DOE/RW-0012
(Overview)

Nuclear Waste Policy Act
(Section 112)

Draft Environmental Assessment
Overview

Yucca Mountain Site, Nevada Research and Development Area, Nevada

December 1984

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

The reader is cautioned that this overview is for public information purposes and does not provide a sufficient basis for commenting on the draft EA for the Yucca Mountain site because of the amount and the complexity of the information presented in that document. The reader who is interested in commenting is therefore referred to the draft EA for the necessary background information. Copies of the draft EA can be obtained by writing to the following address:

EA
U.S. Department of Energy
Attn: EA
1000 Independence Avenue, S.W.
Washington, D.C. 20585

Copies of the draft EA may also be obtained by calling the following telephone numbers:

Nationwide Toll Free	800-858-1600
Maryland (outside of the Metropolitan Washington, D.C. area)	800-638-2054
Metropolitan Washington, D.C. area	530-7700

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ABSTRACT

In February 1983, the U.S. Department of Energy (DOE) identified the Yucca Mountain site in Nye County, Nevada, as one of nine potentially acceptable sites for a mined geologic repository for spent nuclear fuel and high-level radioactive waste. To determine their suitability, the Yucca Mountain site and the eight other potentially acceptable sites have been evaluated in accordance with the DOE's General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories. These evaluations are reported in the draft environmental assessment (EA), which is being issued for public review and comment. The DOE findings and determinations that are based on the evaluations contained in the draft EAs are preliminary and subject to public review and comment. A final EA will be prepared after considering the comments received on the draft EA.

The Yucca Mountain site is located in the Great Basin, one of five distinct geohydrologic settings that are being considered for the first repository. On the basis of the evaluations reported in the draft EA, the DOE has found that the Yucca Mountain site is not disqualified under the guidelines. The DOE has also found that it is suitable for site characterization because the evidence does not support a conclusion that the site will not be able to meet each of the qualifying conditions specified in the guidelines. On the basis of these findings, the DOE is proposing to nominate the Yucca Mountain site as one of five sites suitable for characterization. Furthermore, having performed a comparative evaluation of the five sites proposed for nomination, the DOE has determined that the Yucca Mountain site is one of three sites preferred for site characterization.

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1. INTRODUCTION

By the end of this century, the United States plans to begin operating the first geologic repository for the permanent disposal of commercial spent nuclear fuel and high-level radioactive waste. Public Law 97-425, the Nuclear Waste Policy Act of 1982 (the Act), specifies the process for selecting a repository site and assigns to the U.S. Department of Energy (DOE) the responsibility for locating, constructing, operating, closing, and decommissioning the repository. Congress approved geologic disposal by declaring that one of the key purposes of the Act is "to establish a schedule for the siting, construction, and operation of repositories that will provide reasonable assurance that the public and the environment will be adequately protected from the hazards posed by high-level radioactive waste and such spent nuclear fuel as may be disposed of in a repository" [Section 111(b)(1)].

A geologic repository can be viewed as a large underground mine with a complex of tunnels occupying roughly 2000 acres at a depth between 1000 and 4000 feet. To handle and process the waste received for disposal, surface facilities will be developed; they will occupy about 400 acres. The repository will be in operation for about 25 to 30 years. After the repository is closed and sealed, waste isolation will be achieved by a system of multiple barriers, both natural and engineered, that will act to contain and isolate the waste as required by regulations. The natural barriers consist of the geologic, hydrologic, and geochemical environment of the site. The engineered barriers consist of the waste package and the underground facility. The waste package includes the waste form, the canister, and materials placed over and around the canisters. The underground facility consists of underground openings and backfill materials, not associated with the waste package, that are used to further limit ground-water circulation around the waste packages and impede the subsequent transport of radionuclides to the environment.

In February 1983, the DOE carried out the first requirement of the Act by formally identifying nine sites in the following locations as potentially acceptable sites for the first repository (the host rock of each site is noted in parentheses):

1. Vacherie dome, Louisiana (domal salt)
2. Cypress Creek dome, Mississippi (domal salt)
3. Richton dome, Mississippi (domal salt)
4. Yucca Mountain, Nevada (tuff)
5. Deaf Smith County, Texas (bedded salt)
6. Swisher County, Texas (bedded salt)
7. Davis Canyon, Utah (bedded salt)
8. Lavender Canyon, Utah (bedded salt)
9. Reference repository location, Hanford Site, Washington (basalt flows)

The locations of these sites are shown in Figure 1.

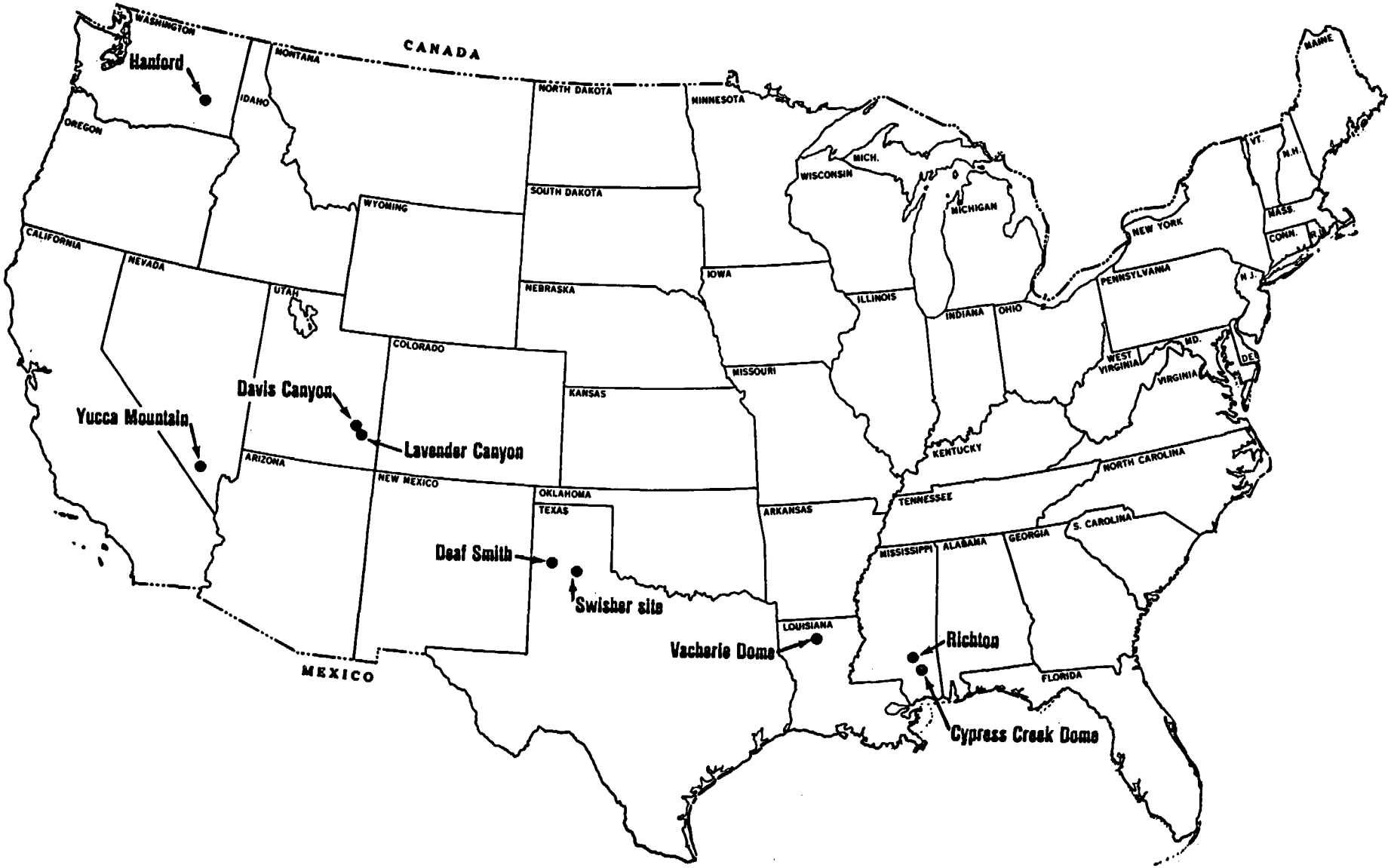

Figure 1. Potentially acceptable sites for the first repository.

After identifying these potentially acceptable sites, the DOE published draft General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories (the guidelines) in accordance with the Act. The draft guidelines were revised in response to extensive comments and received the concurrence of the Nuclear Regulatory Commission (NRC) in June 1984. Final guidelines were published in December 1984 as 10 CFR Part 960.

The Act requires the DOE to nominate at least five sites as suitable for site characterization--a formal information-gathering process that will include the sinking of one or more shafts at the site and a series of experiments and studies underground. The DOE must then recommend to the President not fewer than three of those sites for characterization as candidate sites for the first repository. After site characterization is completed, one of the characterized sites will be recommended for development as a repository.

The Act also requires the DOE to prepare environmental assessments (EA) to serve as the basis for site-nomination decisions. These EAs contain the following information and evaluations consistent with the requirements of Section 112 of the Act:

- A description of the decision process by which the site is being considered for nomination (EA Chapters 1 and 2).
- A description of the site and its surroundings (EA Chapter 3).
- An evaluation of the effects of site-characterization activities on public health and safety and the environment and a discussion of alternative activities that may be taken to avoid such effects (EA Chapter 4).
- An assessment of the regional and local effects of locating a repository at the site (EA Chapter 5).
- An evaluation as to whether the site is suitable for site characterization (EA Chapter 6).
- An evaluation as to whether the site is suitable for development as a repository (EA Chapter 6).
- A reasonable comparative evaluation of the site with other sites that have been considered (Chapter 7).

This overview highlights the important information and evaluations found in the draft EA for the Yucca Mountain site. Section 2 of this overview presents a summary of the decision process and preliminary findings leading to the nomination and recommendation of the Yucca Mountain site. Sections 3 through 7 summarize the results of evaluations contained in corresponding chapters in the draft EA.

The reader is cautioned that this overview does not provide a sufficient basis for commenting on the draft EA because of the amount and the complexity of the information presented in that document. The reader interested

in commenting is therefore referred to the draft EA for the necessary background information.

2. DECISION PROCESS AND PRELIMINARY CONCLUSIONS

2.1 Decision process

The guidelines require the DOE to implement the following seven-part evaluation and decision process for nominating and recommending sites for characterization:

1. Evaluate the potentially acceptable sites in terms of the disqualifying conditions specified in the guidelines.

2. Group all potentially acceptable sites according to their geohydrologic settings.

3. For those geohydrologic settings that contain more than one potentially acceptable site, select the preferred site on the basis of a comparative evaluation of all potentially acceptable sites in that setting.

4. Evaluate each preferred site within a geohydrologic setting and decide whether such site is suitable for the development of a repository under the qualifying condition of each applicable guideline.

5. Evaluate each preferred site within a geohydrologic setting and decide whether such site is suitable for site characterization under the qualifying condition of each applicable guideline.

6. Perform a reasonable comparative evaluation under each guideline of the sites proposed for nomination.

7. Consider an order of preference of the nominated sites as recommended sites and, on the basis of this order of preference, recommend not fewer than three sites for characterization to the President.

The DOE has prepared a draft EA for each of the nine potentially acceptable sites to give all interested parties an opportunity to review the full evaluation of all sites considered. In preparing the final EAs, the DOE will consider all comments that are received.

After the final EAs are issued, the DOE will formally nominate at least five sites as suitable for characterization. The Secretary of Energy will then recommend not fewer than three of these sites to the President as candidate sites for characterization. After the President approves the Secretary's recommendation, characterization activities will begin at those sites. After characterization is completed, the DOE will again evaluate each site against the guidelines and, after completing an environmental impact statement, will recommend one site to the President for the first repository. The President may then recommend the site to Congress. At this point, the

host State may issue a notice of disapproval that can be overridden only by a joint resolution of both Houses of Congress. If the notice of disapproval is not overridden, the President must submit another repository site recommendation within 12 months. If no notice of disapproval is submitted, or if Congress overrides the notice of disapproval, then the site designation becomes effective, and the DOE will proceed to file an application with the NRC to obtain a construction authorization for a repository at that site.

2.2 Preliminary findings and determinations

Summarized below are the DOE's preliminary findings and determinations that apply to the Yucca Mountain site.

2.2.1 Evaluation against the disqualifying conditions

The evidence does not support the disqualification of the Yucca Mountain site under the guidelines; nor are any of the other eight potentially acceptable sites found to be disqualified.

2.2.2 Grouping of sites by geohydrologic setting

The nine potentially acceptable sites are contained within five distinct geohydrologic settings as defined by the U.S. Geological Survey. The sites are grouped by the DOE's geohydrologic designations as follows:

Geohydrologic setting	Site
Columbia Plateau	Reference repository location, Hanford Site, Washington
Great Basin	Yucca Mountain, Nevada
Permian Basin	Deaf Smith and Swisher, Texas
Paradox Basin	Lavender Canyon and Davis Canyon, Utah
Gulf Interior Region of the Gulf Coastal Plain	Vacherie dome, Louisiana; Cypress Creek dome and Richton dome, Mississippi

The Yucca Mountain site is distinct from the other sites in terms of the host rock (tuff--a rock of volcanic origin) and the geohydrologic setting. The region in which the site is located is characterized by fault-block mountains and valleys filled with alluvial sediments derived from the erosion of surrounding mountains. The proposed repository horizon at the site is hydrologically distinct because it is in the dry unsaturated zone above the

water table. The proposed horizons at the other eight sites are all situated well below the water table.

2.2.3 Selection of the preferred site in the Great Basin

The Yucca Mountain site is the only potentially acceptable site identified in the Great Basin. The process by which it was identified as the preferred site in that setting is described in Chapter 2 of the Yucca Mountain EA.

2.2.4 Suitability of the Yucca Mountain site for development as a repository

Section 112(b) of the Act requires the DOE to evaluate the suitability of a site for development as a repository under each guideline that does not require site characterization as a prerequisite for the application of such guideline. The intent is to preclude the investment of money and effort in sites that could be disqualified under those guidelines for which substantial information is available for site evaluations. The guidelines that do not require characterization address mainly those characteristics of a site that are related to the effects of a repository on public health and safety, the quality of the environment, and socioeconomic conditions during the operating period, before the repository is closed and sealed.

For a site to be suitable for repository development under each of those guidelines that do not require site characterization, no disqualifying conditions can be present, and each of the qualifying conditions must be met. A final determination of suitability for repository development cannot be made until site characterization is complete. However, at this stage, the evidence does not support a finding that the Yucca Mountain site is disqualified. Furthermore, the evidence does not support a finding that the Yucca Mountain site is not likely to meet all the qualifying conditions under those guidelines that do not require site characterization.

2.2.5 Suitability of the Yucca Mountain site for characterization

To determine whether a site is suitable for characterization, the DOE must evaluate the site against all the guidelines, including those that require site characterization. To judge that a site is suitable, the DOE must conclude that the evidence does not support a finding that the site is not likely to meet all of the guidelines. The evaluations against the guidelines have led to a preliminary conclusion that the Yucca Mountain site is suitable for characterization.

2.2.6 Preliminary decision on nomination

Having made the above findings, the DOE proposes to nominate the Yucca Mountain site as suitable for characterization. The other potentially acceptable sites proposed for nomination are Davis Canyon, Utah; Deaf Smith, Texas; the reference repository location at the Hanford site, Washington; and the Richton dome, Mississippi.

2.2.7 Comparative evaluation of sites proposed for nomination and order of preference

The DOE has performed a comparative evaluation of the five sites proposed for nomination against each of the siting guidelines. On the basis of the ranking developed during this evaluation, the DOE has determined the three sites that are preferred for characterization. In alphabetical order, those sites are Deaf Smith, Texas; the reference repository location at the Hanford Site, Washington; and Yucca Mountain, Nevada. No order of preference is assigned to these three sites.

3. THE SITE

The Yucca Mountain site is in Nye County, Nevada, on and adjacent to the southwest portion of the DOE's Nevada Test Site, about 100 miles northwest of Las Vegas (see Figure 2). The Yucca Mountain site is on three adjacent parcels of Federal land, each under the separate control of the DOE, the U.S. Air Force, and the Bureau of Land Management.

Yucca Mountain is in the southern part of the Great Basin. The Great Basin is that part of the Basin and Range Province in which all surface waters drain into closed basins rather than flowing into the ocean. As shown in Figure 3, the rocks in this province can be divided into four groups in the order of decreasing geologic age: (1) crystalline "basement" rocks; (2) sedimentary rocks that in the geologic past were folded, faulted, and uplifted, thereby forming large mountain ranges that eventually eroded to a gentle plain; (3) the tuffaceous volcanic material that now makes up Yucca Mountain; and (4) alluvium derived from the erosion of the surrounding mountains. The tuffaceous rocks occur in thick layers of 6000 feet or more.

The faulting and volcanism that produced the Basin and Range Province took place concurrently approximately 10 to 40 million years ago. In the vicinity of Yucca Mountain, tectonic activity has steadily decreased over the last 10 million years. Minor volcanic activity has continued during basin filling and, most recently, produced thin, areally restricted flows and cones of basaltic material on Crater Flat, west of Yucca Mountain. Some faults in the vicinity of Yucca Mountain show evidence of continued movement during the last 2 million years. However, there is no evidence that faults at and near Yucca Mountain have had surface displacements in the last 40,000 years. Yucca Mountain and areas to the west and south have had a relatively low level of seismicity throughout the historical record.

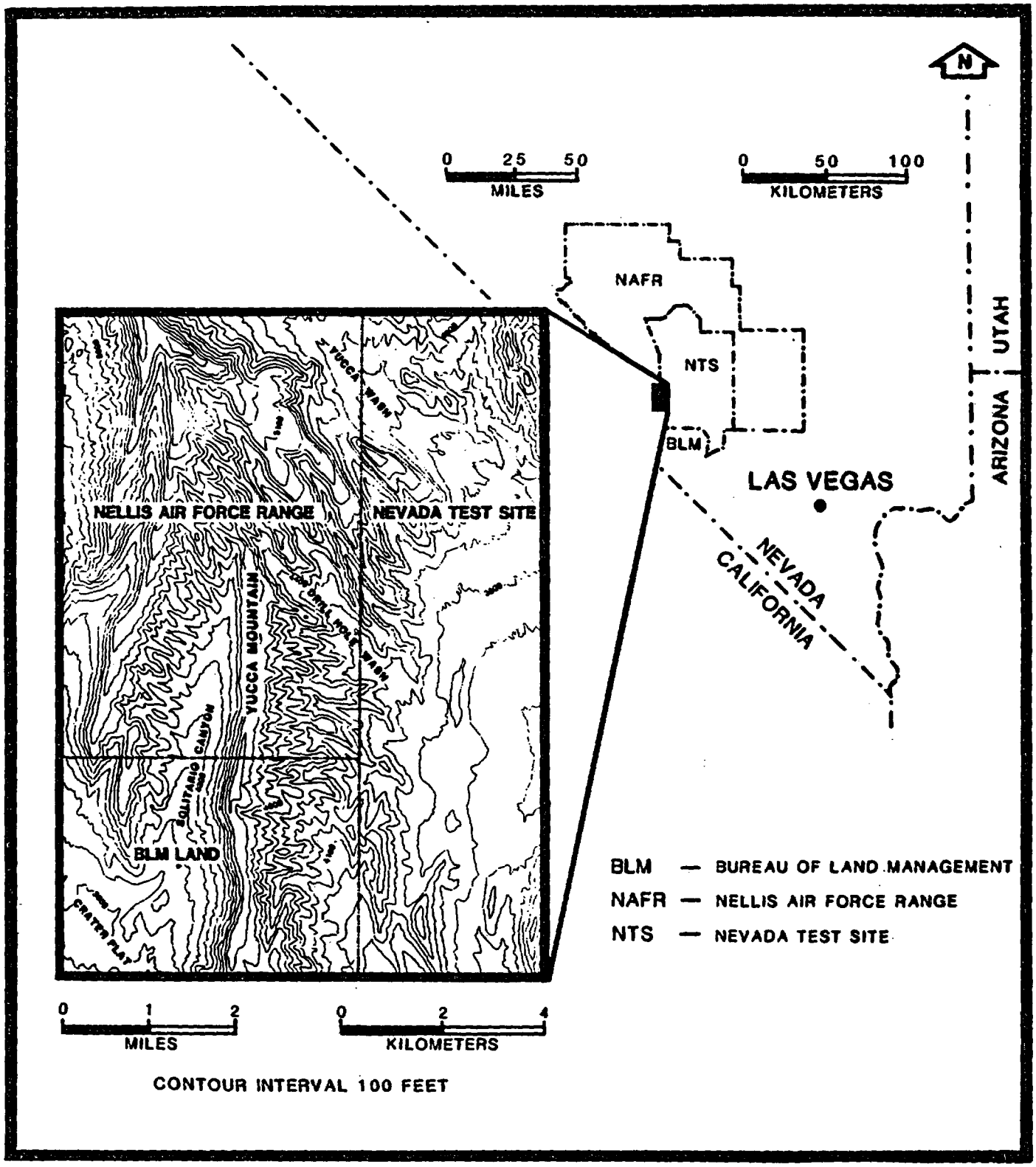

Figure 2. Yucca Mountain site in southern Nevada.

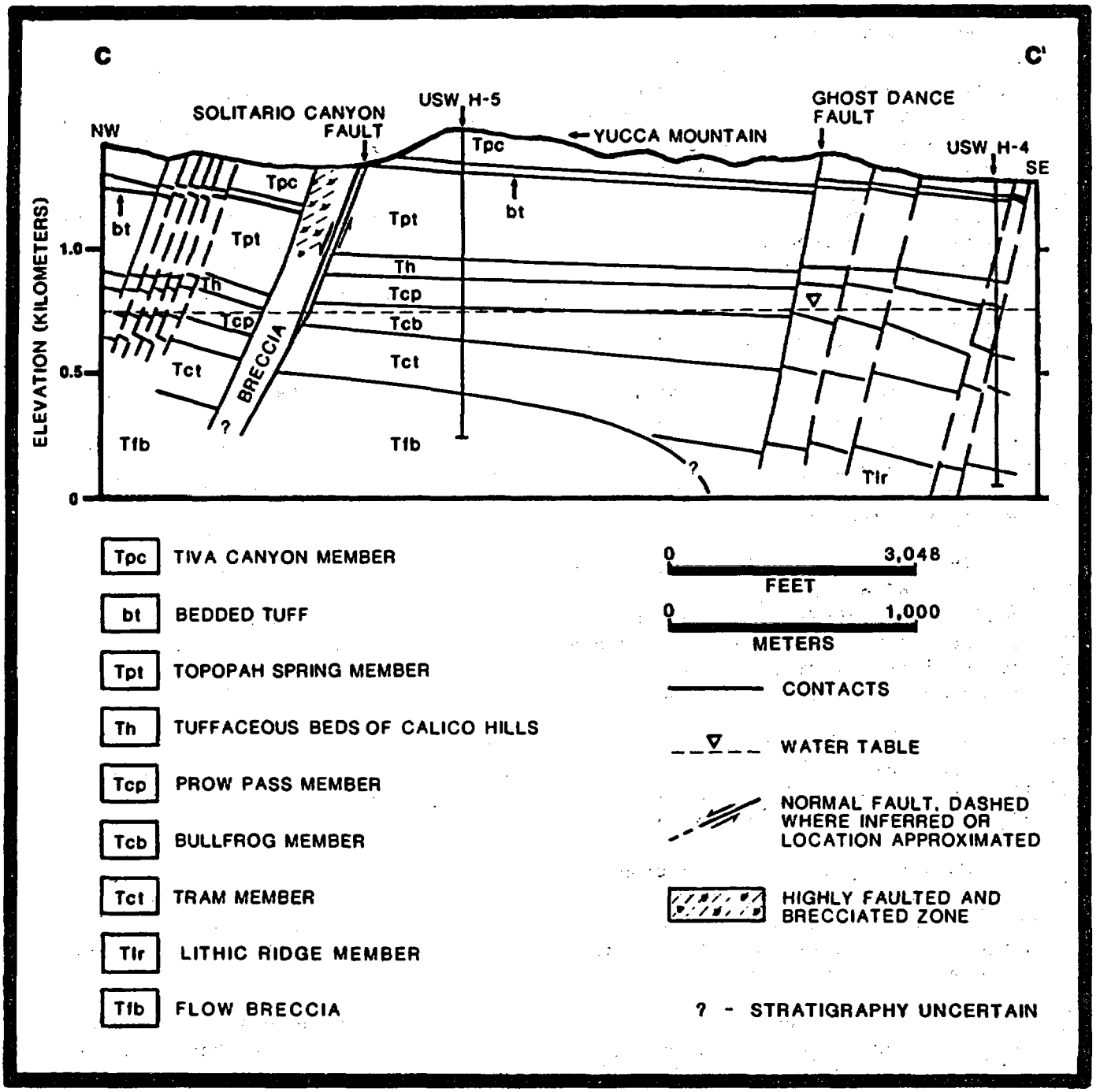

Figure 3. Geologic cross section of the Yucca Mountain site.

The hydrologic system of the southern part of the Great Basin is characterized by low precipitation, deep water tables, and closed topographic and ground-water basins that contain all surface-water flow within the region. At some places in the Great Basin, including parts of Yucca Mountain, the water table is more than 1600 feet below the surface. Ground water is recharged by the slow infiltration of rain and surface water through intergranular pores and perhaps through fractures in the rocks overlying the water table. Most infiltration is restricted to elevations higher than Yucca Mountain, which receive more precipitation. At Yucca Mountain, most precipitation apparently evaporates before it can infiltrate deep enough for ground-water recharge. The average annual precipitation at the site is about 6 inches per year; only a small fraction (3 percent or less) of that amount reaches the depth proposed for the repository.

At Yucca Mountain, a repository would be constructed in the unsaturated zone above the water table. The movement of ground water in the unsaturated zone is typified by a very low flux of water moving downward mainly through the intergranular pores of the tuff layers. In the saturated zone below, water moves laterally through fractures and pores in both the tuffs and in the underlying carbonate-rock aquifers.

There is no evidence that the Yucca Mountain site contains any economic resources of oil and gas, uranium, or geothermal energy, although low-grade uranium and geothermal resources are found in the general area of the site. In spite of the many small mining operations in the area, there is no potential at the site for extracting the limited mineral resources under foreseeable economic conditions.

No permanent or major sources of seasonal surface water are present on Yucca Mountain. The larger washes and drainages in the area tend to contain a distinct flora consisting of species that, though present in the surrounding vegetation, are most common in washes.

No site-specific information about air quality is available for the Yucca Mountain site. However, data from other remote desert areas of the West suggest that the quality of the air at Yucca Mountain probably surpasses the National Ambient Air Quality Standards. Suspended particulates are probably the most important source of air pollution at Yucca Mountain.

None of the plants or animals that inhabit the area around Yucca Mountain are listed as threatened or endangered. However, the Mojave fishhook cactus and the desert tortoise, both of which occur in the area, are being considered for Federal protection as threatened species.

Literature reviews and field surveys of the archaeological, cultural, and historical resources of Yucca Mountain and its vicinity have led to the identification of 178 prehistoric aboriginal sites. These sites are evidence that the area of Yucca Mountain was used by small and highly mobile groups or bands of aboriginal hunter-gatherers.

The area expected to experience socioeconomic effects of the repository consists of Nye and Clark Counties. Sufficient community services are generally available in these two counties, but the service base is more developed in Clark County.

Nye County is largely rural, with a population density of 0.5 person per square mile--one of the lowest population densities in the United States. Approximately 30 percent of the county population lives in each of the three largest townships: Tonopah, Pahrump, and Beatty.

U.S. Highway 95, a four-lane road between Las Vegas and Mercury, is the major artery over which materials, workers, and the radioactive waste would be transported.

4. EFFECTS OF SITE CHARACTERIZATION

To obtain the information necessary for evaluating the suitability of the Yucca Mountain site for a repository, the DOE will conduct a site-characterization program of underground testing. To carry out this program, the DOE will construct two shafts (one shaft for exploration and one for emergency egress), excavate drifts at the proposed repository depth, and construct support structures on the surface. In addition to the tests performed underground and in the exploratory shaft, geologic field studies will be conducted to characterize underground conditions. This site-characterization program will require the clearing of about 700 acres of land.

At the same time, the DOE will study the environment of the site and its vicinity, including weather conditions, air quality, noise, plant and animal communities, and archaeological and cultural resources. Socioeconomic conditions will also be investigated in the area expected to be affected by the repository.

The site-characterization program will last several years. At the end of this period, if the site is found unsuitable for a repository, the shafts will be filled and sealed, and the site will be reclaimed.

Site characterization is expected to have minimal effects on surface- and ground-water quality, land use, noise, aesthetics, and transportation. However, some potentially adverse effects that would result from site characterization have been identified. Some animal species may be adversely affected by the loss of vegetation and the loss of habitat resulting from the clearing of land for site exploration and testing. Wildlife in the surrounding areas could also be disturbed by human presence and activity. In addition, some roadkills from vehicle traffic are expected. The measures that can be taken to mitigate such effects include avoiding sensitive areas (such as habitats for the Mojave fishhook cactus) and making provisions for revegetation at the end of site characterization. Because the site and its immediate surroundings do not support any ecologically unique communities and because the area to be cleared is very small in relation to the surrounding undisturbed area, the ecological effects on a regional level will be minimal.

Adverse effects on air quality may result from the particulates generated by site-characterization activities and wind erosion. Because the Yucca Mountain site is in an area where the quality of the air is considered to be good, site characterization could be subject to regulations designed to

prevent a significant deterioration of the ambient air quality. Fugitive dust can be controlled as necessary by mitigating measures.

Because of site-characterization activities and increased human activities in the area, there is a potential for unauthorized nonscientific excavation of archaeological sites or the collection of artifacts. The removal of even a few chronologically or functionally sensitive artifacts can reduce or distort the research and cultural value of the small archaeological sites that are present in the area. To mitigate this effect, sensitive sites will be identified in cultural-resource surveys and avoided or protected where possible. An archaeologist will supervise the collection of artifacts in the areas directly affected by site-characterization activities and where sites cannot be avoided or adequately protected.

5. REGIONAL AND LOCAL EFFECTS OF REPOSITORY DEVELOPMENT

To determine the effects of developing a repository at the site, three phases of repository development were examined: construction, operation, and closure and decommissioning. During the construction phase, which will last approximately 5 years, the DOE would construct surface and support structures, construct access shafts, excavate and prepare underground tunnels and waste-disposal rooms, and improve access roads and utility services. During the first few years of the operation phase, the repository would receive small amounts of waste--about 400 metric tons of uranium per year--while the surface and underground facilities are completed. After construction is completed, the rate of waste receipt would increase to a maximum of 3000 metric tons of uranium per year. During the operation phase, underground development would continue concurrently with waste emplacement until the required area is excavated. This full-operation phase is estimated to last some 25 to 30 years; it would be followed by a "caretaker" period because the NRC requires the DOE to preserve the option of retrieving the waste for 50 years after the initial emplacement. During closure and decommissioning, shafts and boreholes would be closed and sealed, land-use controls would be instituted, the surface facilities would be decontaminated and decommissioned, and permanent markers or monuments would be erected at the site to warn future generations about the presence of the underground repository.

Both adverse and beneficial effects could result from the development of a repository at Yucca Mountain. It is expected that any adverse effects on the quality of surface and ground water, on land use, on aesthetic resources, and on socioeconomic conditions would be minimal. However, the repository is expected to exert some potentially adverse effects on air quality; plant and animal communities; and archaeological, cultural, and historical resources. The increased economic activity that would result from a repository would be beneficial in stimulating the local economy, but it could also lead to shortages in some services at the local level.

The potentially adverse effects on ambient air quality would be due largely to the particulates generated by site clearing, construction activities, traffic, and wind erosion. The ambient levels of regulated pollutants are expected to be below State and Federal standards for ambient air quality; however, a more precise determination of air-quality effects and

the measures that can be taken to reduce them will be made during site characterization.

The potentially adverse effects on the terrestrial ecosystem would occur through the disturbance of 900 acres of vegetation and wildlife habitat. On a regional scale, the disturbed area would be small, and hence no ecologically unique communities would be disturbed. The mitigation measures that can be used to diminish these impacts include the avoidance of significant habitats for the two site species being considered for threatened status and the maintenance of natural site soils to facilitate revegetation after site closure. The noise levels at the site may also disturb wildlife.

The construction and operation of the repository may lead to the physical disturbance of archaeological sites and possibly the loss of data that are crucial for interpreting these sites. Several mitigating measures would be used to protect known sites where such impacts could occur; for example, fences could be erected around significant sites, and a professional archaeologist could be employed to monitor construction within sensitive locations.

The economy of Nye and Clark Counties is expected to experience beneficial effects. During the peak years of construction, about 8500 people, including both primary and secondary workers, would be employed; during operation, about 5900 people would be employed; and during closure and decommissioning, about 3900 people would be employed. Most of the required workers would be available in the two-county area, with only minimal numbers of specially skilled workers coming from outside this area. The peak annual direct wages are expected to be between 131.5 million and 157.5 million dollars during the construction period. Furthermore, additional revenues would result from local repository-related purchases.

The repository-induced regional population increases are projected to be considerably lower that the growth rates experienced in the past. Nonetheless, the population increase in Nye County may adversely affect the county's school system. If settlement patterns are similar to those for present workers, about 80 percent of the population growth can be expected to occur in Clark County. The specific details of the effects on community services and net government revenues are not certain at this time; however, the Act provides for mitigation assistance where needed.

Two types of transportation effects would result from increased commuter traffic and the hauling of supplies and radioactive waste. They are radiological risks, which would result from the direct external radiation emitted by the radioactive waste as a shipment passes by, and nonradiological risks. The latter are traffic accidents and the health effects that result from the pollutants emitted by combustion engines; they would occur regardless of the cargo carried by the railcar or truck. In general, both types of risk will vary with the distance traveled and with the mode of transportation (road or rail). Since the Yucca Mountain is far from the sources of waste, the nonradiological risks are likely to be relatively high. While the nonradiological risks would vary with the transportation mode, they are expected to be lower for rail transport.

The radiological risks are expected to be much lower than the nonradiological risks. The actual radiological risks would vary with the number of shipments in each transportation mode; they are expected to be lower for shipments by road. The State of Nevada, in cooperation with the Department of Energy, has developed a capability to respond to waste-transportation accidents by preparing emergency plans and procedures.

Access routes would be relatively easy to construct at the Yucca Mountain site and would traverse flat terrain, thereby reducing the risk of accidents. These routes would also bypass local towns and communities, providing direct access to regional and national transportation networks.

Legal impediments in California and Arizona could affect the transportation of waste into Nevada. The weather conditions at the site are not expected to disrupt transportation on a seasonal basis.

6. EVALUATIONS OF SITE SUITABILITY

The DOE has evaluated the Yucca Mountain site to determine its suitability as a candidate for site characterization. This evaluation was based mainly on the siting guidelines, but it was also based in part on the expected effects of site characterization and of repository development, as summarized in the preceding sections.

6.1 The structure of the guidelines

The guidelines are divided into two sets: postclosure (the period after the repository is permanently closed) and preclosure (the period of repository siting, construction, operation, closure, and decommissioning). The postclosure and the preclosure guidelines contain both technical and system guidelines. The technical guidelines address the specific characteristics of the site that are considered to have a bearing on the preclosure and the postclosure performance of the repository. The system guidelines address the expected performance of the total system, including its engineered components; their objective is to protect public health and safety and to preserve the quality of the environment.

The postclosure technical guidelines address the characteristics that could affect the long-term ability of the site to isolate the waste from the accessible environment. In particular, they cover geohydrologic conditions, geochemical conditions, rock characteristics, climatic changes, erosion, dissolution, tectonics, and human interference. The postclosure system guideline requires the site to contain and isolate the waste from the accessible environment in accordance with the standards and the regulations specifically promulgated for repositories by the EPA and the NRC. In order to achieve the specified level of containment and isolation, the site must allow for the use of engineered barriers.

The set of preclosure guidelines is divided into three groups: (1) preclosure radiological safety; (2) the environment, socioeconomics, and

transportation; and (3) the ease and cost of siting, construction, operation, and closure. A preclosure system guideline is specified for each of these groups. The associated technical guidelines address site suitability in terms of population density and distribution, site ownership and control, meteorology, offsite installations and operations, environmental quality, socioeconomics, transportation, surface characteristics, rock characteristics, hydrology, and tectonics.

6.2 Summary of site evaluations against the postclosure guidelines

The features of the Yucca Mountain site that contribute to its long-term ability to isolate the waste from the accessible environment include (1) an unsaturated environment, (2) the probable occurrence of zeolite minerals along the paths of ground-water flow to the accessible environment, and (3) a low potential for human intrusion.

Ground-water flow is a mechanism by which radionuclides could travel from the repository to the accessible environment after closure. The unsaturated zone at the Yucca Mountain site is the most significant barrier to waste migration because the amount of water available for the corrosion of waste canisters and radionuclide transport is very limited in this zone. Furthermore, the climate of the region is very arid, has not changed appreciably in the last 2 million years, and is not expected to change in the next 10,000 years--the time required for waste isolation. Therefore, the present low flux of water through the unsaturated zone is not expected to change.

The probable occurrence of zeolite minerals along flow paths to the accessible environment would provide a barrier to radionuclide migration because of the radionuclide-sorption capacity of the zeolites. The characteristics of the probable flow paths, coupled with the characteristics of the unsaturated zone, would substantially limit the movement of radionuclides.

No economic deposits of oil or gas mineral resources have been found at the site, and none are expected to be found. Thus, there is very little potential for inadvertent human interference to disrupt the isolation capabilities of the Yucca Mountain site.

A condition that may adversely affect the ability of the site's natural barriers to isolate the waste is the presence of oxidizing ground water. At Yucca Mountain, oxidizing ground water is present in the saturated zone and is expected in the unsaturated zone. The presence of oxidizing waters is of concern mainly because it may increase canister-corrosion rates and the solubility and mobilization of radionuclides. However, because the repository would be in the unsaturated zone and thus have little exposure to the ground water, the presence of the oxidizing ground water may not significantly affect the lifetime of the canister or the movement of radionuclides, even though they may be more soluble. In addition, many canister materials, when exposed to oxidizing conditions, form protective coatings that would prolong the lifetime of the canister.

With respect to the possibility of disruptive events that would affect repository performance, the Yucca Mountain site is in an area where earthquakes of greater magnitude than those recorded in the area could occur. However, if these events do occur, they are not expected to affect the waste-isolation capabilities of the site, because such events are not likely to alter the natural characteristics of the unsaturated zone, which is the primary mechanism for controlling radionuclide migration.

In order to meet the EPA standard for long-term waste containment and isolation, the NRC requires that the waste package provide substantially complete containment of the waste for a minimum of 300 years and that, after this period of containment, the radionuclide-release rate not exceed one part in 100,000 per year of the inventory calculated to be present after 1000 years. The lifetime of waste packages at the Yucca Mountain site is expected to be more than 3000 years. (There is an issue as to the rate of corrosion in the unsaturated zone; it will be addressed further during site characterization.) After the period of containment, the fractional rate of radionuclide release from the engineered-barrier system is estimated to be within the NRC regulatory limits. The time of ground-water travel from the disturbed zone to the accessible environment is conservatively estimated to be more than 20,000 years and possibly as long as 4.7 million years. Preliminary assessments of engineered-barrier performance based on realistic but conservative assumptions indicate that the EPA's limit on the release rate to the accessible environment would be met at the Yucca Mountain site.

6.3 Summary of site evaluations against the preclosure guidelines

The evaluations of the Yucca Mountain site against the three groups of preclosure guidelines are summarized below.

6.3.1 Radiological safety

Preliminary preclosure assessments for the Yucca Mountain site indicate that radioactivity releases would not exceed any of the applicable radiation standards during repository operation and closure. In addition, the site was evaluated against the four technical guidelines that address the radiological impacts of repository operation: population density and distribution, site ownership and control, meteorology, and the effects of operations and accidents at nearby installations.

The Yucca Mountain site is on Federal lands remote from populated areas. It is about 100 miles from Las Vegas, which is the nearest population center. The population density of Nye County is only 0.5 person per square mile. As a result, it is unlikely that radioactive releases from the repository could affect large numbers of people.

The weather conditions at the site are such that an atmospheric release of radioactive material, should a release occur, is not expected to be preferentially transported toward population centers. Also, there is little probability of operational accidents from weather and other natural phenomena.

There is little potential for the disruption of repository operations as a result of accidents at the Nevada Test Site. However, routine weapons testing at the Site would temporarily disrupt operations at the repository because during such testing the repository workers would not be allowed to enter the underground area for safety reasons.

6.3.2 Environment, socioeconomics, and transportation

Three technical guidelines address the environmental, socioeconomic, and transportation effects of repository siting, construction, operation, closure, and decommissioning. These effects, which would be both beneficial and adverse, are summarized in Sections 4 and 5 above. Preliminary analyses indicate that the expected adverse effects can be mitigated.

With respect to the system guideline on the environment, socioeconomics, and transportation, the evidence does not support a finding that the Yucca Mountain site is not likely to meet the qualifying condition of protecting the public and the environment from the potential hazards of waste disposal.

6.3.3 Ease and cost of siting, construction, operation, and, closure

Four technical guidelines address the ease and cost of siting, construction, operation, and closure: surface characteristics, rock characteristics, hydrology, and tectonics. The characteristics of the tuff at Yucca Mountain are favorable. For example, underground openings are expected to require minimal support, such as light rock bolting and wire mesh. There appears to be no requirement for extensive maintenance to keep passageways open to the required dimensions. It is expected that excavated openings would remain stable enough to allow the retrieval of the waste, if necessary. Current information indicates that the Yucca Mountain site offers limited lateral flexibility and adequate vertical flexibility for designing and constructing the repository. The predicted peak seismicity of the site is within the range that would be considered acceptable for the design of existing nuclear facilities.

These preliminary evaluations indicate that the repository can be constructed and operated with reasonably available technology and that the costs would be comparable to the costs of constructing a repository at the other potentially acceptable sites. There is therefore no evidence to support a finding that the site is not likely to meet the qualifying condition of the system guideline on the ease and cost of siting, construction, operation, and closure.

7. COMPARATIVE EVALUATION OF SITES PROPOSED FOR NOMINATION

The five sites proposed for nomination were compared to derive a ranking of sites for each technical guideline. These rankings were then combined, or aggregated, to derive for each site (1) a ranking for the set of postclosure guidelines, (2) rankings for each of the three subordinate groups of preclosure guidelines, (3) a ranking for the entire set of preclosure guidelines, and (4) an overall ranking for all of the guidelines. These overall rankings provided the basis for determining which sites are preferred for characterization.

Since the ranks assigned to sites might depend on the method of ranking, three different methods were used to perform the aggregations mentioned above. These methods appear to best fit the characteristics of the problem and are described in Chapter 7 and Appendix B of the draft EAs.

7.1 Site comparison by individual technical guidelines

Table 1 shows the ranking of the five sites for each postclosure technical guideline. All five sites were ranked equal under the guidelines on climatic changes, erosion, and site ownership and control because the evidence was insufficient to discriminate among sites at this time.

Table 2 shows the ranking of the five sites for each preclosure technical guideline. The rankings for any particular site vary for each guideline. In fact, each of the five sites is ranked first for at least one guideline and last for at least one guideline.

7.2 Comparison of sites by guideline groups and sets

Tables 3 and 4 show the rankings of the five sites for the set of postclosure guidelines and for the three groups of preclosure guidelines, respectively. The results indicated for aggregation methods 1, 2, and 3 progressively take into account more factors and require more assumptions.

With respect to the postclosure set of guidelines (Table 3), though the rankings for the postclosure set vary with the method, there is little difference among the sites.

With respect to the subordinate groups of preclosure guidelines (Table 4), the following conclusions can be drawn:

- All of the methods rank the Hanford, the Yucca Mountain, and the Deaf Smith sites in the top three positions for the preclosure-guideline group on radiological safety. For one method, though, the Deaf Smith site is tied for the third rank with the Davis Canyon and the Richton sites. All of the methods rank the Richton site last or tied for last for this guideline group.

- All of the methods rank the Hanford, the Yucca Mountain, and the Deaf Smith sites in the top three positions for the preclosure-guideline group on the environment, socioeconomics, and transportation. For two of the methods, though, the Deaf Smith site is tied for the third rank with the Richton site. All of the methods rank the Davis Canyon site last for this guideline group.

- All of the methods rank the Yucca Mountain, the Deaf Smith, and the Richton sites in the top three positions for the preclosure-guideline group on the ease and cost of siting, construction, operation, and closure. All of the methods rank the Hanford site last for this guideline group.

To summarize, the Yucca Mountain site is in the top two ranks for each of the three preclosure-guideline groups. The Hanford site is first in two of the three groups, but last in the other. The Deaf Smith site is second or third in all of the groups, while the Richton site is in the top three ranks in two of the three groups. The Davis Canyon site is in the bottom two ranks in two of the three groups.

These rankings for the subordinate groups of preclosure guidelines can be used to derive a ranking for the entire set of preclosure guidelines. In general, the results for the preclosure set indicate that the Yucca Mountain, the Hanford, and the Deaf Smith sites are most favorable. The Richton and the Davis Canyon sites are generally less favorable with respect to the entire set of preclosure guidelines.

7.3 Preferred sites for characterization

Table 5 shows the overall rankings for the five sites for (1) the case in which the sets of postclosure and preclosure guidelines are assigned approximately equal weight and (2) for the case where within the preclosure set, the three subordinate groups are also assigned approximately equal weight. This table leads to the following conclusions:

- All of the methods rank the Yucca Mountain site in the top two ranks.

- All of the methods rank the Hanford site in the top three ranks.

- All of the methods rank the Deaf Smith site second or third.

- All of the methods rank the Richton site fourth and the Davis Canyon site fifth; this result is shown to be insensitive to the aggregation method.

This overall result is the same within broad ranges of weighting assignments; that is, the Deaf Smith, the Hanford, and the Yucca Mountain sites are in the top three positions, whereas the Davis Canyon and the Richton sites are in the bottom two positions.

In conclusion, the DOE believes that the Deaf Smith, the Hanford, and the Yucca Mountain sites offer, on balance, the most advantageous combination of

characteristics and conditions for the successful development of a repository and should therefore be recommended for characterization.

Table 1. Rankings of sites for each technical guideline in the postclosure set[a]

Geohydrology	**Dissolution**
1. Davis Canyon, Deaf Smith, Richton	1. Hanford, Yucca Mountain
2. Yucca Mountain	2. Davis Canyon, Deaf Smith
3. Hanford	3. Richton
Geochemistry	**Tectonics**
1. Hanford	1. Deaf Smith
2. Davis Canyon, Deaf Smith, Yucca Mountain	2. Richton
3. Richton	3. Davis Canyon
	4. Hanford
	5. Yucca Mountain
Rock characteristics	**Natural resources**
1. Davis Canyon, Richton	1. Yucca Mountain
2. Deaf Smith	2. Hanford
3. Hanford, Yucca Mountain	3. Davis Canyon, Deaf Smith
	4. Richton
Climatic changes	**Site ownership and control**
All sites equal[b]	All sites equal[b]
Erosion	
All sites equal[b]	

[a]The listing of more than one site for any particular rank indicates a tie.

[b]All sites are ranked equal if the evidence for a technical guideline is insufficient to discriminate among sites at this time.

Table 2. Rankings of sites for each technical guideline in the preclosure set[a]

GROUP 1: RADIOLOGICAL SAFETY

Population density	Site ownership and control	Meteorology	Offsite installations and operations
1. Yucca Mt.	1. Hanford	1. Yucca Mt.	1. Davis Canyon
2. Davis Canyon	2. Deaf Smith, Richton	2. Hanford	2. Richton
3. Hanford, Deaf Smith	3. Yucca Mt.	3. Deaf Smith, Richton	3. Deaf Smith
4. Richton	4. Davis Canyon	4. Davis Canyon	4. Hanford
			5. Yucca Mt.

GROUP 2: ENVIRONMENT, SOCIOECONOMICS, AND TRANSPORTATION

Environmental quality	Socioeconomic impacts	Transportation
1. Hanford, Yucca Mt.	1. Hanford	1. Deaf Smith, Richton
2. Deaf Smith	2. Yucca Mt.	2. Yucca Mt., Hanford
3. Richton	3. Richton	3. Davis Canyon
4. Davis Canyon	4. Deaf Smith	
	5. Davis Canyon	

GROUP 3: EASE AND COST OF SITING, CONSTRUCTION, OPERATION, AND CLOSURE

Surface characteristics	Rock characteristics	Hydrology	Tectonics
1. Deaf Smith, Hanford, Yucca Mt.	1. Yucca Mt.	1. Yucca Mt.	1. Deaf Smith, Richton
2. Richton	2. Davis Canyon, Richton	2. Davis Canyon, Deaf Smith, Hanford, Richton	2. Davis Canyon
3. Davis Canyon	3. Deaf Smith		3. Hanford
	4. Hanford		4. Yucca Mt.

[a]The listing of more than one site for any particular rank indicates a tie.

Table 3. Ranking of sites for the set of postclosure guidelines[a]

Method 1	Method 2	Method 3
1. Deaf Smith	1. Davis Canyon, Deaf Smith	1. Yucca Mountain
2. Davis Canyon	2. Hanford	2. Deaf Smith
3. Hanford	3. Richton, Yucca Mountain	3. Davis Canyon, Hanford
4. Yucca Mountain		4. Richton
5. Richton		

[a]The listing of more than one site for any particular rank indicates a tie.

Table 4. Ranking of sites for preclosure groups of guidelines[a]

Method 1	Method 2	Method 3
GROUP 1: RADIOLOGICAL SAFETY		
1. Hanford	1. Hanford	1. Hanford
2. Yucca Mountain	2. Yucca Mountain	2. Yucca Mountain, Deaf Smith
3. Deaf Smith	3. Deaf Smith, Davis Canyon, Richton	3. Davis Canyon
4. Davis Canyon, Richton		4. Richton
GROUP 2: ENVIRONMENT, SOCIOECONOMICS, AND TRANSPORTATION		
1. Hanford	1. Hanford	1. Hanford
2. Yucca Mountain	2. Yucca Mountain	2. Yucca Mountain
3. Deaf Smith, Richton	3. Richton, Deaf Smith	3. Deaf Smith
4. Davis Canyon	4. Davis Canyon	4. Richton
		5. Davis Canyon
GROUP 3: EASE AND COST OF SITING, CONSTRUCTION, OPERATION, AND CLOSURE		
1. Yucca Mountain	1. Yucca Mountain	1. Yucca Mountain
2. Deaf Smith	2. Richton, Deaf Smith	2. Richton, Deaf Smith
3. Richton	3. Davis Canyon	3. Davis Canyon
4. Davis Canyon	4. Hanford	4. Hanford
5. Hanford		

[a]The listing of more than one site for any particular rank indicates a tie.

Table 5. Overall rankings of sites obtained by three aggregation methods

Method 1	Method 2	Method 3
1. Yucca Mountain	1. Hanford	1. Yucca Mountain
2. Deaf Smith	2. Yucca Mountain	2. Deaf Smith, Hanford
3. Hanford	3. Deaf Smith	3. Richton
4. Richton	4. Richton	4. Davis Canyon
5. Davis Canyon	5. Davis Canyon	

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