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Nuclear Waste Policy Act
(Section 112)

Draft Environmental Assessment
Overview

Reference Repository Location
Hanford Site, Washington

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ABSTRACT

In February 1983, the U.S. Department of Energy (DOE) identified the reference repository location at the Hanford Site in Washington 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 reference repository location at the Hanford 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 reference repository location at Hanford is located in the Columbia Plateau, 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 reference repository location at Hanford 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 reference repository location at Hanford 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 reference repository location at Hanford 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 the operation of 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 decisions on 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 (EA Chapter 7).

This overview highlights the important information and evaluations found in the draft EA for the reference repository location at Hanford. Section 2 of this overview presents a summary of the decision process and preliminary findings leading to site nomination and recommendation of the reference repository location at Hanford. 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 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 reference repository location at the Hanford Site.

2.2.1 Evaluation against the disqualifying conditions

The evidence does not support the disqualification of the reference repository location at the Hanford 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 reference repository location is distinct in terms of the host rock and the geohydrologic setting. The region in which the site is located is characterized by a thick and laterally extensive sequence of basalt flows. The hydrologic system is a complex sequence of horizontal aquifers separated by the dense interiors of basalt flows. Ground-water movement in the region is predominantly through zones at and near the top of basalt flows and, to a lesser extent, through cooling joints and other fractures within the basalt flows.

2.2.3 Selection of the preferred site in the Columbia Plateau

The reference repository location at the Hanford Site is the only potentially acceptable site identified in the Columbia Plateau. The process by which it was identified as the preferred site in that setting is described in the draft EA for Hanford.

2.2.4 Suitability of the reference repository location at Hanford 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 such 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 primarily relate to 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 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 reference repository location is disqualified. Furthermore, the evidence does not support a finding that the reference repository location is not likely to meet all the qualifying conditions under those guidelines that do not require site characterization.

2.2.5 Suitability of the reference repository location at Hanford for site 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 reference repository location at Hanford is suitable for characterization.

2.2.6 Preliminary decision on nomination

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

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 reference repository location (for brevity referred to in this section as "the site") is in the west-central part of the DOE-controlled Hanford Site in south-central Washington (Figure 2). The site lies within the Pasco Basin, a 1900-square-mile topographic depression in the Columbia River Plateau and, more specifically, in the central part of the Cold Creek Syncline. This location was chosen partly because the basalt flows within the syncline are nearly flat-lying and should be structurally less disturbed than other areas at the Hanford Site (Figure 3). The terrain at the site is relatively flat--its features were formed by glacially related floods and more-recently developed sand dunes. The terrain to the north and to the west is dominated by prominent linear ridges formed by arch-like folds (anticlines) of basalt.

The Columbia River Plateau is underlain by a thick sequence of strata deposited during the Miocene epoch (over 6 million years before present). These strata consist entirely of basalt-lava flows in the lower part and of increasing amounts of interbedded sedimentary deposits in the upper part. Semiconsolidated sediments overlie the basalt sequence and attain thicknesses of as much as 1200 feet. Approximately 50 basalt flows, with a total thickness of perhaps 16,000 feet, have been identified within the Pasco Basin. Four of these basalt flows have been identified as candidate host horizons for the repository. Each horizon is continuous throughout the vicinity of the site, and each is more than 130 feet thick. Structures at the Hanford Site consist of long, narrow anticlines and broad synclines (trough-like folds) that trend roughly east-west. Faults associated with anticlinal fold axes probably developed concurrently with folding.

Ground water occurs at the site both in an unconfined aquifer and in numerous confined aquifers. The unconfined aquifer consists of sediments that lie above the sequence of basalt flows. Confined aquifers occur at greater depths, within the sequence of basalt flows. There are three dominant pathways for ground-water movement in the basalt sequence: (1) the more permeable contact zones between basalt flows and in the sedimentary interbeds; (2) structural discontinuities, such as faults or fracture zones, that may cross-cut the basalt flows; and (3) stratigraphic discontinuities within the basalt flows. The shallow basalts are thought to recharge locally in outcrop areas where the rocks are exposed at the surface and to discharge to the overlying unconfined aquifer and the Columbia River. The deeper basalts appear to be recharged from interbasin ground-water movement and vertical

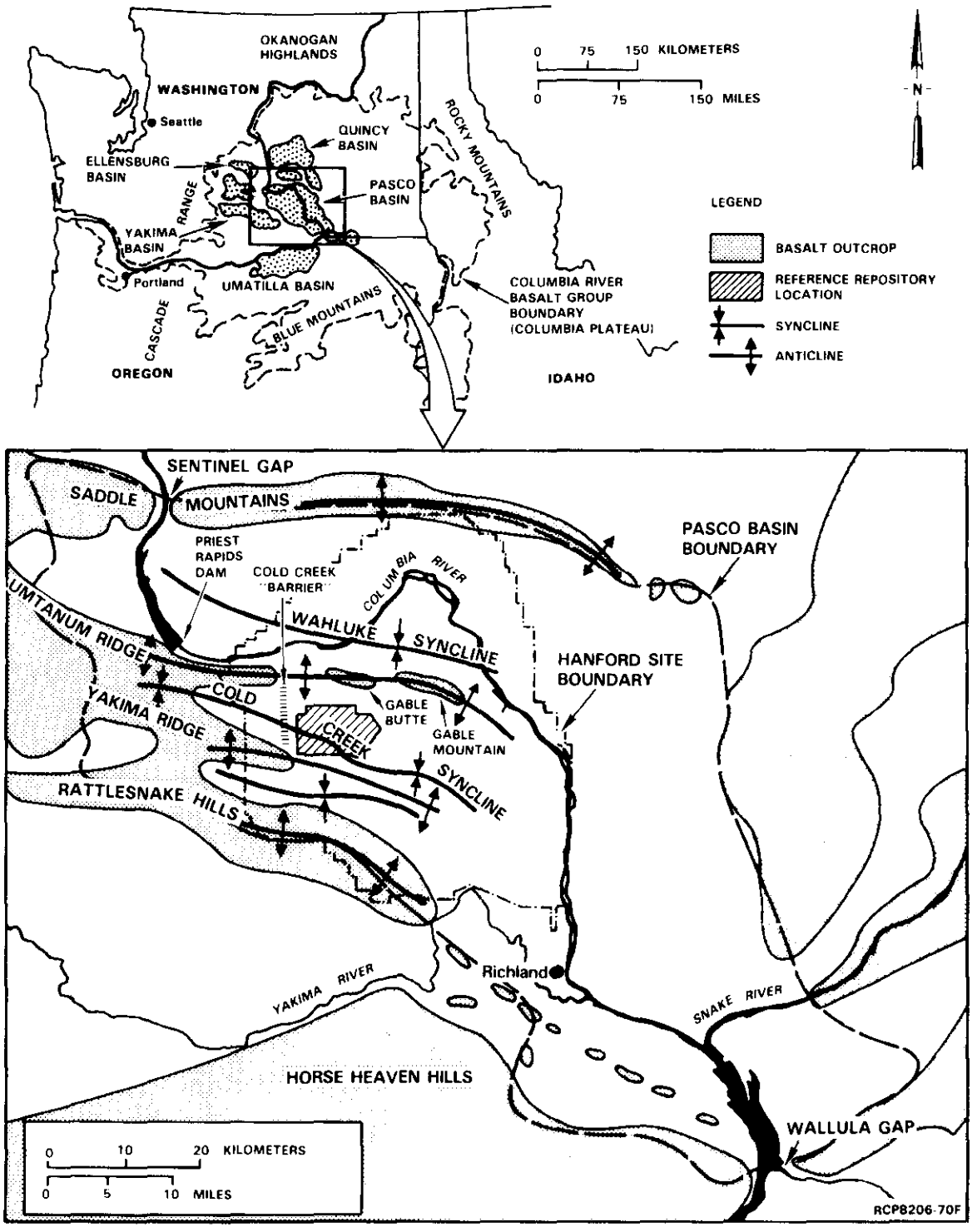

Figure 2. Reference repository location on the Hanford site, Washington.

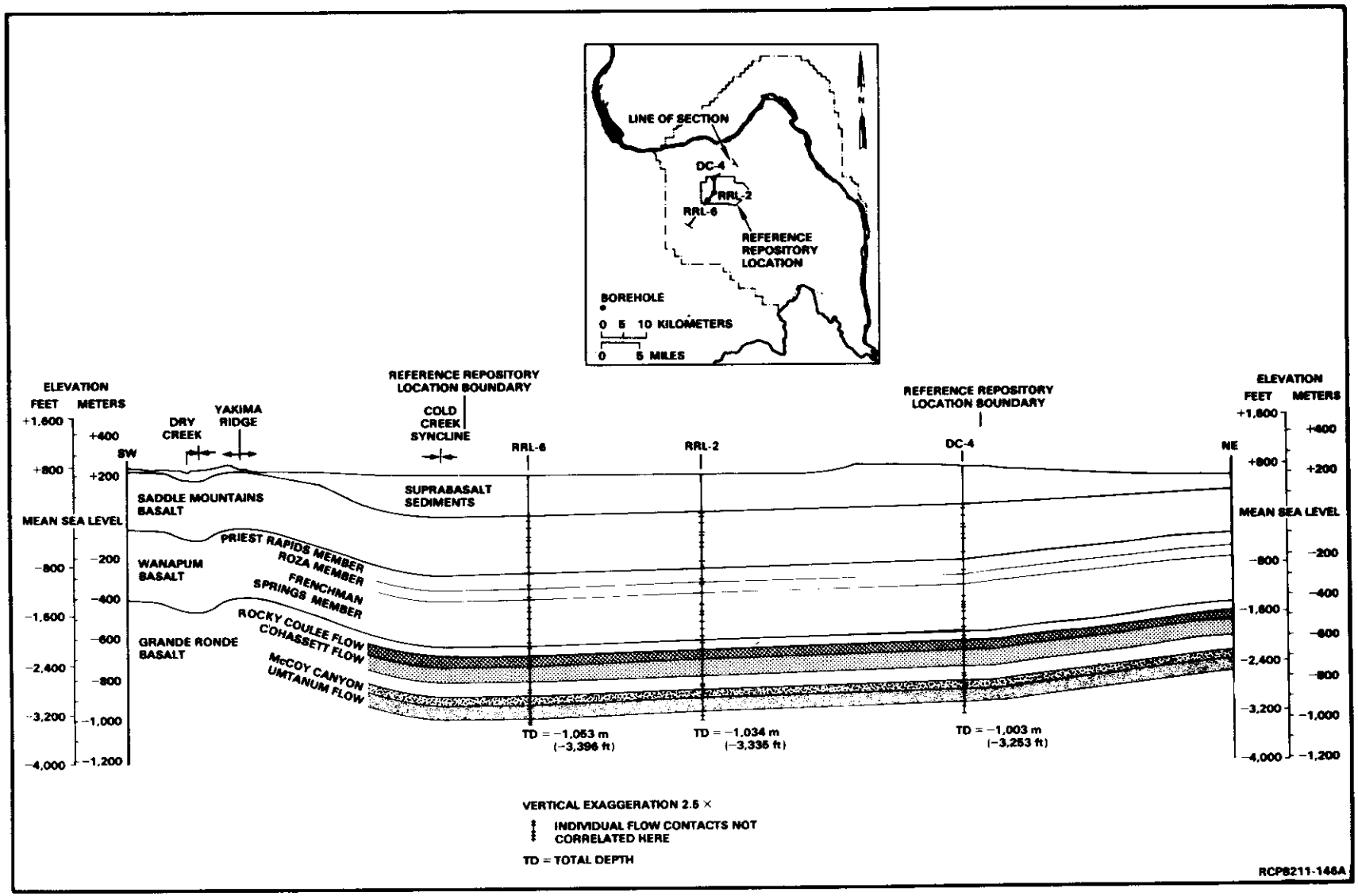

Figure 3. Geologic cross section of the reference repository location on the Hanford site.

leakage from the upper to the lower basalts. The location of ground-water discharge is not known; it has been speculated to be south of the Hanford Site.

No mining or exploration activities have occurred at the site since 1943, when the Federal Government assumed control of the area now known as the Hanford Site. Although exploration for natural gas is currently being conducted near the Hanford Site, the geologic conditions at the site are not expected to be favorable for the commercial production of natural gas, petroleum, or other mineral resources.

Atmospheric dispersion over the site is generally good, although periods of shallow mixing depths, low-level inversions, and light winds occur. Air quality in the vicinity of the site is generally good and in compliance with applicable air-quality standards. However, occasional dust storms produce high short-term concentrations of total suspended particulates.

The Columbia River system, several natural springs, and a number of ponds (both natural and manmade) and ditches comprise the aquatic environment of the Hanford Site. Manmade catchments at the Hanford Site support a variety of aquatic plants and animals that would not normally occur in this arid region.

No threatened or endangered animals or plants and no critical habitats are known to occur at the site. However, the bald eagle (an endangered species) and the peregrine falcon (a threatened species) have been sighted at the Hanford Site.

The area surrounding the Columbia River was the most densely inhabited region of aboriginal North America. At present, nine archaeological sites at the Hanford Site are listed in the National Register of Historic Places. The closest known archaeological site is 1.6 miles to the west of the site. Field surveys have not revealed any archaeological sites of national significance at the reference repository location. The natural aesthetic features in the area include the Columbia River, the Yakima and Snake Rivers, and nearby mountains and bluffs.

The areas most likely to experience socioeconomic effects from site characterization or repository development are Benton and Franklin Counties. These counties include the cities of Richland, Kennewick, and Pasco (the Tri-Cities); West Richland; Benton City; and several unincorporated towns. The 1982 population of these two counties was 143,941. While the socioeconomic study area was one of the fastest growing metropolitan areas in the country during the 1970s, its economic and population bases currently are declining, largely because the construction of the nuclear power plants of the Washington Public Power Supply System has ceased. As a result, this area has excess housing and public-service capacity. The DOE controls the railspur to the Hanford Site; this railspur ties in with the Union Pacific tracks southeast of Richland. Road access to the site is provided by State Route 240 and DOE roadways.

Unlike much of the land in southeastern Washington, the Hanford Site is not developed for agricultural use. The Hanford Site is institutionally controlled and has been restricted to projects directly associated with nuclear activities since 1943. The major nuclear facilities and activities occupy only about 6 percent of the total restricted land area at the site.

4. EFFECTS OF SITE CHARACTERIZATION

To obtain the information necessary for evaluating the suitability of the reference repository location at Hanford 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 45 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.

The land at the reference repository location has been dedicated to DOE activities and, consequently, there will be no land-use conflicts. Since there are no aquatic habitats at the selected site, no direct effects on aquatic ecosystems are expected. However, activities like drilling may be carried out near the Columbia River, and care will be taken to avoid affecting threatened and endangered species like the bald eagle.

Both adverse and beneficial effects may result from characterization activities at the site. The site tends to experience naturally generated fugitive dust, which leads to elevated levels of total suspended particulates. Site-characterization activities would aggravate this condition; site preparation and earth-moving activities could significantly increase the potential for dust emission from cleared areas. The actual level of total suspended particles will depend on a number of factors, including the amount of activity at the site, the size of the exposed surface area, soil characteristics, weather conditions, and the dust-suppression techniques being employed. Though dust-suppression techniques will be used, the environmental conditions are such that the site area could still experience higher than normal dust levels. However, it is expected that such emissions can be mitigated to acceptable levels, as has been demonstrated in the past by large-scale construction projects at the Hanford Site.

Some tall structures (e.g., the drilling rig for the exploratory shaft) and the night lighting used for site-characterization activities will be visible from Route 240. However, the structures will not be within the line of site of any scenic view or overlook, and the light is not expected to have a significant effect. Noise impacts are not expected to be significant due to the remoteness of the site from population centers.

The Hanford Site and surrounding area have an excellent transportation network that should be adequate for the requirements of site characterization.

Archaeological field surveys have not identified any potential archaeological resources at the site, nor are any known to exist. Site-characterization activities in other parts of the Hanford Site will avoid any known archaeological sites.

Examples of the types of mitigating measures that will be taken include locating and conducting site-characterization activities in a way that tends to minimize adverse environmental effects, employing equipment and engineering measures to reduce the adverse conditions created by site-characterization activities, and using appropriate control measures to minimize the adverse environmental effects of those conditions.

The clearing of site areas for exploration and testing has the potential for adverse effects on the terrestrial ecosystem through the loss of vegetation and wildlife habitat and through direct kills. Half the area needed for site characterization has already been cleared. The effects of clearing additional land can be mitigated, to some degree, by avoiding sensitive areas; the loss of habitat during site characterization is expected to be insignificant. After site restoration, if the reference repository location is not selected for development, the cleared areas can be allowed to revegetate.

The local economy may benefit from project expenditures during site characterization. Given the extent to which the local economy has developed for other large construction projects, it is likely that local firms will be able to provide many of the necessary materials and services and will benefit accordingly.

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 7 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, the underground repository would be backfilled, 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 may result from the development of a repository at the reference repository location. As in the case of site characterization, the most significant effects will be on air quality and the terrestrial ecosystem. In addition, adverse effects may result from transporting the waste to the repository.

It is expected that a repository would exert little, if any, effect on land use. Surface facilities would occupy a small area, and less than 3 miles of new roads would be needed. In addition, there would be no interference with security at the Hanford Site.

Repository development, especially site preparation and underground development and to some extent the decommissioning of surface facilities and the closure of the repository, could increase the potential for dust emissions and, consequently, increase the concentrations of total suspended particulates. Both wind erosion of cleared areas and mechanical activity would be responsible for these dust emissions. Just as in site characterization, dust-suppression techniques would be used, and it is expected that dust emissions can be controlled to acceptable levels. The expected levels of dust emissions and methods for their suppression will be evaluated during site characterization.

While surface facilities would be visible from Route 240, the structures could be comparable with those of other facilities already present at the Hanford Site. No significant visual effects are therefore expected.

Repository development also has the potential for affecting the terrestrial ecosystem at the site. The most significant effect would be the loss of vegetation and wildlife habitat from the 200 acres cleared for site development. Several plant and animal species are present and may be adversely affected. However, special measures can be taken to minimize effects, where appropriate. These include careful route selection for utility lines, the timing of construction activities, and the use of as many existing site facilities as possible. It is not expected that the presence of a repository would have any effect on the local aquatic ecosystems. Moreover, the evidence does not demonstrate that a repository would have an adverse effect on the fisheries in the Columbia River. Noise levels during the construction and, to a lesser extent, the operation of a repository at the site would be high. However, because of the remoteness of the site from human populations, the noise would not affect any members of the public. Several field studies produced no data indicating that the site contains cultural resources that would be affected by a repository.

The communities surrounding the Hanford Site should be able to absorb population changes without significant effects. Unexpected cutbacks in the job market and work stoppage in 1981 at two of the three of the nuclear power plants of the Washington Public Power Supply System left the area with excess capacities in community services and housing. If current conditions continue, this situation is expected to last into the 1990s. Repository construction and operations would generate approximately 1100 and 900 jobs, respectively, and thus strengthen the local economy. Much of the required work force would be available from the highly skilled labor force in the Tri-City area. Although some miners would have to be hired from outside the area, the likely employment opportunities in the short term and the for long-term economic potential of the project should exert a beneficial economic effect on the area.

Increases in local tax bases, especially for sales, use, business, and occupational taxes, as well as grants-in-lieu-of-taxes and financial assistance from the DOE to provide for additional community services are also expected to be beneficial to local public fiscal conditions.

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 reference repository location at Hanford is farther from the sources of waste than the other potentially acceptable sites, its 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 than for shipment by truck.

The radiological risks for the site 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 Washington has developed the capability to respond to waste-transportation accidents through its emergency plans and procedures.

On the local level, because major municipalities near the Hanford Site are geographically arranged in a linear pattern along existing transportation routes, traffic bottlenecks would have been expected. However, recent highway construction has alleviated this concern. Transportation to the site has some positive aspects. The access routes that would be constructed from the surface facilities of the repository to the local rail line or highway would not exceed 3 miles and would be economical to construct. Possible access routes are free of terrain-related hazards. Minimal upgrading would be required for the existing local system in connection with the regional transportation network.

There are no legal impediments in the State of Washington or in adjoining States that would prevent or impede waste transportation. There is also little likelihood that weather conditions will cause transportation to be disrupted on a seasonal basis.

6. EVALUATIONS OF SITE SUITABILITY

The DOE has evaluated the reference repository location 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 reference repository location at the Hanford Site that contribute to its ability to isolate the waste from the accessible environment include the time of ground-water travel to the accessible environment and a favorable geochemical environment.

Estimates of ground-water travel times from existing data yield a median value of approximately 80,000 years. Although there are many uncertainties in the travel-time calculations, there is no reason to believe on the basis of current information, that the ground-water travel time is not well in excess of 10,000 years. If credit were taken for ground-water travel through the dense interior of the host rock, then travel times to the accessible environment would be longer than the times calculated solely for travel in the basalt flow tops. There is also evidence that the reference repository location has chemically reducing conditions that will promote precipitation and will maintain radionuclides in their least mobile state. Moreover, clay minerals and zeolites in the rock and lining joints and fractures have a high sorption capability and will further retard the movement of radionuclides.

Other favorable attributes of the reference repository location include ownership of the land by the Federal Government and its control by the DOE, as well as the remoteness of the site from highly populated areas. Moreover, socioeconomic benefits to the area are expected from the development of a repository at the site.

Conditions that could adversely affect the ability of the geologic setting to isolate the waste are the fractured and jointed nature of basalt flows as well as the resulting complex geohydrologic system and potentially adverse rock characteristics. Ground-water systems in multilayered, fractured basalt are difficult to characterize and to model; the potential for vertical flow through them is unknown. In addition, the fractures in the basalt flows and the high in-situ stress beneath the reference repository location could result in the instability of excavated openings and the consequent requirement for extensive ground support.

Because methane gas may be present, the potential for human interference may influence the ability of the site's natural barriers to isolate waste. Methane gas has been found off the site in the sediments underlying the basalt flows, but these deposits are thought to be associated with traps in anticline structures. Because the site is located in a syncline, it is not thought to be a likely target of future exploration for methane. Thus, the potential for human interference appears to be low, but the issue will be studied further during site characterization.

In order to meet EPA standards for long-term waste isolation, the NRC requires that the engineered barriers at the site meet two performance objectives: the waste package must provide substantially complete containment of the waste for a minimum of 300 years, and the radionuclide-release rate beyond the period of containment must not exceed one part in 100,000 per year of the repository inventory at 1000 years after closure. The lifetime of waste packages at the reference repository location is estimated to exceed 6000 years. Moreover, the expected favorable geochemical conditions would enhance the control of releases from the engineered-barrier system. Preliminary assessments of engineered-barrier performance under realistic but conservative assumptions indicate that the EPA's limit on release rates to the accessible environment could be met at the reference repository location.

6.3 Summary of site evaluations against the preclosure guidelines

The evaluations of the reference repository location against the three groups of preclosure guidelines are summarized below.

6.3.1 Radiological safety

Preliminary assessments of preclosure performance for the reference repository location at Hanford do not indicate releases that would exceed any applicable radiation standards during repository operation and closure regardless of the mix of spent fuel, commercial high-level waste, or defense high-level waste. In addition, the site was evaluated against the following technical guidelines that are concerned with the radiological effects of

repository operation on public health and safety: population density and distribution, site ownership and control, the meteorological conditions of the site, and the effects of operations and accidents at nearby installations.

The reference repository location is 22 miles from Richland, the closest highly populated area. The closest Indian reservation, governed by the Yakima Indian Nation, is 31 miles away. The population density for the Hanford Site is 0.13 person per square mile. The meteorological conditions at the site are such that the atmospheric releases of radioactive material, should such releases occur, are not expected to be preferentially transported toward population centers. There are occurrences of high winds, dust storms, and severe temperatures, but these conditions can be accommodated through repository design. Finally, there are nearby nuclear facilities and other hazardous installations within 5 miles of the area proposed for the surface facilities at the repository. However, these installations will not present any conflict with repository operations that would result in radioactive releases exceeding allowable limits.

6.3.2 Environment, socioeconomics, and transportation

Three technical guidelines address the environmental, socioeconomic, and transportation effects of a repository before closure. These effects, which could 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 reference repository location is not likely to meet the qualifying conditions of protecting the public and the environment from the potential hazards associated with waste disposal.

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

The major conditions that affect the ease and cost of repository siting, construction, operation, and closure are the site's surface characteristics, rock characteristics, tectonic stability, and hydrologic conditions. Because the site is on level terrain, the construction of surface facilities would be relatively easy. The major potential difficulty lies in the rock characteristics: there is evidence of stratigraphic and structural discontinuities in the basalts (e.g., the faults and breccia zones). The possible existence of these features at the reference repository location, coupled with the high in-situ stress and the potential for inflows of ground water, could make construction difficult and expensive. Also, there is some risk of microearthquakes in the vicinity of the site as well as the possibility of rock bursts during repository development. It is expected that the configuration of the access tunnels can be designed to accommodate the expected stress conditions, but more than minimal support may be required for underground openings. Because there is no natural surface water at the site and because the drainage channels for the 100-year flood do not intersect this area, flooding of the surface facilities is not expected. Also, more than

sufficient water is available for construction. Each of these issues will be investigated further during site characterization.

These evaluations suggest that the repository can be constructed with reasonably available technology and that the cost would be comparable to the cost of constructing a repository at the other potentially acceptable sites.

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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