (representatives from Federal, state, tribal, or local agencies; members of Congress or state legislatures; unions, educational groups, environmental groups, industrial groups, etc.; and members of the general public).

storage

The collection and containment of waste or *spent nuclear fuel* in a way that does not constitute *disposal* of the waste or *spent nuclear fuel* for the purposes of awaiting treatment or disposal capacity.

storage cask

See *cask*.

storage container
See *cask.*

stratigraphy
The branch of geology that deals with the definition and interpretation of rock strata, the conditions of their formation, character, arrangement, sequence, age, distribution, and especially their correlation by the use of fossils and other means of identification. See *stratum.*

stratosphere
The atmospheric shell above the troposphere and below the mesosphere. It extends from 10 to 20 kilometers (6 to 12 miles) to about 53 kilometers (33 miles) above the surface.

stratum
A sheetlike mass of sedimentary rock or earth of one kind lying between beds of other kinds.

strike-slip fault
A fault with purely horizontal relative displacement.

subcritical
Having an effective multiplication constant less than 1, so that a self-supporting *chain reaction* cannot be maintained in a *nuclear reactor.*

subsidiary fault
See *intrablock fault.*

substrate
Basic surface on which a material adheres.

subsurface
A zone below the surface of the Earth, the *geologic* features of which are principally layers of rock that have been tilted or faulted and are interpreted on the basis of drill hole records and geophysical (*seismic* or rock vibration) evidence. In general, it is all rock and solid materials lying beneath the Earth's surface.

sulfur dioxide
A pungent, colorless gas produced during the burning of sulfur-containing fossil fuels. It is the main pollutant involved in the formation of acid rain. Coal- and oil-burning electric utilities are the major source of sulfur dioxide in the United States. Inhaled sulfur dioxide can damage the human respiratory tract and can severely damage vegetation. See *criteria pollutants, ambient air quality standards.*

sulfur oxides
A mixture of sulfur dioxide, sulfur trioxide, and inorganic sulfites and sulfates. Sulfur dioxide combines with oxygen in the air to form sulfur trioxide and microscopic aerosol sulfite and sulfate particles, all of which are lung irritants. See *criteria pollutants, ambient air quality standards.*

supernate

A concentrated form of *radioactive* waste that floats to the top of an undisturbed container of liquid *high-level radioactive waste.*

thermal loading

(1) The spatial density at which *waste packages* would be emplaced within the repository as characterized by the areal power density and the *areal mass loading*. (2) The application of heat to a system, usually measured in terms of watts per unit area. The thermal load for a repository would be the watts per acre produced by the *radioactive* waste in the active disposal area.

thermal shunt

A metal structure, usually aluminum, that would be added to *waste packages* as needed to greatly improve heat conduction between the center of the waste package and the outer edge, thereby providing a reliable means to keep the temperature of the *cladding* within design limits.

threatened species

A species that is likely to become an *endangered species* within the foreseeable future throughout all or a significant part of its range.

thrust fault

A *reverse fault* in which the angle of the fault plane is less than 45 degrees.

total employment

The sum of direct and indirect employment resulting from initiation of an activity. Direct employment consists of jobs performing the activity. Indirect employment consists of jobs in other activities supporting the direct employees. Also defined as composite employment.

total population

The sum of all people associated with direct and indirect employees and their families resulting from initiation of an activity.

Total System Performance Assessment

A risk assessment that quantitatively estimates how the proposed Yucca Mountain Repository system could perform under the influence of specific features, events, and processes, incorporating *uncertainty* in the models and data. See *performance assessment.*

toxic air pollutants

Hazardous pollutants not listed as either *criteria pollutants* or *hazardous pollutants.*

traditional cultural property

A property that is eligible for inclusion in the National Register of Historic Places because of its association with cultural practices or beliefs of a living community that are rooted in that community's history, and are important in maintaining the continuing cultural identity of the community. Culture includes the traditions, beliefs, practices, lifeways, arts, crafts, and social institutions of any community, be it a Native American tribe, a local ethnic group, or the people of the Nation as a whole. Properties can include buildings, structures, and sites; groups of buildings, structures, or sites forming historic districts; and individual objects.

transpiration

The process by which water enters a plant through its root system, passes through its vascular system, and is released into the atmosphere through openings in its outer covering. It is an important process for removal of water that has infiltrated below the zone where it could be removed by evaporation.

transuranic waste

Waste materials (excluding *high-level radioactive waste* and certain other waste types) contaminated with alpha-emitting radionuclides that are heavier than uranium with half-lives greater than 20 years and that occur in concentrations greater than 100 nanocuries per gram. Transuranic waste results primarily from treating and fabricating plutonium as well as research activities at DOE defense installations.

trunnion

A projection from a vessel or other piece of equipment that facilitates attachment to a lifting device.

tuff

Igneous rock formed from compacted volcanic fragments from *pyroclastic* (explosively ejected) flows with particles generally smaller than 4 millimeters (about 0.16 inch) in diameter—the most abundant type of rock at the Yucca Mountain site. Nonwelded tuff results when volcanic ash cools in the air sufficiently that it doesn't melt together, yet later becomes rock through compression. See *welded tuff.*

ultraviolet radiation

Electromagnetic radiation with wavelengths from 4 to 400 nanometers. This range begins at the short wavelength limit of visible light and overlaps the wavelengths of long *x-rays* (some scientists place the lower limit at higher values, up to 40 nanometers). Also known as ultraviolet light.

uncanistered spent nuclear fuel

Commercial spent nuclear fuel placed directly into shipping casks. At the repository, *spent nuclear fuel* assemblies would be removed from the *shipping cask* in a *disposal container* or in the fuel pool to accomodate *blending*.

uncertainty

A measure of how much a calculated or estimated value that is used as a reasonable guess or prediction might vary from the unknown true value.

unique farmland

Land other than *prime farmland* that is used for the production of specific high-value food and fiber crops such as citrus, tree nuts, olives, cranberries, fruits, and vegetables.

unsaturated zone

The zone of soil or rock below the ground surface and above the *water table.*

vadose zone

See *unsaturated zone.*

variation

As used in the transportation analysis in this EIS, a strip of land, approximately 400 meters (0.25 mile) wide, from one point along a corridor to another point along the same corridor that describes a different route. See *alternate*, *option*, *corridor*.

Viability Assessment

An assessment of the prospects for geologic disposal at the Yucca Mountain site, based on repository and *waste package* design, a *Total System Performance Assessment*, a *License Application* plan, and repository cost and schedule estimates. DOE issued the *Viability Assessment of a Repository at Yucca Mountain* in December 1998.

vicinity (in relation to the Yucca Mountain Repository)

A general term used in nonspecific discussions in this EIS about the area around the Yucca Mountain site.

viewshed

A total field of vision or a vista. In particular, an area with visual boundaries seen from various points within the area.

vitrification

A waste treatment process that uses glass (for example, *borosilicate glass*) to encapsulate or immobilize *radioactive* wastes.

vitrophyre

A volcanic rock with large crystals embedded in a glassy, obsidian-like matrix.

waste form

A generic term that refers to the different types of *radioactive* wastes.

waste package

A sealed container containing waste that is ready for *emplacement*. The waste package would contain the *waste form* and any internal structures necessary for structural support, thermal control, or nuclear control.

water table

(1) The upper limit of the *saturated zone* (the portion of the ground wholly saturated with water). (2) The upper surface of a zone of saturation above which the majority of pore spaces and fractures are less than 100 percent saturated with water most of the time (*unsaturated zone*) and below which the opposite is true (saturated zone).

welded tuff

A *tuff* deposited under conditions where the particles making up the rock were heated sufficiently to cohere. In contrast to nonwelded tuff, welded tuff is denser, less porous, and more likely to be fractured (which increases *permeability*).

wetland

A shoreline or other area, such as a marsh or swamp, that is saturated with moisture, especially when thought of as the natural habitat of wildlife.

wet storage

Storage of *radioactive* material that uses water for cooling or *shielding*, such as a spent nuclear fuel storage pool.

worker year

2,000 hours of paid labor; a project requiring 1.5 worker years would take 3,000 hours to complete.

X-rays

Penetrating electromagnetic *radiation* having a wavelength much shorter than that of visible light. X-rays are identical to *gamma rays* but originate outside the *nucleus*, either when the inner orbital *electrons* of an excited atom return to their normal state or when a metal target is bombarded with high-speed electrons.

Yucca Mountain Repository EIS

See *environmental impact statement (EIS).*

Yucca Mountain site (the site):

The area on which DOE has built or would build the majority of facilities or cause the majority of land disturbances related to the proposed repository.

zeolite

Any of a group of hydrated silicates of aluminum with alkali metals, commonly occurring as secondary minerals in cavities in basic volcanic rocks.

zirconium alloy

An alloy material containing the element zirconium that might have any of several compositions. It is used as a *cladding* material.

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CONVERSIONS

METRIC TO ENGLISH			ENGLISH TO METRIC		
Multiply	**by**	**To get**	**Multiply**	**by**	**To get**
Area					
Square meters	10.764	Square feet	Square feet	0.092903	Square meters
Square kilometers	247.1	Acres	Acres	0.0040469	Square kilometers
Square kilometers	0.3861	Square miles	Square miles	2.59	Square kilometers
Concentration					
Kilograms/sq. meter	0.16667	Tons/acre	Tons/acre	0.5999	Kilograms/sq. meter
Milligrams/liter	1[a]	Parts/million	Parts/million	1[a]	Milligrams/liter
Micrograms/liter	1[a]	Parts/billion	Parts/billion	1[a]	Micrograms/liter
Micrograms/cu. meter	1[a]	Parts/trillion	Parts/trillion	1[a]	Micrograms/cu. meter
Density					
Grams/cu. cm	62.428	Pounds/cu. ft.	Pounds/cu. ft.	0.016018	Grams/cu. cm
Grams/cu. meter	0.0000624	Pounds/cu. ft.	Pounds/cu. ft.	16,025.6	Grams/cu. meter
Length					
Centimeters	0.3937	Inches	Inches	2.54	Centimeters
Meters	3.2808	Feet	Feet	0.3048	Meters
Kilometers	0.62137	Miles	Miles	1.6093	Kilometers
Temperature					
Absolute					
Degrees C + 17.78	1.8	Degrees F	Degrees F – 32	0.55556	Degrees C
Relative					
Degrees C	1.8	Degrees F	Degrees F	0.55556	Degrees C
Velocity/Rate					
Cu. meters/second	2118.9	Cu. feet/minute	Cu. feet/minute	0.00047195	Cu. meters/second
Grams/second	7.9366	Pounds/hour	Pounds/hour	0.126	Grams/second
Meters/second	2.237	Miles/hour	Miles/hour	0.44704	Meters/second
Volume					
Liters	0.26418	Gallons	Gallons	3.78533	Liters
Liters	0.035316	Cubic feet	Cubic feet	28.316	Liters
Liters	0.001308	Cubic yards	Cubic yards	764.54	Liters
Cubic meters	264.17	Gallons	Gallons	0.0037854	Cubic meters
Cubic meters	35.314	Cubic feet	Cubic feet	0.028317	Cubic meters
Cubic meters	1.3079	Cubic yards	Cubic yards	0.76456	Cubic meters
Cubic meters	0.0008107	Acre-feet	Acre-feet	1233.49	Cubic meters
Weight/Mass					
Grams	0.035274	Ounces	Ounces	28.35	Grams
Kilograms	2.2046	Pounds	Pounds	0.45359	Kilograms
Kilograms	0.0011023	Tons (short)	Tons (short)	907.18	Kilograms
Metric tons	1.1023	Tons (short)	Tons (short)	0.90718	Metric tons
ENGLISH TO ENGLISH					
Acre-feet	325,850.7	Gallons	Gallons	0.000003046	Acre-feet
Acres	43,560	Square feet	Square feet	0.000022957	Acres
Square miles	640	Acres	Acres	0.0015625	Square miles

a. This conversion is only valid for concentrations of contaminants (or other materials) in water.

METRIC PREFIXES

Prefix	Symbol	Multiplication factor	
exa-	E	1,000,000,000,000,000,000	= 10^{18}
peta-	P	1,000,000,000,000,000	= 10^{15}
tera-	T	1,000,000,000,000	= 10^{12}
giga-	G	1,000,000,000	= 10^{9}
mega-	M	1,000,000	= 10^{6}
kilo-	k	1,000	= 10^{3}
deca-	D	10	= 10^{1}
deci-	d	0.1	= 10^{-1}
centi-	c	0.01	= 10^{-2}
milli-	m	0.001	= 10^{-3}
micro-	µ	0.000 001	= 10^{-6}
nano-	n	0.000 000 001	= 10^{-9}
pico-	p	0.000 000 000 001	= 10^{-12}