DOE/RW-0076

Nuclear Waste Policy Act
(Section 112)

Environmental Assessment
Overview

Reference Repository Location, Hanford Site, Washington

May 1986

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

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FOREWORD

The Nuclear Waste Policy Act of 1982 (the Act) established a process for the selection of sites for the disposal of spent nuclear fuel and high-level radioactive waste in geologic repositories. The first steps in this process were the identification of potentially acceptable sites and the development of general guidelines for siting repositories. In February 1983, the DOE identified nine sites in six States as potentially acceptable for the first repository. The Hanford site in Benton County, Washington, was identified as one of those sites. The general guidelines were issued in November 1984 as Title 10 of the Code of Federal Regulations, Part 960. The DOE is now proceeding with the next step in the site-selection process for the first repository: the nomination of at least five of the nine potentially acceptable sites as suitable for site characterization, which is a program of detailed studies.

The Act requires that site nomination be accompanied by an environmental assessment (EA). The DOE has prepared EAs for the nominated sites through a process that provided opportunity for public input. Public hearings were held during March, April, and May 1983 to obtain recommendations on the issues to be addressed in an EA. All such recommendations were considered in preparing the EAs. The DOE issued draft EAs for public review and comment in December 1984 and conducted a series of public hearings in February and March 1985. The issues raised in the comment letters and hearings were considered in preparing the final EAs. These issues are addressed in a comment-response document appended to the final EAs (Appendix C).

The information presented in the EAs is derived from hundreds of technical reports containing more-detailed data and analyses. All of these reference documents are available to the public in various libraries and reading rooms; a listing of their locations is given in Appendix B.

After the nomination, the Secretary is required by the Act to recommend to the President not fewer than three of the nominated sites for characterization as candidate sites for the first repository. This recommendation will be submitted and documented in a separate report that is being issued separately from this environmental assessment. After submittal, the Act provides the President 60 days to approve or disapprove the candidate sites. The President may delay his decision for up to six months if he determines that the information supplied with the recommendation of the Secretary is insufficient to permit a decision within the 60-day period. If the President does not approve, disapprove, or delay the decision, the candidate sites shall be considered approved. After the President approves the candidate sites, the DOE will start site characterization.

ABSTRACT

In February 1983, the U.S. Department of Energy (DOE) identified a reference repository location at the Hanford Site in Washington as one of the nine potentially acceptable sites for a mined geologic repository for spent nuclear fuel and high-level radioactive waste. The site is in the Columbia Plateau, which is one of five distinct geohydrologic settings considered for the first repository. To determine their suitability, 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 the Nuclear Waste Repositories. These evaluations were reported in draft environmental assessments (EAs), which were issued for public review and comment. After considering the comments received on the draft EAs, the DOE prepared the final EAs.

On the basis of the evaluations reported in this EA, the DOE has found that the Hanford 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 nominating the Hanford site as one of five sites suitable for 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 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 2,000 acres at a depth between 1,000 and 4,000 feet. To handle the waste received for disposal, surface facilities will be developed which will occupy about 400 acres. The repository will be operational 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 together to contain and isolate the waste as required by regulations. The natural barriers include 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 waste disposal container, and materials placed over and around the containers. 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 to impede the subsequent transport of radionuclides into 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 (welded 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 not fewer than three of those sites for characterization as candidate sites for the first repository. After site characterization is complete, one of the characterized sites will be recommended for development as a repository.

The Act also requires the DOE to prepare environmental assessments (EAs) 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 the proposed 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 EA for Hanford. Section 2 of this overview presents a summary of the decision process and findings leading to the nomination of the Hanford site. Sections 3 through 7 summarize the results of evaluations contained in corresponding chapters in the EA.

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 against 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 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 for the five nominated sites, the DOE has considered all comments that were received.

With the issuance of the final EAs, 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, and (or) an Indian Tribe on whose reservation the proposed repository would be located, may issue a notice of disapproval that can be overridden only by a joint resolution of both Houses of the U.S. 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 is effective, and the DOE will 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 is 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 Chapter 2 of the EA.

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, 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 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 the Hanford Site is suitable for characterization.

2.2.6 PRELIMINARY DECISION ON NOMINATION

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

3 THE SITE

The reference repository location is in the west-central part of the DOE-controlled Hanford Site in south-central Washington (Fig. 2). The reference repository location lies within the Pasco Basin, a 4,850-square-kilometer (1,900-square-mile) topographic depression in the Columbia Plateau and, more specifically, in the central part of the Cold Creek syncline. This location was chosen partly because the basalt flows there are nearly flat lying and should be structurally less disturbed than other areas at the Hanford Site (Fig. 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 lavas.

The Columbia Plateau is underlain by a thick sequence of strata deposited many millions of years ago in Miocene time. The lower strata consist entirely of basalt-lava flows and the upper strata include increasing amounts of interbedded sedimentary deposits. Semiconsolidated sediments overlie the basalt sequence and attain thicknesses of as much as 525 meters (1,200 feet). Approximately 50 basalt flows, with a total thickness of perhaps 5,000 meters (16,000 feet), have been identified within the Pasco Basin. One of these basalt flows, the Cohassett flow, has been identified as the candidate horizon for the repository. Structures at the Hanford Site consist of long, narrow anticlines and broad synclines (trough-like folds) that roughly trend east-west. Faults associated with anticlinal fold axes probably developed concurrently with folding.

Ground water occurs at the reference repository location in an unconfined aquifer and in numerous confined aquifers. The unconfined aquifer is in the sediments that lie above the sequence of basalt flows. Confined aquifers occur at greater depths, within the sequence of basalt flows. There are three potential pathways for ground-water movement in the basalt sequence: (1) The more permeable contact zones between basalt flows and in the sedimentary interbeds, (2) the structural discontinuities (e.g., faults or fracture zones) that may cross-cut the basalt flows, and (3) the 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 leakage from the upper to the lower basalts. The location of ground-water discharge is not known; it has been suggested to be south of the Hanford Site.

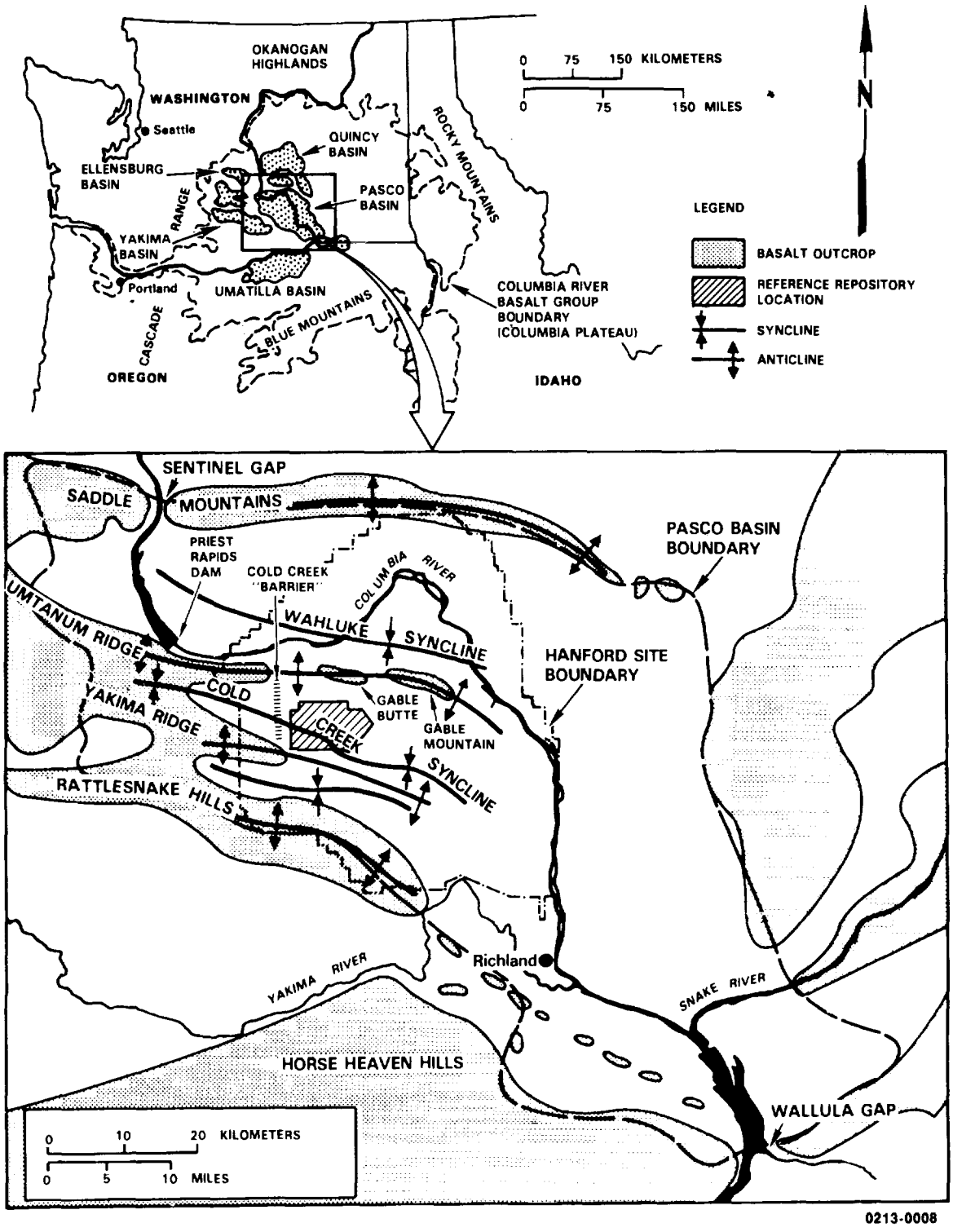

Figure 2. Reference repository location on the Hanford site, Washington.

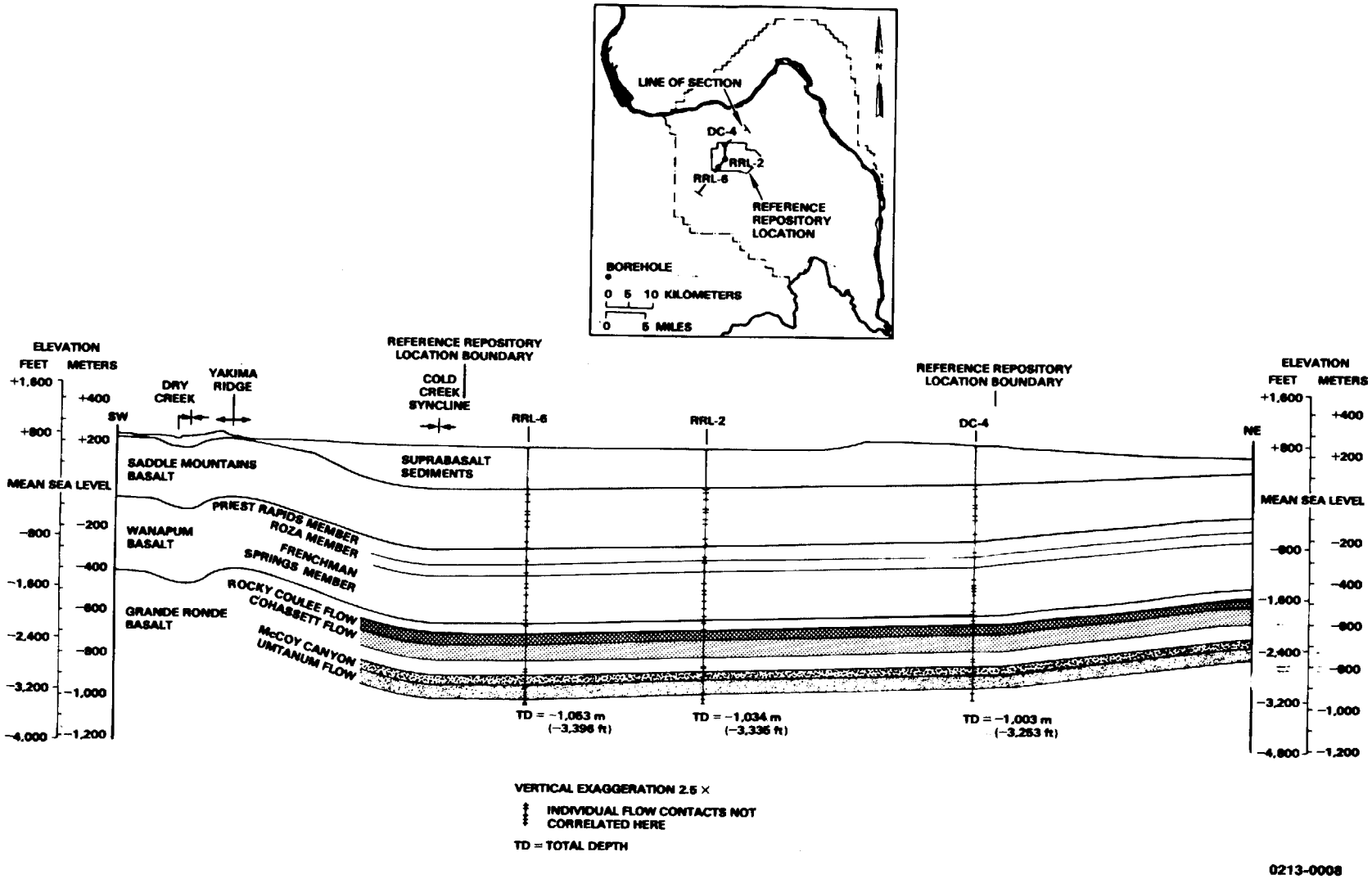

Figure 3. Geologic cross section of the reference repository location on the Hanford site.

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 do occur. Air quality in the vicinity of the site is generally good and in compliance with applicable air-quality standards. Occasional dust storms produce high short-term concentrations of total suspended particulates.

The Columbia River system, several natural springs, and a number of ponds (natural and manmade) and ditches comprise the aquatic environment of the Hanford Site. No naturally occurring surface waters, however, are on the reference repository location. Manmade catchments on 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 are known to reside or grow and no critical habitats are known to exist at the reference repository location. However, the bald eagle (an endangered species) and the peregrine falcon (a threatened species) reside on other parts of the Hanford Site.

The area surrounding the Columbia River was a 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 2.5 kilometers (1.6 miles) to the west of the reference repository location. 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, 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, and Benton City, Washington, and several unincorporated towns. The 1984 population of these two counties was 138,840. While the socioeconomic study area was one of the fastest growing metropolitan areas in the country during the 1970's, its economic and population bases currently are declining, largely because construction activities at the nuclear powerplants of the Washington Public Power Supply System have ceased. As a result, this area has excess housing and public-service capacity. The U.S. Department of Energy controls the rail spur to the Hanford Site; this rail spur ties in with the Union Pacific tracks southeast of Richland, Washington. Road access to the reference repository location is provided by Route 240 and DOE roadways. Barge access to the Hanford Site is provided through the Port of Benton in north Richland, Washington.

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 Hanford 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, excavate drifts at the proposed repository depth, and construct support facilities 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 requires the clearing of 18 hectares (46 acres) of land of which 8 hectares (20 acres) have already been cleared and stabilized.

At the same time, the DOE will study the environment of the reference repository location and its vicinity, including weather conditions, air quality, noise, plant and animal communities, and archaeological and cultural resources. Socioeconomic conditions will also be further 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 reference repository location is found unsuitable for a repository, the shafts will be filled and sealed, and the surface facilities will be removed.

The land at the reference repository location has been dedicated to the DOE or related nuclear activities, and, consequently, land-use conflicts are not expected. Since there are no natural aquatic habitats at the selected site, no direct effects on natural aquatic ecosystems are expected. However, some small-diameter borehole drilling may be carried out near the Columbia River, and care will be taken to avoid affecting threatened species (the peregrine falcon) and endangered species (the bald eagle). While the impacts of noise on the local wildlife may be adverse, the effects on the local human population will be minor because of the remoteness of any human habitations.

Adverse and beneficial effects may result from characterization activities at the Hanford Site. The Hanford Site tends to experience naturally generated fugitive dust, which leads to elevated levels of total suspended particulates. Site-characterization activities would aggravate this condition, since site-preparation and earth-moving activities could significantly increase the potential for dust generation from cleared areas. The actual level of total suspended particulates will depend on a number of factors, including the amount of activity at the site, size of the exposed surface area, soil characteristics, weather conditions, and dust-suppression techniques employed. Although dust-suppression techniques will be used, the

environmental conditions are such that higher than normal dust levels could still occur. However, it is expected that fugitive dust 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 drill rig for the exploratory shafts) 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 sight of any scenic view or overlook, and the light is not expected to have a significant effect.

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

Archaeological field surveys have not identified any potential archaeological resources at the reference repository location, nor is any known to exist. Site-characterization activities at 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 impacts, 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 impacts of those activities.

The clearing of areas for exploration and testing has the potential for adverse impacts on the terrestrial ecosystem through the loss of vegetation and wildlife habitat and through direct kills. Approximately half the area needed for site characterization has already been cleared and stabilized. 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 is expected to benefit from projected 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 support facilities, construct access shafts, excavate and prepare underground drifts 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 while the surface and underground facilities are completed. After construction is completed, the rate of waste receipt would increase to a maximum of 3,000 metric tons (3,300 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 U.S. Nuclear Regulatory Commission 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, surface facilities would be decontaminated and decommissioned, and permanent markers or monuments would be erected at the site to warn future generations of the underground repository.

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.

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 5 kilometers (3 miles) of new roads would be needed. In addition, there would be no interference with security measures at the Hanford Site.

Repository development, especially site preparation and underground development and to some extent the decommissioning of surface facilities and closure of the repository, could increase the potential for dust generation and, consequently, increase the concentrations of total suspended particulates. Wind erosion of cleared areas and mechanical activity would be responsible for fugitive dust. 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 specific methods for their suppression will be evaluated during site characterization.

While surface facilities would be visible from Route 240, the structures would be comparable with those of other facilities already present at the Hanford Site. Therefore, no significant visual effects are 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 80 hectares (200 acres) cleared for facility development. Several plant and animal species are present and may be adversely affected. However, special measures can be taken to minimize impacts, where appropriate. These include careful route selection for utility lines, timing of construction activities, and use of as many existing facilities as possible. It is not expected that the presence of a repository would have any effect on the local manmade 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 elevated locally. However, because of the remoteness of the site from human habitations, the noise would not affect any members of the public. Several field surveys have produced no indications that the reference repository location contains cultural resources that could be impacted by a repository.

The communities surrounding the Hanford Site should be able to absorb population changes without significant impacts. Unexpected cutbacks in the job market and work stoppage in 1981 at two of the three nuclear powerplants of the Washington Public Power Supply System resulted in excess capacities in community services and housing. If current conditions continue, this situation is expected to last into the 1990's. Repository construction and operation would generate approximately 1,100 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-Cities area. Although some miners would have to be hired from outside the area, the likely employment opportunities in the short term and for the 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, and business and occupation taxes, as well as grants-equal-to-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 which could result from possible radioactive material releases due to transportation accidents, and nonradiological risks. The latter are the nonradiological consequences of 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 the Hanford Site is farther from the sources of waste than the other potentially acceptable sites, its nonradiological risks are likely to be higher than the other sites. 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 rail.

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 problem. Transportation to the repository facilities from existing roadways would be relatively simple. The access routes that would be constructed from the surface facilities of the repository to the local rail line or highway would be less than 5 kilometers (3 miles)

long 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, and closure and decommissioning). The postclosure and the preclosure guidelines contain 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 Environmental Protection Agency (EPA) and the Nuclear Regulatory commission (NRC).

The set of preclosure guidelines is divided into three groups: (1) Preclosure radiological safety; (2) environment, socioeconomics, and transportation; and (3) 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 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 the flow top above the Cohassett flow interior to the accessible environment yield a median value of slightly greater than 70,000 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 Cohassett flow interior, then travel times to the accessible environment would be significantly longer than the times calculated solely for travel in the basalt flow tops. There are also strong indications 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 itself and lining joints and fractures have a high sorptive capacity 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 reference repository location from highly populated areas. Moreover, socioeconomic benefits to the area would be 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. Ground-water systems in multilayered, fractured basalt are difficult to characterize and to model; the potential for vertical flow through them is currently 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 that would require ground support.

Because methane gas may be commercially 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 Hanford Site in the sediments underlying the basalt flows, but these deposits are thought to be associated with traps in anticlinal 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.

To meet EPA standards for long-term waste isolation, the NRC requires that the engineered barriers at the site meet two performance objectives: (1) The waste package must provide substantially complete containment of the waste for a minimum of 300 years and (2) the radionuclide-release rate beyond the period of containment must not exceed one part in 100,000 per year of the repository inventory at 1,000 years after closure. The lifetime of waste packages at the reference repository location is estimated to be between 4,500 and 8,500 years. Moreover, the expected favorable geochemical

conditions would further control releases from the engineered barrier system. Preliminary assessments of engineered barrier performance under realistic but conservative assumptions indicate that the EPA limit for 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 the Hanford Site 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, meteorological conditions of the site, and effects of operations and accidents at nearby installations.

The reference repository location is 24 kilometers (15 miles) from Sunnyside, Washington, the closest highly populated area. The closest Indian reservation, governed by the Yakima Indian Nation, is 50 kilometers (30 miles) away. The population density for the Hanford Site is 0.34 person per square kilometer (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 exceed exposure limits to the general public. 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 potentially hazardous installations within 8 kilometers (5 miles) of the area proposed for the surface facilities at the repository. However, these installations are not expected to present any conflict with repository operations or 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 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., 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. It is expected that the configuration of the access tunnels can be designed to accommodate the expected stress conditions, but some support will be required for underground openings. Because there is no natural surface water at the reference repository location and because the drainage channels for the 100-year flood do not intersect this area, flooding of the surface facilities during repository operations is not expected. Repository facilities would be designed to minimize any impacts that might result from the probable maximum flood. 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 NOMINATED SITES

7.1 INTRODUCTION

7.1.1 PURPOSE AND REQUIREMENTS

Chapter 7 presents a comparative evaluation of the five sites nominated as suitable for site characterization in order to satisfy the following:

1. Section 112(b)(1)(E)(iv) of the Nuclear Waste Policy Act of 1982, which requires that a "reasonable comparative evaluation" be included in the environmental assessments that accompany site nomination.

2. Section 960.3-2-2-3 of the DOE's siting guidelines (10 CFR Part 960), which requires that a reasonable comparative evaluation be made and that a summary of evaluations with respect to the qualifying condition for each guideline be provided to "allow comparisons to be made among sites on the basis of each guideline."

The evaluation in Chapter 7 is intended to allow the reader to compare the more detailed suitability evaluations of the individual sites that are presented in Chapter 6 of each environmental assessment. The comparison should assist the reader in understanding the basis for the nomination of five sites as suitable for characterization; it is not intended to directly support the subsequent recommendation of three sites for characterization as candidate sites.

7.1.2 APPROACH AND ORGANIZATION

This comparative evaluation of the five nominated sites is based on the postclosure and preclosure guidelines (10 CFR Part 960, Subparts B and C, respectively). The approach used to compare the sites with respect to each system and technical guideline is summarized below.

7.1.2.1 Technical guidelines

Major considerations that could be used to compare the sites on the basis of the qualifying condition of each technical guideline were derived by identifying the favorable, potentially adverse, and disqualifying conditions that deal with the same general topic. Contributing factors that represent the characteristics of the site that are potentially important in evaluating the sites with respect to each major consideration were also identified. The relative importance of the major considerations was determined primarily by the degree to which they contribute to the qualifying condition; that is, the stronger the tie between the consideration and the qualifying condition, the greater the importance of the consideration.

The purpose of identifying major considerations for each guidelines is to combine closely related site conditions so that the balance of the favorable and potentially adverse conditions can be considered directly. Most guidelines that contain a disqualifying condition also have one or more potentially adverse conditions that relate to the disqualifying condition. Since these potentially adverse conditions are considered in the formulation of a major consideration, the important aspects of the disqualifying conditions indirectly enter the comparative evaluation. Where a major consideration that is needed to evaluate the qualifying condition does not have a related favorable or potentially adverse condition, the consideration is derived directly from the qualifying or disqualifying condition.

7.1.2.2 System guidelines

The comparison of sites on the basis of the individual technical guidelines uses the major considerations to incorporate the favorable and potentially adverse conditions in an evaluation of a site's standing on the qualifying conditions for each technical guideline. It is not appropriate, however, to use this approach for a comparative evaluation of sites on the basis of the system guidelines. The qualifying conditions for the system guidelines do not lend themselves to the identification of major considerations in the way that the qualifying conditions for the technical guidelines do. The system guidelines for postclosure repository performance and preclosure radiological safety are stated in terms of regulatory requirements of the NRC and the EPA. The evaluations of these two system guidelines are based on preliminary performance assessments. These evaluations are summarized directly in Chapter 7 from Sections 6.3.2 and 6.2.2.1 of each environmental assessment.

The system guidelines for environmental quality, socioeconomics, and transportation, and for the ease and cost of repository construction, operation, and closure are not stated as regulatory standards, and they cannot be evaluated by a performance assessment as are the other two system guidelines. Instead, they are evaluated by considering the individual guidelines that make up these two system guidelines collectively to determine whether each site meets the qualifying condition of the relevant system guidelines. The evaluation of these system guidelines is summarized in Chapter 7 from information contained or referenced in Sections 6.2.2.2 and 6.3.4 in each environmental assessment.

This overview summarizes the major considerations and contributing factors for each technical guideline. It does not discuss the comparative evaluations of sites in Chapter 7; these comparisons are already a summary of information in Chapter 6 of each environmental assessment, and the DOE believes that a further synopsis of the evaluation in Chapter 7 for the purpose of this overview would distort the information and possibly mislead the reader. For the systems guidelines, this overview summarizes (1) the conclusions of the performance assessments for postclosure repository performance and preclosure radiological safety, and (2) the conclusion on the qualifying condition for environmental quality, socioeconomics, and transportation, and the ease and cost of constructing, operating, and closing the repository. For a discussion of the initial order of preference of sites, the reader is referred to the separate report on the multiattribute utility analysis of the nominated sites.

7.2 COMPARISON OF THE SITES ON THE BASIS OF THE POSTCLOSURE GUIDELINES

The postclosure guidelines are concerned with the characteristics, processes, and events that may affect the performance of the repository after closure. Their objective is to ensure that the health and safety of the public will be protected for thousands of years, until the radioactivity of the waste has diminished to safe levels.

7.2.1 TECHNICAL GUIDELINES

7.2.1.1 Geohydrology

Four major considerations are identified that influence the favorability of the sites with respect to the qualifying condition for the geohydrology guideline. The first consideration, ground-water travel time and flux, addresses geohydrologic conditions that control ground-water travel time between the disturbed zone and the accessible environment, and ground-water flux (volumetric flow rate) across or through the repository and through the host rock to the accessible environment. This is the most important major consideration because transport by ground water is the primary control of radionuclide movement from the repository to the accessible environment. At each of the sites there are uncertainties in the conceptual ground-water flow model and in the values of key hydraulic parameters that control ground-water travel time and flux. Taking these uncertainties into account, there are ranges of possible travel times between the disturbed zone and accessible environment at each site. Therefore, ground-water travel time was stochastically modeled at each site, using reasonably conservative assumptions about the geohydrologic system and ranges of hydraulic parameters. In general, ground-water flux is expected to be low to very low at each of the nominated sites.

The second consideration, changes in geohydrologic processes and conditions, addresses potential changes in natural processes in the geologic setting that could change geohydrologic conditions so as to affect the ability of a repository to isolate the waste. The DOE has concluded that climatic change is the only factor that has a likely potential for significantly affecting the hydrologic system at any of the nominated sites during the next 100,000 years. Therefore, climatic change is the only potential cause of change to the geohydrologic system that is addressed in the evaluations of individual sites.

The third consideration is ease of characterizing and modeling the geohydrologic system. Since it is not an intrinsic physical characteristic of the geohydrologic setting, this consideration is not as important as the first two considerations. Some of the contributing factors that influence the ease of characterization and modeling are the presence of faults, folds, and brine pockets, dissolution effects, lithologic variations, interrelationships among hydrostratigraphic units, availability of testing techniques and analytic models, and understanding of flow mechanisms.

The last consideration, presence of suitable ground-water sources, addresses the possibility that radionuclides migrating from a repository could mix with ground-water sources suitable for crop irrigation or human consumption without treatment along flow paths to the accessible environment. This consideration is less important than the other three, because it is unlikely that ground-water resources could be contaminated if a site is selected on the basis of its ability to isolate wastes, as reflected in the other three considerations.

7.2.1.2 Geochemistry

Three major considerations are identified that influence the favorability of the sites with respect to the qualifying condition for the geochemistry guideline. The first consideration, mass transfer of radionuclides, includes geochemical conditions within the immediate vicinity of the waste package after permanent closure of the repository. The mass transfer of radionuclides is the most important consideration because it describes the processes by which radionuclides that are initially sealed in the waste package as part of the solid waste form will be released to the ground-water system or be contained within the engineered-barrier system. The most important contributing factors include the volumetric flow rate of ground water near (within a few meters) the waste package and the chemistry of the ground water.

The second consideration, radionuclide transport, addresses geochemical conditions outside the immediate vicinity of the waste package after the permanent closure of the repository. Radionuclide transport near the waste package is considered to be slightly less important than the first major condition because geochemical conditions that influence transport may act as a secondary barrier to radionuclides escaping from the engineered barrier system. The contributing factors that are the most important for the quantitative evaluation of this consideration include the potential for sorption and precipitation, and redox conditions.

The last consideration addresses geochemical processes that could adversely affect the sorptive capacity or strength of the host rock, or both. This is the least important consideration under the geochemistry guideline because mineral alteration and changes in rock strength in the vicinity of the waste-package would affect only a small percentage of the total rock mass surrounding the repository. The major contributing factors for this consideration are the stability of mineral assemblage and effects of changes in the structure of minerals on sorption and rock strength.

7.2.1.3 Rock characteristics (postclosure)

Three major considerations are identified that influence the favorability of the sites with respect to the qualifying condition for rock characteristics guideline. The first consideration is the impact on waste isolation of repository-induced heat. The contributing factors for this condition are thermal properties of the host rock such as its ability to conduct heat or expand in response to heat; mechanical properties such as ductility; thermomechanical behavior such as the potential for thermally induced fractures; and geochemical factors such as the potential for brine migration, hydration, or dehydration of the mineral components. The impact of repository-induced heat is the most important of the three major considerations because it has the greatest potential for affecting waste isolation.

The complexity of engineering measures is the second major consideration. It addresses in situ characteristics and conditions that could require engineering measures beyond reasonably available technology to ensure waste containment and isolation. The major contributing factors to this consideration are the uncertainty in the integrity of man-made sealing materials during the postclosure period and the effects of the in situ environment on the performance of engineered-barriers (such as the effects of brine on the waste-disposal container). Complexity of engineering methods is considered less important than repository-induced heat effects because of the greater potential of repository-induced heat to impair the isolation capabilities of the site.

The last consideration for this guideline is whether the host rock is large enough to allow flexibility in determining the depth, configuration, and location of the underground facility. Added flexibility in locating the repository will help avoid geologic features or anomalies that could adversely affect the isolation capabilities of the site. Even after requirements for preclosure host-rock flexibility have been satisfied, added flexibility is still necessary to satisfy this postclosure consideration in terms of depth of excavations, orientations of drifts and where they intersect, and location of seals. A greater volume of host rock could provide isolation capability over and above the degree deemed minimally acceptable. However, the contribution to waste isolation added flexibility in locating the underground facility is less than that of the other two considerations for this guideline.

7.2.1.4 Climatic changes

One major consideration, the effects of climatic changes in the future on the ability of the site to isolate waste, is identified that influences the favorability of the sites with respect to the qualifying condition for the climatic changes guideline. The major contributing factors to this consideration are climatic cycles during the Quaternary Period and in situ conditions at a site.

7.2.1.5 Erosion

The single major consideration under this guideline is the potential effects of erosion on the ability of the repository to isolate wastes. Contributing factors include the depth of waste emplacement, evidence of extreme erosion during the Quaternary Period, the potential for the waste to be exhumed by erosion, and the assessment of future erosion rates and geomorphic processes.

7.2.1.6 Dissolution

The single major consideration for this guideline is evidence of dissolution of the host rock during the Quaternary Period. The contributing factors for this consideration include the solubility of the host rock under nonextreme geologic and hydrologic conditions, and unusual ground-water chemistry.

7.2.1.7 Tectonics (postclosure)

The single major consideration for this guideline is the potential for increased igneous and tectonic activity during next 10,000 years and the effect that these processes have on radionuclide releases. The contributing factors include evidence of tectonic or igneous activity during the Quaternary Period, the likelihood of tectonic and igneous events during the next 10,000 years that could alter the regional ground-water flow system, the historical record of seismicity, the correlation of earthquakes with tectonic features, and evidence of tectonic activity during the Quaternary Period.

7.2.1.8 Human interference

The potential for human interference after the repository is closed and decommissioned requires an analysis of (1) the natural resources at or near a site, including past, current, and future exploration for and uses of these resources and (2) site ownership and control.

7.2.1.8.1 Natural resources

Three major considerations are identified that influence the favorability of the sites with respect to the qualifying condition for the natural resources guideline. Although the major considerations are listed in decreasing order of importance, there are relatively small differences in importance, particularly between the second and third considerations.

The first consideration is evidence of subsurface mining, resource extraction, and drilling at the site. It assesses the impacts on the isolation and containment system from existing mines and drill holes within the site.

The second consideration is the potential for foreseeable human activities that could affect the ability of the site to contain and isolate wastes. Contributing factors include the potential for ground-water withdrawal, irrigation, injection of fluids, underground pumped storage, and large-scale surface-water impoundments. This consideration is not as important as the first major consideration because the first consideration is based on existing evidence of resources, while the second is based on projected, more speculative human activities. In evaluating this major consideration the environmental assessments have qualitatively considered the effectiveness of markers and records in reducing the potential for of human intrusion in the controlled area.

The last major consideration, potential for intrusion to extract resources after the repository is closed. Contributing factors include the presence or indications of resources (including water) at the site, their value, scarcity, and depth, and whether they are available from other sources. This consideration is third in importance because the potential for resources is based on speculative or indirect evidence.

7.2.1.8.2 Site ownership and control

The purpose of the postclosure guideline on site ownership and control is to help ensure that the repository can function far into the future without adverse human interference. This guideline specifies that the DOE, in accordance with the requirements of 10 CFR Part 60, must obtain ownership of surface and subsurface rights to land and minerals within the controlled area of the repository. A similar guideline on site ownership is also provided for the preclosure period. The DOE has determined that the necessary land area and controls are the same for both the postclosure and preclosure periods at the five nominated sites. Whichever site is selected, the DOE must obtain ownership and surface and subsurface rights before beginning construction; there is no basis for distinguishing among the sites on the basis of their site ownership and control status at the beginning of the postclosure period.

7.2.2 POSTCLOSURE SYSTEM GUIDELINE

The results of preliminary system-performance assessments are described in Section 6.4.2 of each environmental assessment and briefly reviewed here. These preliminary assessments are based on limited geologic, hydrologic, and geochemical information, preliminary conceptual models, and relatively simple analytical techniques. The DOE is therefore not yet prepared to provide assurance that the regulatory criteria will be met at any of the sites. These preliminary assessments do, however, appear adequate to evaluate the sites in terms of the postclosure system guideline.

The guideline addresses the following capabilities of the geologic setting at a site:

1. The capability of the geologic setting at the site to allow for the physical separation of the waste from the accessible environment after closure in accordance with the requirements of the EPA standard in 40 CFR Part 191, Subpart B, as implemented by the NRC rule in 10 CFR Part 60.

2. The capability of the geologic setting at the site to allow for the use of engineered barriers to ensure compliance with the requirements of the EPA and the NRC. Two requirements are pertinent here: (1) the time of substantially complete containment (i.e., a period between 300 and 1,000 years); and (2) the limit on the rate of radionuclide releases from the engineered-barrier system (i.e., one part in 100,000 per year of the individual radionuclide inventory or one part in 100,000 per year of the total inventory calculated to be present at 1,000 years after repository closure, whichever is greater).

With regard to the capability of the geologic setting to separate the waste from the accessible environment, the results of the preliminary assessments do not exceed the EPA standard at any of the sites. For example, the mean ground-water travel time from the repository to the accessible environment is expected to be much longer than 10,000 years at all five nominated sites.

Because of the different characteristics of the sites, different approaches to the performance assessments and different levels of conservatism have been used for each site. Since site-specific data is limited prior to characterization, the degree of conservatism resulting from such assumptions in each case is not currently known. Nonetheless, the degree of conservatism is believed to be sufficient to establish outside bounds on actual site performance. The preliminary performance assessments do not provide any reason to believe that any of the sites would not adequately isolate the waste from the accessible environment.

With regard to the requirements for the performance of the engineered-barrier system, the preliminary assessments indicate that the system would meet the regulatory performance objectives at all sites. For example, analyses of the waste-package performance indicate that the container lifetime is expected to exceed the 300- to 1,000-year requirement for substantially complete containment at each site. For each site, the calculations of the rate of radionuclide release after the failure of the waste package suggest that the criterion for the rate of release from the engineered-barrier system would not be exceeded. Extremely conservative assumptions have been used to make these estimates. Again, the degree of conservatism provided by these assumptions is not presently known. However, the DOE is confident that the use of conservative assumptions establishes outside bounds on actual performance of the waste package, and the analyses appear to be sufficient to indicate that there is no evidence that the criteria for the performance of the waste-package and engineered-barrier systems would not be met at each of the nominated sites. Furthermore, the available data and the preliminary analyses based on these data have not identified any conditions or features at any of the sites that would prevent these engineered components from meeting the performance requirements.

7.3 COMPARISON OF SITES ON THE BASIS OF PRECLOSURE GUIDELINES

The preclosure guidelines address (1) preclosure radiological safety; (2) the environmental, socioeconomic, and transportation-related impacts associated with repository siting, construction, operation, and closure; and (3) the ease and cost of repository siting, construction, operation, and closure. Both technical and system guidelines are provided for each of these three categories.

7.3.1 PRECLOSURE RADIOLOGICAL SAFETY

7.3.1.1 Technical guidelines

There are four technical guidelines that contribute to the assessment of preclosure radiological safety: (1) population density and distribution, (2) site ownership and control, (3) meteorology, and (4) offsite installations and operations. The objective of these guidelines is to protect the health and safety of the public and the workers at the repository by keeping exposures to radiation within the limits prescribed by regulations.

7.3.1.1.1 Population density and distribution

Two major considerations are identified that influence the favorability of the sites with respect to the qualifying condition for the population density and distribution guideline. The first major consideration is the remoteness of a site as measured by the site's distance from highly populated areas of 2,500 people or more, or from a one mile by one mile (2.6 square kilometers) area that contains 1,000 or more individuals. The contributing factors for this consideration are the air distance of the site from population concentrations and the size of those concentrations.

The second major consideration, population density, is evaluated for each site on the basis of density within the projected site boundaries, near the site (within a radius of 10 miles), and in the general region of the site (within a radius of 50 miles). In the evaluation of this major consideration, a "low population density" is defined as being less than the average population density of the contiguous United States in 1980, or 76 persons per square mile.

7.3.1.1.2 Site ownership and control

The single major consideration for this guideline is the complexity of procedures for acquiring land needed for the repository. The DOE has evaluated this guideline on the basis of what property would be required for repository construction, operation, closure, and decommissioning. Land acquisition procedures, such as leasing, that might be employed during site characterization are not considered in the evaluation of this guideline.

Sites for which land will be easier to acquire from a procedural and legal point of view are more favorable than sites that are more difficult to acquire. This does not mean that the DOE discounts the socioeconomic impact of acquiring land, especially privately-owned land. The socioeconomic impacts of land acquisition are considered under the socioeconomic guideline.

7.3.1.1.3 Meteorology

Two major considerations are identified that influence the favorability of the sites with respect to the qualifying condition for the meteorology guideline. The first major consideration is conditions that affect the transport of radionuclides in the atmosphere to unrestricted areas where the public might be exposed, and the significance of transport. Contributing factors include dispersion characteristics of the atmosphere, wind speed and direction, frequency of stagnation episodes, atmospheric mixing levels, local terrain, and locations of nearby population concentrations. This is the most important consideration under this guideline because the potential for radionuclides to be transported in the direction of population concentrations directly affects a site's ongoing ability to meet the requirements of the preclosure system guideline for radiological safety, and reflects the focus on routine exposures in the qualifying condition for meteorology.

The second major consideration, extreme-weather phenomena, addresses the historical frequency and intensity of extreme weather such as hurricanes, tornadoes, floods, and winter storms that could have a significant effect on repository operations or closure. This consideration is less important than the first major consideration because, unlike atmospheric transport characteristics, which tend to reflect on-going or frequent meteorological conditions, extreme weather phenomena reflect infrequent or episodic conditions.

7.3.1.1.4 Offsite installations and operations

Two major considerations are identified that influence the favorability of the site with respect to the qualifying condition for the offsite installations and operations guideline. The first major consideration is the presence of nearby nuclear installations or operations. This consideration addresses radionuclide releases from atomic energy defense activities and nuclear installations regulated by the NRC, which could, together with operational releases from the repository, subject the general public to radionuclide exposures above allowable limits. The evaluation of this consideration accounts for the proximity of nuclear installations and operations to the site and the level of radionuclide releases during accidents and routine operating conditions at these installations.

The second major consideration is the possible adverse effects of nearby hazardous operations and installations on repository, construction, operation, and closure. Such operations and installations could include chemical plants; fuel production, refining, transportation, and storage facilities; pipelines; major transportation routes that could carry hazardous materials; air traffic associated with nearby airports; military operations areas; and facilities that handle toxic materials including hazardous waste disposal sites.

7.3.1.2 Preclosure system guideline for radiological safety

For preclosure radiological safety the pertinent system elements are (1) the site-specific characteristics that affect radionuclide transport; (2) the engineered components whose function is to control releases of radioactive materials; and (3) the people who, because of their location and distribution in unrestricted areas, may be affected by radionuclide releases. This guideline is assigned the greatest importance among the three preclosure system guidelines because it is directed at protecting both the public and the repository workers from radiological exposures.

This guideline requires that projected radiological exposures of the general public and projected releases to restricted and unrestricted areas during the preclosure period shall meet applicable requirements set forth in 10 CFR Part 20, 10 CFR Part 60, and 40 CFR 191, Subpart A. The specific requirements of these regulations and how well each site performs against these regulations are detailed in performance assessments that are presented in Section 6.4.1 of each environmental assessment. On the basis of these preliminary assessments it appears that a repository can be located and

operated at any of the nominated sites with insignificant radiological exposure risks to the public.

7.3.2 ENVIRONMENT, SOCIOECONOMICS, AND TRANSPORTATION

7.3.2.1 Technical guidelines

Three technical guidelines are associated with the preclosure system guideline for environmental quality, socioeconomics, and transportation. Their objective is to ensure that the well being of the public and the quality of the environment are adequately protected from the hazards posed by the disposal of radioactive wastes.

7.3.2.1.1 Environmental quality

Four major considerations are identified that influence the favorability of the sites with respect to the qualifying condition for the environmental quality guideline. The first major consideration is the ability of a site to meet applicable environmental requirements. This consideration addresses the procedural and substantive requirements of environmental regulations with which the repository project must comply. A site's standing against this consideration is determined by evaluating the degree to which project activities will comply with applicable requirements as well as their ability to do so within specific time constraints.

The second major consideration is the significance of environmental impacts that could arise from the project and the degree to which such impacts can be mitigated. It also considers features of the mitigation measures such as their time requirements and technological feasibility, and the social, economic, or environmental factors that affect their applicability to a particular site. Because the environmental requirements and environmental impact considerations both reflect the requirement in the qualifying condition that the quality of the environment as a whole must be protected, these considerations are of equal importance. At the same time, they are each more important than either of the two remaining considerations.

The third major consideration is effects of the repository on protected Federal resource areas. It addresses the following Federal lands: the National Park System, the National Wildlife Refuge System, the National Wild and Scenic Rivers System, the National Wilderness Preservation System, and National Forest Land, as well as designated critical habitats for threatened or endangered species. The evaluation of sites for this consideration is based on their proximity to, and the degree of projected impacts on, the listed areas, except for critical habitats. Critical habitats are considered on the basis of whether they could be compromised by the repository.

The fourth major consideration under the environmental quality guideline is impacts on protected State or regional resource areas, Native American resources, and cultural sites. The evaluation of this consideration addresses the combined effects of a site's proximity to resource areas and the projected level of impact on those areas. Because these last two considerations address the protection of the environment in terms of a subset of environmental conditions (i.e., specific resource areas), they are equally important as a group, but less important than the first two considerations.

7.3.2.1.2 Socioeconomic impacts

Six major considerations are identified that influence the favorability of the sites with respect to the qualifying condition for the socioeconomics guideline.

The first consideration is potential impacts to community services and housing. This consideration relates to the requirement in the qualifying condition that impacts on community services or housing in affected areas and communities can be mitigated or compensated. Impacts on community services and housing depend on five contributing factors: population composition and density, the distribution of in-migrants, current capacity and trends in use of community services and infrastructure, housing supply and demand, and the ability of affected communities to accommodate growth.

The second major consideration is potential impacts on direct and indirect employment and business sales. Two factors contribute to the evaluation of this consideration: project-related needs for labor and expected local hires, and local project-related purchases of materials.

The third major consideration is potential impacts on primary sectors of the economy. The three contributing factors for this consideration are the major sectors of the economy, employment distribution and trends by economic sector, and the compatibility of a repository with the economic base of the affected area.

The fourth major consideration is potential impacts on the revenues and expenditures of public agencies in the affected area. Impacts on revenues and expenditures depend on three contributing factors: the sources of, and trends in, expenditures and revenues of local government, the additional needs for community services induced by the repository project, and economic growth in the area and resulting increases in tax revenues associated with the repository.

The fifth major consideration is the need to purchase or acquire water rights that could affect development in the area. The need to acquire water rights depends on two contributing factors: project-related water requirements, and current water rights, use, and capacity.

The last major consideration under the socioeconomics guideline is potential social impacts. Three factors contribute to the potential for social impacts: the quality of life and existing social problems in the

affected communities, the size of the in-migrating population in comparison to the existing population, and the compatibility of the in-migrating population with the lifestyles and characteristics of the current residents.

7.3.2.1.3 Transportation

Four major considerations are identified that influence the favorability of sites with respect to the qualifying condition for the transportation guideline. The first and most important major consideration is transportation safety. Contributing factors include the distance of travel, the location of access routes, local terrain, and regional weather conditions.

The second major consideration is the environmental impacts of improving the existing infrastructure and of constructing new access routes to the site. For example, transportation operations and development of access routes might adversely affect sensitive species on a large scale (over many miles), and the aesthetic quality of the region may be degraded by the construction of road and rail routes. This consideration focuses on local conditions around the site since the environmental concerns along the national highway and rail network were already considered during the development of those networks for regular commercial traffic. In this respect, the incremental environmental impacts of transporting radioactive wastes are not considered to be significant on a national scale. Contributing factors for this consideration include the need to construct lengthy access roads, conflicts with current land use plans, and the need for cuts, fills, tunnels, or bridges to reach the site.

The third major consideration is the cost of constructing and upgrading the access routes to the sites. This is not as important as the first consideration since the protection of health and safety is more important than reducing costs. The main contributing factors that influence costs are the extent of needed repairs, local terrain, and costs for rights-of-way.

The least important consideration is the cost of developing the cask fleet and shipping the wastes to the repository. The cost of transporting spent fuel to the repository is determined, in part, by the distance of the site from the spent-fuel sources. Nonetheless, it costs about as much to ship waste 1,000 miles as it does 500 miles. This consideration, as well as the consideration of transportation safety, is also affected by decisions about the configuration of the waste-management system, such as the second repository. The effect of the second repository is considered as quantitatively as possible. Other contributing factors include local weather conditions, availability of carriers, emergency-response capabilities, legal impediments to transport, and the number of railway crew changes.

7.3.2.2 System guideline on environment, socioeconomics, and transportation

Ranked second in importance in the preclosure system guidelines is environment, socioeconomics, and transportation. The pertinent system elements will, in general, consist of (1) the people who may be affected, including their lifestyles, sources of income, social and aesthetic values, and community services; (2) the air, land, water, plants, animals, and cultural resources in the areas potentially affected by such activities; (3) the transportation infrastructure; and (4) the potential mitigating measures that can be used to achieve compliance with this guideline.

On the basis of the evaluation of the guidelines for environmental quality, socioeconomics, and transportation, the evidence does not support a conclusion that the qualifying condition for this system guideline would not be met at any of the nominated sites.

7.3.3 EASE AND COST OF SITING, CONSTRUCTION, OPERATION, AND CLOSURE

7.3.3.1 Technical guidelines

The four technical guidelines in this group address the surface characteristics of the site, the characteristics of the host rock and the surrounding strata, hydrologic conditions, and tectonics. These guidelines are concerned with the ease and cost of siting, constructing, operating, and closing the repository.

7.3.3.1.1 Surface characteristics

Two major considerations are identified that influence the favorability of the sites with respect to the qualifying condition for the surface-characteristics guideline. The first consideration is the potential for flooding of surface or underground facilities. This is the most important consideration under this guideline because the effects of flooding can be important factors in the design of the repository. The primary contributing factors for this consideration include the location and likelihood of flooding due to natural causes at the surface or in the underground facilities, or the potential for failure of man-made surface water impoundments or engineered components of the repository.

The second consideration is the effects of the terrain and drainage characteristics of a site on repository construction, operation, and closure. It is less important than the first consideration because terrain and drainage are more closely related to the ease and cost of construction than to safety, and can generally be mitigated more readily than conditions that could cause flooding (i.e., the first consideration). Contributing factors for this major consideration include the configuration of the repository, the potential for landslides, and soil characteristics.

7.3.3.1.2 Rock characteristics (preclosure)

Three major considerations are identified that influence the favorability of the sites with respect to the qualifying condition for the rock characteristics guideline. The first consideration addresses in situ conditions that could lead to safety hazards or difficulties during repository siting, construction, operation, and closure, including retrieval. Because of the DOE's emphasis on safety of personnel, this is the most important major consideration of the three related to this guideline.

The second consideration addresses in situ characteristics and conditions that could require engineering measures beyond reasonably available technology in the construction of shafts and underground facilities. Although the success of repository construction depends on its technical feasibility, the complexity of engineering measures is second in importance to personnel safety because of the DOE's primary emphasis on safety.

The third major consideration is whether the host rock is large enough to allow flexibility in selecting the depth, configuration, and location of the underground facility. This consideration is judged to be third in importance, because although adequate host rock to accommodate a repository is necessary, and additional host rock to provide flexibility is desirable, it is not as essential as worker safety and technical feasibility.

7.3.3.1.3 Hydrology

Three major considerations are identified that influence the favorability of the sites with respect to the qualifying condition for the preclosure hydrology guideline. The first major consideration is ground-water conditions that could necessitate complex ground-water control measures in shafts and drifts during repository siting, construction, operation, and closure. This is the most important consideration because it has the most impact on the ease and cost of repository construction, operation, and closure.

The second major consideration is the existence of surface-water systems that could flood the repository. This consideration includes ponds, lakes, streams, and man-made impoundments that could flood the underground workings. Surface-water flooding of the underground workings is a concern because it could endanger the safety of personnel and interrupt repository operations. However, standard engineering measures such as dikes and berms can minimize the risk of flooding. This consideration is considered second in importance because it is generally easier to manage the potential for surface flooding than underground flooding.

The last major consideration under this guideline is the availability of an ample source of ground or surface water for repository construction, operation, and closure. This consideration is third in importance because, although it affects the ease and cost of construction, it has a limited effect on the technical feasibility of developing the repository.

7.3.3.1.4 Tectonics (preclosure)

Two major considerations are identified that influence the favorability of the sites with respect to the preclosure tectonics guideline. The first consideration is the potential for earthquake ground motion at the site. This consideration requires an evaluation of whether ground motion at the site could lead to safety hazards or difficulties during repository siting, construction, operation, and closure. The evaluation of ground motion depends on the evaluation of potential surface faulting in the geologic setting. Contributing factors for this major consideration include the historical earthquake record, evidence of man-induced seismicity, estimates of ground motion from historical and man-induced earthquakes, correlation of earthquakes with tectonic structures and faults, and evaluations of the effects of ground-motion hazards on design.

The second consideration, expected impact of fault displacement at the site, requires an assessment of the potential for fault displacement at the site that could lead to safety hazards or difficulties during repository siting, construction, operation, and closure. This consideration is about equal in importance to the potential for earthquake ground motion. Although the likelihood of faulting at a site is generally lower than the likelihood of ground motion, the need to design for fault displacement can have a significant effect on the site's favorability. Successful construction experience where fault displacement conditions exist is an important contributing factor to this consideration. The other major contributing factors are the evidence and location of, and rates of movement on, Quaternary faults in the geologic setting.

7.3.3.2 System guideline on the ease and cost of siting, construction operation, and closure

The third preclosure system guideline is ease and cost of siting, construction, operation, and closure. It is ranked lowest because it does not directly relate to the health, safety, and welfare of the public or the quality to the environment. Here the pertinent elements are (1) the site characteristics that affect siting, construction, operation, and closure; (2) the engineering, materials, and services necessary to conduct these activities; (3) written agreements between the DOE and affected States and affected Indian tribes and the Federal regulations that establish the requirement for these activities; and (4) the repository personnel at the site during siting, construction, operation, or closure.

On the basis of the technical guidelines for ease and cost of repository siting, construction, operation, and closure, the evidence does not support a conclusion that the qualifying condition for this system guideline would not be met at any of the nomimated sites.

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