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Environmental Assessment

Richton Dome Site, Mississippi

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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 Richton Dome site in Perry County, Mississippi, 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 the Richton Dome site in Mississippi as one of the nine potentially acceptable sites for a mined geologic repository for spent nuclear fuel and high-level radioactive waste. To determine their suitability, the Richton Dome 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.

The site is in the Gulf interior region, which is one of five distinct geohydrologic settings considered for the first repository. This setting contains two other potentially acceptable sites--the Cypress Creek Dome site in Mississippi and the Vacherie Dome site in Louisiana. Although the Cypress Creek Dome and the Vacherie Dome sites are suitable for site characterization, the DOE has concluded that the Richton Dome site is the preferred site in the Gulf interior region. On the basis of the evaluations reported in this EA, the DOE has found that the Richton Dome site is not disqualified under the guidelines.

Futhermore, the DOE has found that the site 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 Richton Dome site as one of five sites suitable for characterization.

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EXECUTIVE SUMMARY

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 completed, 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 executive summary highlights the important information and evaluations found in the accompanying EA. Section 2 of this executive summary presents a summary of the decision process and findings leading to the nomination of the Richton Dome 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 site 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, the DOE has considered all comments that were received, as documented in Appendix C.

The final EAs will accompany the formal nomination of five sites as suitable for characterization. The Secretary of Energy will then recommend not fewer than three of these sites to the President as candidate sites for characterization. After the President approves the Secretary's recommendation, characterization activities will begin at those sites. After characterization is completed, the DOE will again evaluate each site against the guidelines and, after completing an environmental impact statement, will recommend one site to the President for the first repository. The President may then recommend the site to Congress. At this point, the host State may issue a notice of disapproval that can be overridden only by a joint resolution of both Houses of U.S. Congress. If the notice of disapproval is

not overridden, the President must then 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 FINDINGS AND DETERMINATIONS

The DOE's findings and determinations that apply to the Richton Dome site are summarized below.

2.2.1 EVALUATION AGAINST THE DISQUALIFYING CONDITIONS

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

2.2.2 GROUPING OF SITES BY GEOHYDROLOGIC SETTING

The nine potentially acceptable sites are contained within the following 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 County and Swisher County, 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 distinctions among the geohydrologic settings and the host rocks are clear not only among basalt, salt, and tuff, but also among the three basins in salt. The bedded salts of the Permian and Paradox Basins are distinct from the dome salt of the Gulf Interior Region in terms of their structure, their rock properties, and the relationship of the host rock to the aquifers in the geohydrologic environment. The bedded salts of the Permian and Paradox Basins

are sequences of sedimentary layers of salt and impurities bounded by aquifers above and below. The domes, on the other hand, are anomalous structures that penetrate the thick sedimentary layers, including aquifers, that are characteristic of the Gulf Interior Region. The bedded salt of the Paradox and Permian Basins are also distinct in terms of their stratigraphic sequence, regional hydrologic setting, history of deposition, and physiography.

2.2.3 SELECTION OF THE PREFERRED SITE IN THE GULF INTERIOR REGION

On the basis of a comparison of the Richton Dome with the other two domes in the Gulf Interior Region, the DOE has identified the Richton Dome as the preferred site, mainly because of its ability to better ensure compliance with the waste-isolation requirements. The features of the Richton Dome that make it preferred are as follows:

- The significantly larger size of the dome allows significant flexibility in the location and design of the underground facility so as to ensure waste isolation.
- There is an absence of known collapse features suggestive of dissolution activity.
- There is an absence of previous subsurface mining or resource extraction within the site that could affect containment or isolation.
- There is limited potential for flooding of the dome area and minimal requirements for the alteration of existing drainages during the construction of the repository.
- There is an absence of projected land ownership conflicts that cannot be successfully resolved through voluntary agreements or legal proceedings.

The Vacherie Dome is expected to be less favorable as a repository site with respect to waste containment and isolation because of the following features:

- The limited lateral extent of the host rock at the proposed repository depth would necessitate a multiple-level repository.
- The presence of an overdome collapse feature is suggestive of host-rock dissolution.
- There is a potential for flooding in the area of the dome and a need for stream diversion during repository construction.

The Cypress Creek Dome is also less favorable than the Richton Dome for the following reasons:

- The limited lateral extent of the host rock at the proposed repository depth would necessitate a multiple-level repository.

- The presence of an overdome depression is suggestive of host-rock dissolution.

- The oil and gas production wells that exist on one flank of the dome could affect waste containment and isolation.

- Congressional action may be required to transfer control of National Forest lands to the DOE.

- There is a potential for flooding in the area of the dome and a need for stream diversion during the construction of the repository.

2.2.4 SUITABILITY OF THE RICHTON DOME SITE FOR THE DEVELOPMENT OF A REPOSITORY

The Act requires the DOE to evaluate the suitability of a site for development as a repository under each guideline that does not require site characterization as a prerequisite for the application. 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 already available for site evaluation. The guidelines that do not require characterization primarily relate to the effects of a repository on public health and safety, the quality of the environment, and socioeconomic conditions before the repository is closed and sealed.

For a site to be suitable for repository development under each of those guidelines that do not require site characterization, no disqualifying conditions can be present, and each of the qualifying conditions under those guidelines 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 Richton Dome site is disqualified. Furthermore, the evidence does not support a finding that the Richton Dome site is not likely to meet all the qualifying conditions under the guidelines that do not require site characterization.

2.2.5 SUITABILITY OF THE RICHTON DOME SITE FOR CHARACTERIZATION

To determine whether a site is suitable for characterization, the DOE must evaluate the site against all of the guidelines, including those that require site characterization. In order to judge that a site is suitable, the DOE must then conclude that the evidence does not support a finding that the site is not likely to meet all of the guidelines. As a result of the evaluations reported in Chapter 6, the DOE has found that the Richton Dome site is suitable for characterization.

2.2.6 DECISION ON NOMINATION

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

3. THE SITE

As shown in Figure 2, the Richton Dome site is in Perry County, Mississippi, 29 kilometers (18 miles) east of Hattiesburg and 16 kilometers (10 miles) northeast of New Augusta (population 585), the county seat. The site is located in a heavily vegetated rural setting, in a region characterized by high annual precipitation and extensive surface-water systems. The proposed restricted area is about 4 kilometers (2.5 miles) northwest of Richton, a town with a 1980 population of 1,205 persons. The nearest interstate highway, I-59, passes about 40 kilometers (25 miles) west and northwest of the site. Hattiesburg is the junction of two main lines of the Illinois Central Gulf Railroad.

All of the land in the area of the Richton Dome is privately owned, and is used mainly for forestry and agriculture, with less than 1 percent in residential use. Approximately 36 percent of the area in the general vicinity of Richton Dome meets U.S. Soil Conservation Service requirements for classification as prime farmland. There are three farm dwellings located within the dome area. West of the town of Richton are several single-family dwellings located within the eastern part of the dome area. The De Soto National Forest is located 5.6 kilometers (3.5 miles) northeast of the center of the Richton Dome. Two federally-designated wilderness areas, parts of the DeSoto National Forest, are about 40 kilometers (25 miles) south of the Richton Dome site. Camp Shelby Military Reservation is located approximately 15 kilometers (9 miles) south of the dome in De Soto National Forest.

The Richton Dome is a northwest-trending elliptical salt dome. A caprock of anhydrite, the residuum of salt dissolution during the growth of the dome, covers the top of the dome and, to some degree, drapes its flanks (Figure 3). The salt bed from which the dome originated is now at a depth of more than 7,000 meters (23,000 feet), and the top of the salt stock is within 244 meters (800 feet) of the ground surface. At the depth proposed for the repository, the horizontal cross-sectional area of the dome is approximately 2,222 hectares (5,489 acres). The sedimentary strata overlying and adjacent to the Richton Dome consist of a thick sequence of clays and silts, with lesser amounts of interbedded limestones and sands. Two parallel faults, trending north and south, have been identified in the subsurface a minimum of 8 kilometers (5 miles) east of the Richton Dome. Another small fault intersects the northwestern edge of the dome, and was probably formed during the period of upward dome movement. Disruption of recent sediments over the dome has not been confirmed. No local earthquake shocks have been felt in the vicinity of Richton Dome, which is in an area of low seismicity.

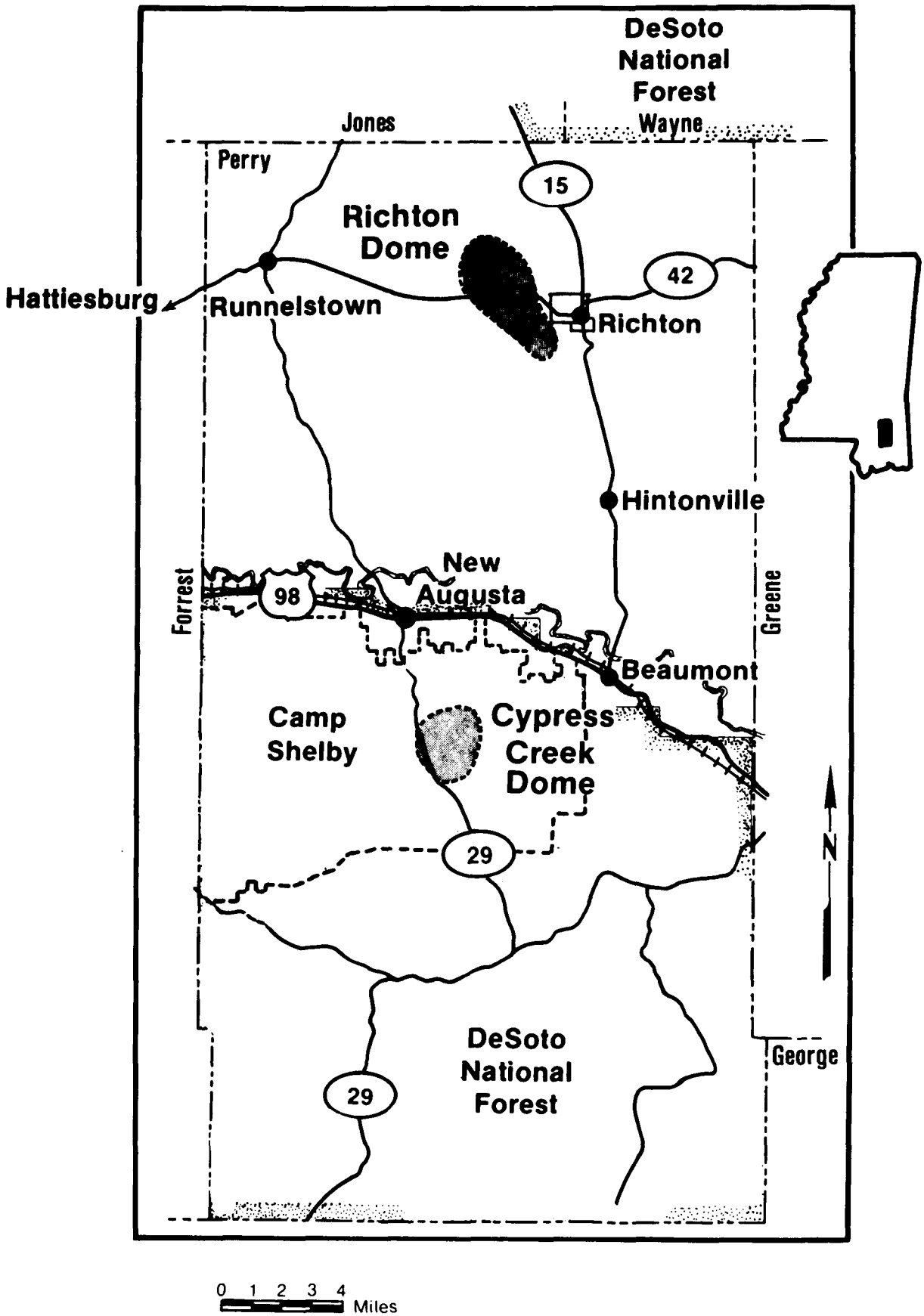

Figure 2. Richton and Cypress Creek Dome, sites, Mississippi.

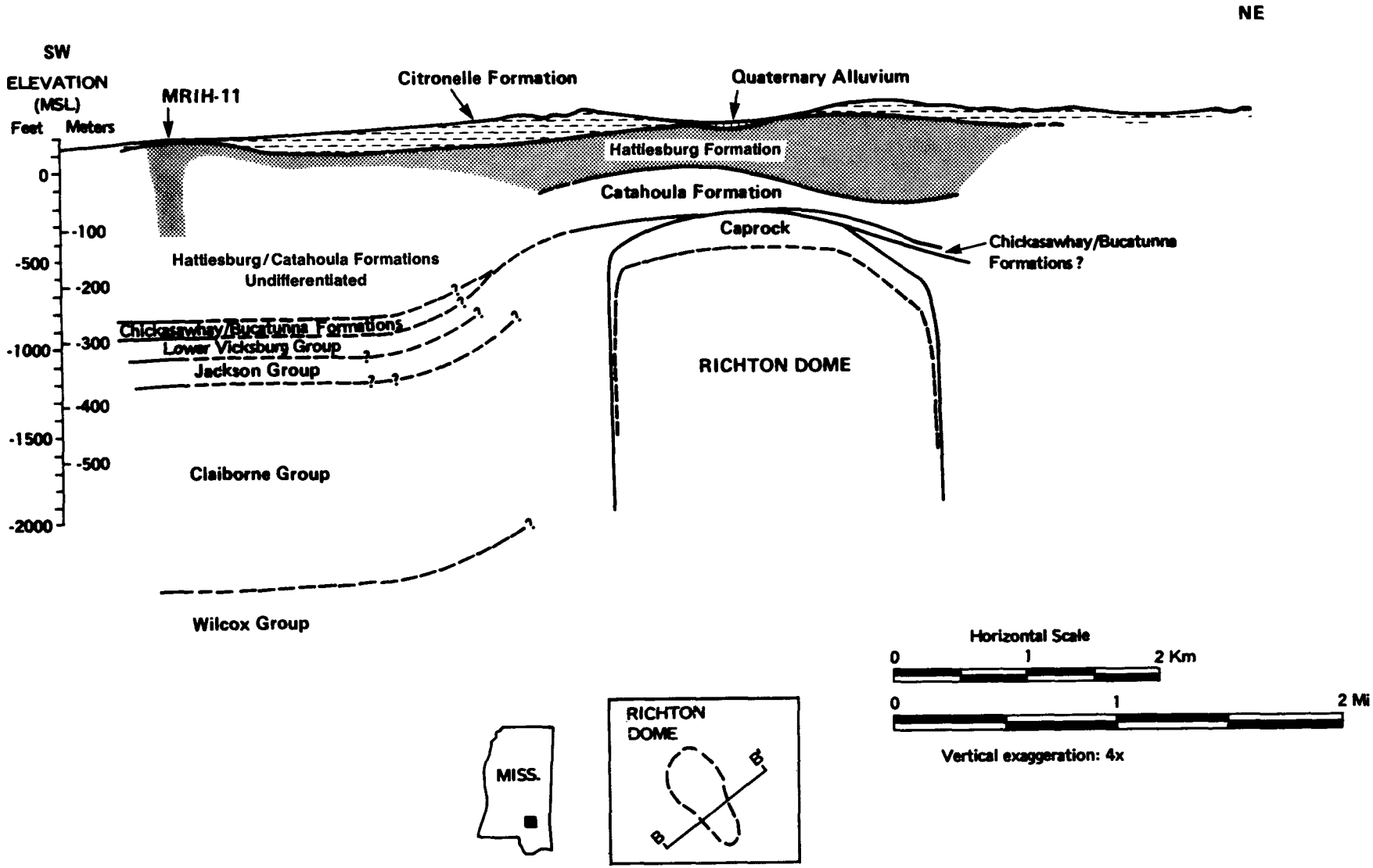

Figure 3. Geologic cross section Richton Dome site.

The Richton Dome site lies on the interfluve of Bogue Homo and Thompson Creeks and is well drained. In the surrounding area, drainages are characterized by low gradients and are associated with marshy swamps. The area experiences localized flooding from summer thunderstorms and hurricanes as well as frontal storms in late winter and early spring. No part of the area of the dome lies within a 100-year floodplain; however, a portion of the probable maximum flood plain is coincident with the proposed restricted area. Surface waters in the area have been classified by the State of Mississippi as either "fish and wildlife" waters or as water for recreation use, and they generally meet their respective water-quality criteria. Surface waters are used mainly for the generation of electricity and for industrial purposes.

Three principal aquifers have been identified in the area of the Richton Dome; from shallowest to deepest, they are the Upper Aquifer, the Upper Claiborne Aquifer, and the Wilcox aquifer. These aquifers consist of a number of sedimentary strata possessing similar hydraulic characteristics, and each aquifer unit is separated from the other by a relatively impervious confining unit. Regional ground-water flow within the aquifers is generally southward and southwest, downdip from outcrop areas where they recharge to areas along the Gulf Coast and in the Gulf of Mexico where they discharge. Local variations in the regional flow pattern are attributable to ground-water withdrawal, vertical leakage from one aquifer to another, and discharge to local streams. These local variations are most prominent near the recharge areas of the aquifers. Most municipal and residential water supplies in the region tap the upper aquifer unit.

Several small oil and gas fields are present within 16 kilometers (10 miles) of the Richton Dome. However, the potential for discovering additional fields seems to be very low, because intensive exploration efforts by private companies have tested all potentially favorable structures and have not located any petroleum reserves. Exploration for sulfur in the caprock over the dome indicates a very low probability of economic mineral resources. The large size, shallow depth, and pure salt of the Richton Dome make it a potential source of salt as well as a potential storage chamber for liquid or gas reserves. Under current market conditions, however, salt production from Richton Dome is considered sub-economic.

The natural vegetation of the Richton Dome area is typified by longleaf pine and slash pine forests; there are also significant numbers of loblolly pine, shortleaf pine, and other southern pines in the area. There are natural bands of hardwoods along small intermittent creeks which cross the dome area. Much of the land has been disturbed by agriculture, forestry, and urban activities. Most of the area which would be restricted for repository development has been recently clear-cut of all woody vegetation and reseeded. There are no unique ecosystems, and no threatened or endangered species or critical habitats are known to occur in areas which would be occupied by repository facilities. However, the endangered red-cockaded woodpecker has been reported in the region, and the endangered American alligator occurs several miles south and west of the dome. The occurrence of the bald eagle and gray bat in the dome area is possible but not expected. Several other State-listed species which inhabit mesic pine flatwoods also could inhabit the dome area. Twenty-six threatened or endangered plant species could potentially occur in the Richton Dome area.

The climate in the area of the Richton Dome is subtropical and humid, with long hot summers and short mild winters. The mean annual precipitation is about 152 centimeters (60 inches). Thunderstorms occur throughout the year, whereas hurricanes occur in the Gulf region from June to November. The prevailing meteorological conditions around the site are expected to provide fair to good atmospheric dispersion of pollutants. The ambient air quality in the area meets or exceeds primary national standards for all regulated air contaminants. Being located in a predominantly rural area, the Richton Dome is removed from major industrial sources of emissions.

There is a potential for prehistoric and historic cultural resources in the dome area, although this potential may be low. No such resource sites near the dome are included in the National Register of Historic Places. One prehistoric site that may have cultural deposits, located 0.8 kilometer (0.5 mile) from the proposed restricted area, is on file in the State of Mississippi Department of Archives and History. The clear-cut proposed restricted area has no unique aesthetic features.

Perry County, in which Richton Dome is located, has a population of 15.2 persons per square mile. Of the eight counties surrounding the dome, two have greater population densities than the national average of 76 persons per square mile. Within 80 kilometers (50 miles) of the site, Hattiesburg (1980 population, 40,829) is the largest city. Other urban areas and their 1980 populations are Laurel, 21,897; Palmer Crossing, 2,765; Petal, 8,476; Ellisville, 4,652; Wiggins, 3,205; and Waynesboro, 4,368. Between 1985 and 2005, the population in the study area is projected to increase by 23 percent. A large summer seasonal population, involving a maximum of 6,000 people during any 2-week period, is associated with summer National Guard training at Camp Shelby in Perry County.

The major employment sectors in the region are manufacturing and government, with wholesale and retail trade important in populated areas. A new paper pulp mill approximately 14 kilometers (9 miles) from Richton Dome is expected to attract 400 employees. In 1982, unemployment in the area ranged from 8.6 to 17.2 percent. Adequate housing, health, and community services are available.

4. EFFECTS OF SITE CHARACTERIZATION

This section describes the activities that would be conducted if the Richton Dome site were selected for site characterization. To obtain the information necessary for evaluating the suitability of the Richton Dome site for a repository, the DOE would conduct a site-characterization program of underground testing. To carry out this program, the DOE would construct two shafts down to the level of the repository (one shaft for removing salt and other materials and lowering test apparatus into the shaft and one for services and facility emergency egress), excavate drifts at the proposed repository depth, and construct support structures on the surface. In addition to the tests performed underground and in the exploratory shaft, geologic field studies would be conducted to characterize underground conditions.

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

Site characterization would produce both adverse and beneficial effects. Current land uses in parts of the site would be disrupted. Approximately 28 hectares (70 acres) of land would be cleared for the exploratory shaft and access roads. The DOE would obtain the needed surface and subsurface rights to this land through negotiation and purchase or, if necessary through condemnation. To conduct geotechnical studies, the DOE would lease or purchase small parcels of land totaling about 202 hectares (500 acres). Most of these activities would have minor land-use impacts and would be located so as to minimize conflict wherever possible.

The excavation of salt from the underground test area would create a surface stockpile of approximately 104,000 cubic meters (136,000 cubic yards), covering an area of about 4 hectares (10 acres). An impermeable liner beneath the pile and surface-runoff ponds would be used to minimize the potential for surface- and ground-water contamination from the salt pile. During salt-handling operations, some windblown salt is likely to be deposited on the ground nearby, but similar salt excavation and management experience indicates that the salt-related impacts of site characterization would not be significant. When stockpiled salt is wetted after spreading and compacting a hard surface crust forms in a few days. This crust prevents the spread of windblown particles. Waste salt and residues would be removed from the site and disposed of in a licensed landfill in the region.

Air quality effects would result mainly from fugitive dust (a major contributor to particulate emissions) and combustion gases from equipment engines. The total concentration of suspended particles (TSP) will meet the 24-hour and annual National Ambient Air Quality Standards (NAAQs). Impacts from gaseous nitrous oxide (NO_x) emissions will not exceed the annual NAAQ standards. Fugitive dust can be controlled by various measures, such as spraying with water and use of surface-stabilizing agents, if necessary.

Runoff and erosion from land disturbed during site characterization may increase sediment discharge and turbidity in nearby creeks. Onsite discharges of liquid wastes and runoff at the exploratory shaft facility and the salt stockpile would be collected in retention ponds. No waste water from these ponds would be discharged to local surface waters. Because the exploratory shaft site would be above the level of the 100-year flood, it would have no effect on floodplain management in the area.

The penetration of water-bearing units, primarily within the Upper Aquifer geohydrologic unit, is unlikely to affect the quality of ground water in local wells. The water needed for site characterization would be obtained from onsite wells.

Wildlife associated with the site would be displaced, and wildlife in the surrounding areas could be disturbed by human presence and activity. Wet areas in the vicinity of the dome could experience temporary changes in water

quality and quantity as well as alterations in the composition of plant communities. The measures that can be undertaken to avoid or mitigate these effects include minimizing land clearing and making provisions for revegetation after site characterization. Although any threatened or endangered species that inhabit the area may be affected by the characterization activities, the overall ecological effects are not likely to be significant because most of the site has recently been clear-cut, and the plant communities that are present at the site are common throughout the State of Mississippi. Moreover, no important or unique habitats appear to be present at the site, and mitigation measures, such as avoiding undisturbed areas, would be undertaken wherever possible to reduce adverse ecological effects.

The forest cover in the area would provide some screening for site features from offsite areas. Site characterization is unlikely to disturb any archaeological, historical, or cultural resources. Before any ground is disturbed, an intensive survey would be made to locate any significant cultural resources. During development of the exploratory shaft facility, blasting to break rock in the shafts will be audible offsite. Over a period of 6 to 12 days, the blasting will be audible 9.6 kilometers (6 miles) from the source under average meteorological conditions. Noise from the diesel generators and heavy construction equipment also will be audible near the site.

Approximately 473 of the 526 workers expected during site characterization would move into the area together with their dependents; the number of people migrating into the area would total approximately 1,027. No adverse effects on economic conditions in the area are expected but local communities may experience some social effects in accommodating the newcomers. Depending on the housing preferences of the in-migrants, population increases would create a need for 95 extra housing units in the town of Richton. The DOE could provide technical assistance to local government and community officials in planning to accommodate service needs of the site characterization project.

Site characterization at Richton Dome would cost $250 million for exploratory shaft facility construction and $225 million for other activities, primarily geologic activities. Seventy percent of this amount would be for materials and 30 percent for wages. It is likely that some materials (such as fuel, concrete, small equipment, lumber, and other building supplies) will be purchased locally. A part of the wages will be spent locally, including wages from indirect jobs generated by the project.

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 6 years, the DOE would construct surface and support structures, construct access shafts, excavate and prepare underground tunnels and waste-disposal rooms, and improve access roads and utility services. During the first few years of the operation phase, the repository would receive small amounts of waste -about 400 metric tons (440 tons) per year - while the

surface and underground facilities are completed. After construction is completed, the rate of waste receipt would increase to a maximum of 3,000 metric tons (3,300 tons) of radioactive waste 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 from 25 to 30 years; it would be followed by a "caretaker" period because the NRC requires the DOE to preserve the option of retrieving the waste for 50 years after the initial emplacement. During closure and decommissioning the underground repository would be backfilled, shafts and boreholes would be closed and sealed, land-use controls would be instituted, the surface facilities would be decontaminated and decommissioned, and permanent markers or monuments would be erected at the site to warn future generations about the presence of the underground repository.

Both adverse and beneficial effects would result from developing a repository at the Richton Dome site. The DOE would obtain title to the site, a surface area of about 1,988 hectares (4,910 acres). About 165 hectares (407 acres) of land would be used for the surface facilities of the repository. The use of the site for commercial forestry would be lost, but this forested land is less than 1 percent of the total forested land in Perry County. About 25 percent of the 299 hectares (739 acres) required for repository surface facilities and utility corridors would already have been disturbed during site characterization. Approximately 7.5 hectares (18.5 acres) of Federally identified wetlands would be disturbed, and 6.6 of these hectares (16.3 of these acres) would be lost. After the closure of the repository, the disturbed areas may be returned to forestry use. Expansion of the town of Richton to the west, including local industrial development, would be influenced by the presence of repository facilities. A number of residences would have to be relocated.

Approximately 3 million tons of excavated salt would be stored at the site to be used for backfilling the repository during closure. The salt-storage pile would cover about 21 hectares (53 acres) and reach a height of about 9 meters (30 feet). Although a hard crust would form over the salt pile, some windblown salt is likely to be deposited in the immediate vicinity of the site during salt-transfer operations. An impermeable liner would be used under the pile to minimize effects on ground water. Collection ponds would be constructed to contain any runoff from the salt pile. It is not expected that windblown salt from salt-handling activities or from the salt pile would significantly affect local soils or surface waters. About 9 million metric tons (10 million tons) of excess salt would be removed from the site. Excess salt can be disposed of by several methods, including placement in an offsite mine; no method of salt disposal has yet been selected.

The ecological effects of repository development would be largely confined to the site; they would be similar to those of site characterization (Section 4). The overall ecological effect is not expected to be significant, especially since extensive logging operations have removed vegetation at the site. However, 6.6 hectares (16.3 acres) of wetlands would be lost.

The potential for adverse air-quality effects arises principally from the emissions of particulates and nitrogen oxides; the greatest levels of these pollutants would be reached during site preparation. The 24-hour National

Ambient Air Quality Standards (NAAQS) for total suspended particles (TSP) and the annual average NAAQS for TSP and nitrous oxides (NO_x) will be met during repository construction, operation, decommissioning, and closure.

The water needed for the repository would be supplied by offsite wells, and therefore no surface waters would be withdrawn and consumed. Local hydrologic conditions could be affected by changes in runoff patterns as well as by stream diversion and rechannelization. The degradation of surface-water quality by spills of fuel and other contaminants is not expected. Protective measures that could be used include erosion-control dikes; retention ponds that can accommodate a 100-year, 24-hour storm; channel diversion; and salt pile management. Ground-water withdrawals and changes in surface conditions might cause changes in the local ground-water system, such as declines in water level. Surface developments and repository shafts would be designed and constructed to avoid potential effects on the surrounding ground-water system.

The erection of large structures and the development in a rural landscape would affect the visual character of the area. Night lighting would contribute to the visual impacts, but the overall effect would be lessened somewhat by the surrounding forest cover. Dust clouds would be visible for short periods during construction. Control measures would be employed to prevent dust from dissipating off site.

Noise impacts from blasting at the locations of the repository shafts will be similar to those from blasting during site characterization. Construction of the rail spur leading to the site also will rovide a short-term noise-level increase. Rail traffic and increased road traffic, as well as repository operation, will produce noise which can be mitigated by control measures such as maintaining a buffer zone of pine forest along the repository boundary.

During the peak year of repository construction, about 2,120 direct and indirect jobs would be created in the region, and a maximum of 2,420 persons would in-migrate. By the peak year of operation, about 2,190 direct and indirect jobs would be created (although there would be a smaller proportion of direct jobs than during construction), and a maximum of 1,970 persons are expected to have migrated into the region. The maximum repository-related population increases during peak operation (approximately the year 2005) will be 2 percent of the baseline populations of Hattiesburg and Laurel and 3 percent of the baseline population of Petal. Richton will undergo a 37 percent population increase during construction, reducing to 28 percent during peak operation. Potentially adverse socioeconomic effects in Richton should be offset by an increased tax base, by grants-equal-to-taxes, and financial assistance provided by the DOE. Residents displaced as a result of project activities would be eligible for assistance, and real property would be acquired at fair market value.

Local business activity would increase. During the 7-year construction period an estimated $37 million would be spent for materials purchased locally. An additional $15 million would be spent locally by in-migrating workers and their families. A portion of the $3 billion anticipated repository operation cost would be recirculated in the local economy.

Two types of transportation effects would result from increased commuter traffic and the hauling of supplies, excess salt, and radioactive waste. Radiological risks would result from the direct external radiation emitted by the radioactive waste as a shipment passes by. Nonradiological risks include 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 Richton Dome site is closer to the sources of waste from commercial nuclear power plants than the other potentially acceptable sites, the nonradiological risks will be relatively low.

Although the risks would vary with the transportation mode, they are expected to be low. The radiological risks for the Richton Dome site are expected to be significantly lower than the nonradiological risks. The transportation costs for the Richton Dome site are projected to be approximately 936.1 million dollars for truck and 982.0 million dollars for rail transport. These costs are lower than for the other salt sites.

The terrain presents no hazards to the transportation of waste, and there are no local conditions that would increase the cost of transportation or pose significant risks to public health and safety. However, the transportation of waste may experience delays due to heavy rains and flooding.

6. EVALUATIONS OF SITE SUITABILITY

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

6.1 THE STRUCTURE OF THE GUIDELINES

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

The postclosure Technical guidelines address the characteristics that could affect the long-term ability of the site to isolate the waste from the accessible environment. In particular, they cover geohydrologic conditions, geochemical conditions, rock characteristics, climatic changes, erosion,

dissolution, tectonics, and human interference. The postclosure System guideline requires the site to contain and isolate the waste from the accessible environment in accordance with the standards and the regulations specifically promulgated for repositories by the EPA and the NRC. In order to achieve the specified level of containment and isolation, both natural and engineered barriers may be used.

The preclosure guidelines are divided into three groups: (1) preclosure radiological safety; (2) the environment, socioeconomics, and transportation; and (3) the ease and cost of siting, construction, operation, and closure. A preclosure System guideline is specified for each of these groups. The associated Technical guidelines address site suitability in terms of population density and distribution, site ownership and control, meteorology, offsite installation 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 that would contribute most to the ability of Richton Dome site to isolate the waste from the accessible environment are a dry environment and favorable geomechanical properties. Very little water is available in the Richton Dome to dissolve the waste and transport radionuclides. Because rock salt is nonporous, it is uncertain whether there is currently any movement of fluids within the Richton Salt Dome. Under the conservative assumption that fluid movement occurs through interconnected pores, the minimum ground-water travel time from the edge of the engineered-barrier system to the dome flank has been calculated to exceed 100,000 years. A calculated median travel time over the same distance is 3.5×10^7 years. Furthermore, there is evidence of a chemically reducing environment within and around the dome; such an environment would maintain radionuclides in their least-mobile state by diminishing their solubility and promoting precipitation. Another favorable characteristic is the ability of a relatively homogeneous body of salt to dissipate waste-generated heat rapidly and to deform plastically, which promotes the closing and sealing of fractures and openings in the salt. Such a combination of conditions is conducive to the containment and isolation of radionuclides within the dome. In addition, the area shows almost no evidence of tectonic instability and has a historical record of low seismicity.

Conditions that might adversely affect the waste-isolation capability of the natural barriers at the site include the process of salt dissolution and the presence of mineral resources that could be considered commercially extractable. The geologic characteristics of the area over the dome suggest that the dissolution of the salt stock in the Richton Dome ended about 2.3 million years ago and has definitely been insignificant during the last 2 million years. The projected rates of dissolution are very low, and dissolution is not expected to significantly affect waste isolation over the next 100,000 years. Considerable past exploration for oil and gas in the dome area indicates little potential for additional economically recoverable reserves. The large size of the dome and the small depth to high-purity salt

make the Richton Dome attractive as a future source of salt; however, under current market conditions, this resource is sub-economic. Depending on the method of salt extraction, the mined-out space could be used for underground storage.

To meet the EPA's standards for long-term waste isolation, the NRC specifies two requirements for the engineered-barrier system: the waste package is to contain the waste for 300 to 1,000 years, and the radionuclide-release rate beyond the period of containment is not to exceed one part in 100,000 per year of the repository inventory at 1,000 years after closure. The waste-package lifetime at the Richton Dome is estimated to exceed 10,000 years. This estimate is based on expected conditions and current information regarding the corrosion of metals like those used for the waste canister. The rate of radionuclide release after the period of containment is estimated to meet regulatory requirements. Preliminary assessments of engineered-barrier performance based on realistic but conservative assumptions indicate that the EPA's limit for releases from the engineered-barrier system would be met at the Richton Dome site.

6.3 SUMMARY OF SITE EVALUATIONS AGAINST THE PRECLOSURE GUIDELINES

The evaluations of the Richton Dome site against the three groups of preclosure guidelines are summarized below.

6.3.1 RADIOLOGICAL SAFETY

Preliminary assessments of preclosure performance for the Richton Dome site do not indicate that any of the applicable radiation standards would be exceeded during repository operation and closure. In addition, the site was evaluated against the four technical guidelines that address the radiological effects of repository operation: population density and distribution, site ownership and control, meteorology, and the effects of operations and accidents at nearby installations.

The average population density in the region is low, 40 persons per square mile, and the nearest highly populated area, Hattiesburg, is sufficiently remote (28 kilometers [18 miles] from the site). The proposed restricted area at the Richton Dome is 4 kilometers (2.5 miles) from the town of Richton.

Severe weather phenomena around the site include tropical storms (some reaching hurricane status) and tornadoes. Surface facilities would be designed to withstand severe weather events, but it may not be possible to mitigate some effects from high winds and severe weather.

6.3.2 ENVIRONMENT, SOCIOECONOMICS, AND TRANSPORTATION

Three Technical Guidelines address the environmental, socioeconomic, and transportation effects of a repository. These effects, which could be both beneficial and adverse, are summarized in Sections 4 and 5 of this executive summary. Preliminary analyses indicate that the expected adverse effects can be mitigated.

With respect to the System Guideline on the environment, socioeconomics, and transportation, there is no evidence to support a finding that the Richton Dome site is not likely to meet the qualifying conditions of protecting the public and the environment from the potential hazards of waste disposal.

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

Four Technical Guidelines address the ease and cost of siting, construction, operation and closure: surface characteristics, rock characteristics, hydrologic conditions, and tectonics.

The surface characteristics are generally favorable because the site (particularly the proposed surface facility area) lies in flat, well-drained terrain. However, a portion of the proposed surface facility area is coincident with the probable maximum flood plain. The Richton Dome is sufficiently large to accommodate a repository with an ample buffer for waste isolation. Furthermore, this great volume allows for flexibility in design and construction to deal with conditions that may be found at depth. The underground excavation in the salt mass of the site should require only minimal support, such as rock bolting. Because salt is plastic under pressure at depth, underground openings in the salt will tend to close and seal. Thus, the openings would require maintenance to keep passage-ways open to the required dimensions. Gas pockets or brine pockets may be hazardous to workers, but preliminary analyses and previous mining experience in salt domes indicate that the potential for such hazards can be diminished by exploration in advance of excavation, repository design, and proper operation. Significant anomalous salt conditions (sedimentary inclusions, shear zones) are not expected within Richton Dome.

The historical seismicity of the area, and thus the predicted seismicity of the site, is significantly lower than that for most other areas of the United States. This should mean a simple design for the surface facilities of the repository, making it less costly to construct. Sufficient water appears to be available from surface- and ground-water sources for repository construction, operation, and closure. There is a potential for localized, temporary ponding of water after major rainstorms.

These preliminary evaluations indicate that the repository can be constructed and operated with reasonably available technology and the costs would be comparable to those of constructing a repository at the other potentially acceptable sites. Thus, with respect to the System guidelines for the ease and cost of construction, there is no evidence to support a finding that the Richton Dome site is not likely to meet the qualifying condition.

7. COMPARATIVE EVALUATION OF NOMINATED SITES

7.1 PURPOSE AND REQUIREMENTS

Chapter 7 presents a comparative evaluation of the five sites nominated as suitable for site characterization: Davis Canyon, Deaf Smith County, Hanford, Richton Dome, and Yucca Mountain. Each site is a preferred site within a geohydrologic setting: Davis Canyon is in the bedded salt of the Paradox Basin in Utah; Deaf Smith County is in the bedded salt of the Permian Basin in Texas; Hanford is in basalt in the Columbia Plateau in Washington; Richton is a salt dome in Mississippi; and Yucca Mountain is in tuff in the Southern Great Basin in Nevada.

The purpose of this chapter is to present a comparative evaluation of the nominated sites 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, and

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."

This comparative evaluation 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 [112(b)(1)(A)]; it is not intended to directly support the subsequent recommendation of three sites for characterization as candidate sites.

7.2 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 evaluation presented in this chapter includes the system guidelines and the technical guidelines. The approach used to compare the sites with respect to each system and technical guideline in summarized below.

7.2.1 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 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.

The comparative evaluation of the sites with respect to each guideline, using the approach described above, is summarized in Sections 7.2 and 7.3 for the postclosure and preclosure guidelines, respectively.* These sections are organized in the following manner:

1. For each guideline, the major consideration(s) and associated contributing factors are identified.

2. The evaluation of each site on the basis of each major consideration is then summarized. The evaluation of each site with respect to each major consideration is presented in alphabetical order, by site.

3. The sites are then compared on the basis of the qualifying condition. This comparative evaluation describes the sites with the most favorable combination of characteristics first and those with a less favorable combination of characteristics last in order to allow easier comparison of the suitability evaluation of the site presented in Chapter 6 with sites having other combinations of characteristics.

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*Since the comparative evaluations in Section 7.2 and 7.3 are already a summary of information in Chapter 6, this executive summary does not attempt to further abstract the substance of the comparative evaluation. The DOE believes that a further synopsis of Section 7.2 and 7.3 for the purpose of this executive summary would distort the information and possibly mislead the reader.

7.2.2 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 EPA. The evaluations of these two system guidelines are based on preliminary performance assessments that consider the associated technical guidelines as the elements of the system. These evaluations are summarized directly from Sections 6.3.2 and 6.2.2.1 of each environmental assessment.

The system guidelines for environment, socioeconomics, and transportation, and for 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 from Section 6.2.2.2 and 6.3.4, in each environmental assessment.

Chapter 1

PROCESS FOR SELECTING SITES FOR GEOLOGIC REPOSITORIES

1.1 INTRODUCTION

By the end of this century, the United States plans to begin the operation of a geologic repository for the permanent disposal of commercial spent nuclear fuel and high-level radioactive waste.* Public Law 97-425, the Nuclear Waste Policy Act of 1982 (the Act), specifies the process for selecting a repository site and assigns to the U.S. Department of Energy (DOE) the responsibility for siting, constructing, operating, closing, and decommissioning the repository.

A number of alternative methods for disposing of spent nuclear fuel and high-level radioactive waste have been studied during the past 10 years (DOE, 1980a; EPA, 1979; Interagency Review Group, 1979; Schneider and Platt, 1974). After an extensive evaluation of these alternatives, as documented in the final environmental impact statement on the management of commercially generated radioactive waste (DOE, 1980a), the DOE chose disposal in mined geologic repositories as the preferred method and documented this decision in a notice published in the Federal Register (Vol. 46, p. 2667, May 14, 1981). Congress endorsed this preference 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)).

1.1.1 THE GEOLOGIC REPOSITORY CONCEPT

A geologic repository will be developed much like a large mine. Shafts will be constructed to allow for the removal of excavated material and to permit the construction of tunnels and disposal rooms at depths between 1,000 and 4,000 feet underground. Other shafts will be constructed to allow for the transfer of waste. Surface facilities will be provided for receiving and

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*High-level radioactive waste means (1) the highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations, and (2) other highly radioactive material that the U.S. Nuclear Regulatory Commission (NRC), consistent with existing law, determines by rule requires permanent isolation. The terms "radioactive waste" and "waste" are used for both spent fuel and high-level radioactive waste.

preparing the waste for emplacement underground. The surface and underground facilities will occupy about 400 and 2,000 acres of land, respectively. When the repository has been filled to capacity and its performance has been shown to be satisfactory, the surface facilities will be decommissioned and all shafts and boreholes will be backfilled and permanently sealed. A more detailed description of a conceptual design for a repository is presented in Section 5.1.

A repository can be viewed as a system of multiple barriers, both natural and engineered, that act together to contain and safely isolate the waste. The engineered barriers will include the waste package, the underground facility, and shaft and tunnel backfill materials. The waste package will consist of the waste form, either spent nuclear fuel or solidified high-level waste, a metal container, and specially designed backfill material to separate the waste container from the host rock. The waste package will contribute to long-term isolation by delaying eventual contact between the waste and the geologic environment. The underground facility will consist of underground openings and backfill materials not associated with the waste package. These barriers will further limit any ground-water circulation around the waste packages and impede the subsequent transport of radionuclides into the environment.

The geologic, hydrologic, and geochemical features of the site constitute natural barriers to the long-term movement of radionuclides to the accessible environment. These natural barriers will provide waste isolation by impeding radionuclide transport through the ground-water system to the accessible environment and will possess characteristics that will reduce the potential for human interference in the future.

Although the DOE plans to use engineered barriers--as required by both the Nuclear Regulatory Commission (NRC) in 10 CFR Part 60 and the Environmental Protection Agency (EPA) in 40 CFR Part 191--the DOE places primary reliance on the natural barriers for waste isolation. Therefore, in evaluating the suitability of sites, the use of an engineered-barrier system will be considered to the extent necessary to meet the performance requirements specified by the NRC and the EPA but will not be relied on to compensate for deficiencies in the natural barriers.

1.1.2 THE NUCLEAR WASTE POLICY ACT OF 1982

The search for suitable repository sites has been under way for about 10 years, although preliminary screening began in the mid-1950s. With the passage of the Act, a specific process for siting and licensing repositories was established. Through provisions for consultation and cooperation as well as financial assistance, the Act also established a prominent role in the siting process for potential host States, affected Indian Tribes, and the public. To pay the costs of geologic disposal, the Act provides for a Nuclear Waste Fund through which commercial electric utility companies are charged a fee that is based on the amount of electricity they produce in nuclear power plants. The DOE's strategy for implementing the Act is discussed in detail in the Mission Plan for the Civilian Radioactive Waste Management Program (DOE, 1985).

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

1. Vacherie Dome, Louisiana (salt dome)
2. Cypress Creek Dome, Mississippi (salt dome)
3. Richton Dome, Mississippi (salt dome)
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 location of these sites in their host States is shown in Figure 1-1.*

The Act further requires the DOE to issue general guidelines to be used in determining the suitability of sites. In February 1983, the DOE published draft General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories (DOE, 1983). The DOE revised the guidelines after receiving extensive comments from the NRC, the States, Indian Tribes, other Federal agencies, and the public. The NRC concurred with the revised guidelines in June 1984, and the final guidelines were promulgated in December 1984 (DOE, 1984a).

The Act requires that, after the guidelines are issued, the DOE nominate at least five sites as suitable for site characterization. The DOE must then recommend not fewer than three of those sites for characterization as candidate sites for the first repository. During site characterization, the DOE will construct exploratory shafts for underground testing to determine whether geologic conditions will allow the construction of a repository that will safely isolate radioactive waste. The Act requires the DOE to prepare site-characterization plans for review by the NRC, States, Indian Tribes, and the public. After site characterization and an environmental impact statement are completed, the DOE will recommend one of the characterized sites for development as the first repository.

1.1.3 THE ENVIRONMENTAL ASSESSMENT

The Act requires the DOE to prepare environmental assessments to serve as the basis for site nominations. Although not required by the Act, draft environmental assessments were prepared for each of the nine potentially acceptable sites and issued for comment by the NRC and other Federal agencies, the States, affected Indian Tribes, and the public. The DOE has considered the comments received on these drafts before making final decisions about

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*In Texas, the DOE first identified two locations that were up to 300 square miles in area. These were subsequently narrowed to 9 square miles. The other potentially acceptable sites identified in February 1983 were on the order of tens of square miles.

Figure 1-1. Potentially acceptable sites for the first repository.

nomination and recommendation. The issues raised by the comments and the DOE's responses are presented in Appendix C.

The final environmental assessments contain the following kinds of information and evaluations to meet the requirements of Section 112 of the Act:

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

1.2 SUMMARY OF THE OVERALL DECISION PROCESS

In seeking sites for geologic repositories, the DOE divides the siting process into the following phases: (1) screening, (2) site nomination, (3) recommendation for characterization, (4) site characterization, and (5) site selection (recommendation for development as a repository). This section describes the site-screening process that led to the identification of the nine potentially acceptable sites listed in Section 1.1 and reviews how the process of site nomination is implemented under the guidelines.

1.2.1 SITE SCREENING

During the screening phase, the DOE identified potentially acceptable sites for characterization. This phase provided the information needed for judging which of these sites appear to justify the investment in characterizing them. Screening consisted of as many as four stages, each of which progressively narrowed the study area to a smaller land unit. These stages were as follows:

1. A survey of the nation or geologic provinces, narrowing to regions. Regions are generally smaller than provinces but may extend across several States and occupy tens of thousands of square miles.

2. A survey of the regions, narrowing to areas, which encompass hundreds to thousands of square miles. For the salt sites, the regional screening phase was completed with the publication of regional characterization reports and area-recommendation reports.

3. A survey of the areas, narrowing to locations, which usually occupy an area smaller than 100 square miles. This phase was completed with the publication of location-recommendation reports for bedded salt and site-recommendation reports for salt domes.

4. A survey of the locations, narrowing to sites, which are generally smaller than 10 square miles. Although a location may be large enough to contain several sites, only one or two potential sites were usually identified in a particular location.

During each screening phase for the first repository, the DOE identified as many potentially suitable land units as were judged to be necessary for an adequate sample to be studied in the next stage. Only the regions and areas believed most likely to contain suitable sites received further study; the evaluation of all others was deferred.

Data for comparing regions, areas, and locations became increasingly detailed as progressively smaller land units were considered and as exploration and testing were concentrated on them. National, province, and regional surveys were based on the distribution of potential host rocks, published geologic maps, maps of earthquake epicenters, land use, available geohydrologic information, and other information available in the open literature. Area and location surveys required more-thorough investigations that included field exploration and testing and drilling of boreholes to investigate subsurface hydrologic, stratigraphic, and geochemical conditions. The field studies were supported by laboratory studies that focused on the waste-isolation and the engineering characteristics of potential host rocks.

The bedded-salt sites under consideration in Texas and Utah were identified by the general siting process described above, beginning with national surveys and progressively narrowing to areas, locations, and sites. The salt domes were selected by a screening that began with more than 200 domes and ended with the one site being nominated.

The screening of sites in basalt and tuff was initiated when the DOE began to search for suitable repository sites on some Federal lands where radioactive materials were already present. This approach was recommended by the Comptroller General of the United States (1979). Although land use was the beginning basis for this screening of Federal lands, the subsequent progression to smaller land units was based primarily on evaluations of geologic and hydrologic suitability. These studies began at roughly the area stage.

The technical factors used to guide site-screening decisions have evolved throughout the screening phase and are specified in a number of published documents (Brunton and McClain, 1977; DOE, 1981; DOE, 1982a; International Atomic Energy Agency, 1977; NAS-NRC, 1978).

The sections that follow summarize how the DOE applied the screening process outlined above to determine that the nine sites listed in Section 1.1.2 are potentially acceptable. Section 2.2 of each environmental assessment discusses in detail how the DOE conducted site screening in specific geohydrologic settings.

1.2.2 SALT SITES

Salt was first recommended as a potentially suitable host rock for waste disposal in 1955, after the National Academy of Sciences-National Research Council evaluated many options (NAS-NRC, 1957). This recommendation was reaffirmed in subsequent reports (e.g., American Physical Society, 1978; NAS-NRC, 1970). Rock salt, which occurs both as bedded salt and in salt domes, has several characteristics that are favorable for isolating radioactive waste, including the following:

- Salt deposits that are sufficiently deep, thick, and laterally extensive to accommodate a repository are widespread in the United States and generally occur in areas of low seismic and tectonic activity.

- Many salt bodies have remained undisturbed and water-free in comparison with other rock types for tens of millions to several hundred million years.

- Because of its high thermal conductivity, rock salt can dissipate the heat that will be generated by the waste.

- Since salt is relatively plastic under high confining pressure, the fractures that might develop at repository depth would tend to close and seal themselves.

- Rock salt undergoes only minor, highly local change as a result of exposure to radiation.

- Rock salt has excellent radiation-shielding properties.

Screening of the entire United States in the 1960s and 1970s resulted in the identification of four large regions that are underlain by rock salt of sufficient depth and thickness to accommodate a repository and represent diverse geohydrologic conditions (Johnson and Gonzales, 1978; Pierce and Rich, 1962). The four regions are as follows:

- Bedded salt in the Michigan and the Appalachian Basins of southern Michigan, northeastern Ohio, western Pennsylvania, and western New York (also called the "Salina Basin").

- Salt domes within a large part of the Gulf Coastal Plain in Texas, Louisiana, and Mississippi.

- Bedded salt in the Permian Basin of southwestern Kansas, western Oklahoma, northwestern Texas, and eastern New Mexico.

- Bedded salt in the Paradox Basin of southeastern Utah, southwestern Colorado, and northernmost Arizona and New Mexico.

This screening at the national level served as the basis for all subsequent screening in salt. After proceeding to the area phase, further screening of the salt deposits in the Salina Basin was deferred. The studies of the Salina region were not specific enough to judge that any part of the region was suitable or unsuitable for a repository. They did reveal a number of unfavorable characteristics, including a high population density associated with the concentration of urban areas in Ohio, Michigan, and New York, and an abundance of natural resources, especially oil and gas. In view of these unfavorable conditions, the DOE decided to concentrate its siting efforts on more-promising areas in the remaining three regions.

1.2.2.1 Salt domes in the Gulf Coast salt-dome basin of Mississippi and Louisiana

There are more than 500 salt domes in the Gulf Coast salt-dome basin of Texas, Louisiana, Mississippi, and areas offshore from these States. An initial screening by the U.S. Geological Survey (USGS) eliminated all offshore domes because siting a repository under water would probably not be feasible. The application of this criterion eliminated about half the domes. The USGS also evaluated the remaining 263 onshore domes (i.e., Gulf interior domes) and identified 36 as being potentially acceptable for a repository and another 89 that were worthy of further study (Anderson et al., 1973). The USGS screening factors were the depth to the top of the dome and present use for gas storage or hydrocarbon production.

The DOE and its predecessor agencies conducted regional studies of the 125 salt domes identified in the above-mentioned USGS screening. All but 11 of the domes were eliminated on the basis of three screening factors: the depth to the salt, the lateral extent of the dome, and the history of use for hydrocarbon production or storage (NUS, 1978; BNI and LETCO, 1980). Three of the 11 domes were removed from consideration on the basis of environmental factors, and a fourth was eliminated because solution mining at the site contributed to a collapse of strata above the dome.

Area-characterization studies were completed for the seven remaining dome areas: Rayburn's and Vacherie Domes in Louisiana; Cypress Creek, Lampton, and Richton Domes in Mississippi; and Keechi and Oakwood Domes in Texas. The geologic field work conducted during this phase included the drilling of deep holes to collect rock cores from the aquifers and other strata for laboratory tests of their properties and geophysical surveys to determine the underlying rock structures. The area environmental studies included descriptions of the plant and animal communities, surface- and ground-water systems, weather conditions, land use, and socioeconomic characteristics. An evaluation of the seven domes on the basis of the DOE's criteria is summarized in a location-recommendation report (ONWI, 1982a).

In the area-characterization studies, the DOE chose a repository-size criterion that was more restrictive than the one used in earlier screening studies. The application of this stricter criterion resulted in the

elimination of Keechi, Rayburn's, and Lampton Domes (ONWI, 1982a). Thus, at the conclusion of area characterization, the Vacherie, Richton, Oakwood, and Cypress Creek Domes were recommended for further screening. After further review of the area-characterization studies, the Oakwood Dome was deferred from further consideration because of uncertainties raised by large-scale petroleum exploration.

In accordance with the Act, the DOE identified the Cypress Creek, Richton, and Vacherie Domes as potentially acceptable sites in February 1983.

1.2.2.2 Bedded salt in Davis Canyon and Lavender Canyon, Utah

Screening criteria were developed for the bedded salt of the Paradox Basin, which the USGS had identified as worthy of further investigation (Pierce and Rich, 1962). The following factors were applied to identify areas for further investigation (Brunton and McClain, 1977; DOE, 1981): the depth to, and the thickness of, the salt; mapped faults; surface igneous features; hydrocarbon and mineral resources, and potential for flooding. The results of this screening were integrated with the results of screening for environmental and socioeconomic factors, such as proximity to urban areas and the presence of certain dedicated lands. On the basis of this regional screening, four areas were recommended for further study: Gibson Dome, Elk Ridge, Lisbon Valley, and Salt Valley (ONWI, 1982b).

The primary screening factors used to identify potentially favorable locations within the four areas were the depth to the salt, the thickness of the salt, proximity to faults and boreholes, and proximity to the boundaries of dedicated lands (ONWI, 1982c). These screening factors were judged to have the strongest potential for differentiating possible locations within the areas.

Salt Valley and Lisbon Valley were both deferred from further consideration because all areas with an adequate depth to the salt were too close to zones of mapped surface faults and, for Lisbon Valley, existing boreholes (ONWI, 1982c).

Application of the screening factors to the Gibson Dome showed a location of 57 square miles near the center of the area that contained appropriately deep and thick salt deposits and was sufficiently far from faults or exploration boreholes that would make a site unsuitable. It was also outside the boundaries of the Canyonlands National Park. This location is referred to as the Gibson Dome location (ONWI, 1982c). The Elk Ridge area contained one location of about 6 square miles and several smaller ones, each less than 3 square miles, that met the screening criteria (ONWI, 1982c). The smaller locations were not large enough for a repository and were therefore excluded from further consideration. The larger location was designated the Elk Ridge location.

Further comparisons of the Gibson Dome and the Elk Ridge locations were made on the basis of more-refined criteria that discriminated between them. The thickness of the salt, the thickness of the shale above and below the depth of a repository, and the minimum distance to salt-dissolution features

were considered the most critical geologic discriminators. Archaeological sensitivity and site accessibility were considered the most important environmental factors. The Gibson Dome location was judged to be superior to the Elk Ridge location in terms of the number and relative importance of favorable factors and was selected as the preferred location (ONWI, 1982c).

During 1982 and 1983 three sites were identified for further evaluation: Davis Canyon, Lavender Canyon, and Harts Draw. Since much of the intrinsic value of southeastern Utah stems from its scenic and aesthetic character, a study of visual aesthetics was performed to evaluate the three sites (Bechtel Group Inc., 1984). Harts Draw was found to be less desirable than the sites at Davis Canyon and Lavender Canyon because it affords a greater total area of visibility, and it was eliminated from further consideration. In February 1983, Davis Canyon and Lavender Canyon were identified as potentially acceptable sites.

1.2.2.3 Bedded salt in Deaf Smith and Swisher Counties, Texas

In 1976, the Permian bedded-salt deposits in the Texas Panhandle and western Oklahoma that had been identified in the USGS study (Pierce and Rich, 1962) were evaluated to determine whether they contained any areas that might be suitable for waste disposal (Johnson, 1976). This screening focused on five subbasins: the Anadarko, Palo Duro, Dalhart, Midland, and Delaware Basins. The primary screening factors were the depth to, and the thickness of, the salt; faults; seismic activity; salt dissolution; boreholes; underground mines; proximity to aquifers; mineral resources; and conflicting land uses, such as historical sites and State or national parks. All the subbasins contain salt beds of adequate thickness and depth. The Palo Duro and the Dalhart Basins had far less potential for oil and gas production and have not been penetrated as extensively by drilling as have the Anadarko, the Delaware, and the Midland Basins. Therefore, the Palo Duro and the Dalhart Basins were judged to be preferable to the other three and were recommended for further studies at the area stage (ONWI, 1983a). These two basins rated higher on six major screening factors: the depth to, and the thickness of, the salt; seismicity; known oil and gas deposits; the presence of exploratory boreholes; and evidence of salt dissolution.

More-detailed geologic and environmental studies of the Palo Duro and the Dalhart Basins began in 1977, and screening criteria were developed to define locations with favorable characteristics. The screening criteria that were most useful in the area-to-location screening were the following: salt depth and thickness, salt purity, existing and abandoned oil and gas fields, flooding, urban areas, and conflicting land use. Six locations in parts of Deaf Smith, Swisher, Oldham, Briscoe, Armstrong, Randall, and Potter Counties, Texas, met the screening criteria. A second set of criteria was then applied to further differentiate among the six locations: distance from the margins of the Southern High Plains, distance from known oil and gas fields, more than one potential repository horizon, depth of salt, number of boreholes that penetrate the repository horizon, a large geographic area, low population densities, and potential land-use conflicts. After applying these criteria, the DOE decided to focus on the two locations that had the greatest likelihood of containing a suitable site, one in northeastern Deaf Smith and southeastern

Oldham Counties and one in northcentral Swisher County. All other locations in the Palo Duro Basin were deferred from further consideration (ONWI, 1983b). In February 1983, the DOE identified parts of Deaf Smith County and Swisher County as potentially acceptable sites and subsequently narrowed the size of the two sites to be considered at each location to 9 square miles each (DOE, 1984b).

1.2.3 SITES IN BASALT AND TUFF

In 1977, the waste-disposal program was expanded to consider previous land use as an alternative basis for site screening. This approach considered the advantages of locating a repository on land already withdrawn from public use and committed to long-term institutional control. Because both the Hanford Site and the Nevada Test Site are dedicated to nuclear operations, will remain under Federal control, have a large geographic area, and are underlain by potentially suitable rocks, screening was initiated in these two areas.

1.2.3.1 Basalt lava in the Pasco Basin, Washington

The DOE and its predecessor agencies have investigated the geologic and hydrologic characteristics of the Pasco Basin since 1977 as a continuation of studies conducted for the defense-waste management program between 1968 and 1972 (Gephart et al., 1979; Myers et al., 1979). These investigations showed that the thick formations of basalt lava in the Pasco Basin are suitable for further investigation as a geologic repository for the following reasons:

- Several basalt flows more than 2,100 feet below ground apparently are thick enough to accommodate a geologic repository.
- The slow rate of deformation of the basalt ensures the long-term integrity of a repository at the Hanford Site. Also, there are synclines where structural deformation appears to be limited.
- The potential for renewed volcanism at the Hanford Site is very low.
- The likely geochemical reactions between the basalt rock, ground water, and the materials that would be emplaced in the repository are favorable for long-term isolation.

The Pasco Basin was selected for screening to provide a broader scope from which to study processes that might affect the Hanford Site and to determine whether there are any obviously superior sites in the natural region outside, but contiguous with, the Hanford Site (Woodward-Clyde Consultants, 1980, 1981).

The first step in screening was to define the candidate area. The screening factors used at this step were fault rupture, ground motion, aircraft traffic, ground transportation, operational radiation releases from nuclear facilities at the Hanford Site, protected ecological areas, culturally

important areas, and site-preparation costs. The DOE identified a candidate area that included the central part of the Hanford Site and adjacent land east of the Hanford Site.

The second step in the screening was to define subareas (locations). The siting factors used in this step were fault rupture, flooding, ground failure, erosion, the presence of hazardous facilities, induced seismicity, and site-preparation costs. This step eliminated approximately half the candidate area.

Locations were identified through an evaluation of the subareas inside and adjacent to the Hanford Site. On the basis of land use, hydrologic conditions, and bedrock dip, subareas outside the Hanford Site were eliminated because they were not obviously superior to those found within the Hanford Site. After these subareas were eliminated, five locations were identified within the boundaries of the Hanford Site.

The identification of sites from among the five locations was based on an evaluation of 23 parameters (Rockwell, 1980). Nine sites were identified, seven of which lay in the Cold Creek Syncline, a major structural feature of the Pasco Basin. This syncline was selected partly because it is not as extensively deformed as nearby anticlines and is underlain by relatively horizontal strata. Since the other two sites were not technically superior to those in the Cold Creek Syncline and were closer to the Columbia River, they were removed from further study. To avoid some geophysical anomalies of uncertain source, the DOE identified three other sites that were largely superimposed on parts of the original seven sites in the Cold Creek Syncline (Myers and Price, 1981).

Since preliminary evaluations of the resulting 10 partly overlapping sites indicated that the sites were too closely matched to be differentiated by routine ranking, a formal decision analysis was used to identify the best site (Rockwell, 1980). Decision criteria were derived from the following siting factors: bedrock fractures and faults, lineaments, potential earthquake sources, ground-water travel times, contaminated soil, surface facilities, the thickness of the proposed repository horizon, the repetitive occurrence of columnar-jointed zones (colonnades) within the host flow, natural vegetative communities, unique microhabitats, and special species. The analysis showed that two approximately coincident sites rated higher than the other sites. These two sites were combined and designated the reference repository location. In February 1983, the DOE identified the reference repository location as a potentially acceptable site.

1.2.3.2 Tuff in the southern Great Basin, Nevada

At the same time that the DOE was considering the Nevada Test Site (NTS) on the basis of land use, the USGS proposed that the NTS be considered for investigation as a potential repository site for a variety of geotechnical reasons, including the following:

- Southern Nevada is characterized by closed hydrologic basins. This means that ground water does not discharge into rivers that flow to major bodies of surface water.

- Long flow paths occur between potential repository locations and ground-water discharge points.

- Many of the rocks occurring at the NTS have geochemical characteristics that are favorable for waste isolation.

- The NTS is located in an arid region (6 to 8 inches per year of rainfall). With the very low rate of recharge, the amount of moving ground water is also low, especially in the unsaturated zone.

In 1977, the geologic medium of prime interest at the NTS was argillite (a clay-rich rock), which occurs under the Syncline Ridge, near the center of the NTS. Geologic investigations and exploratory drilling there revealed a complex geologic structure in the center of the area being considered (Hoover and Morrison, 1980; Ponce and Hanna, 1982). It was decided in July 1978 that the geologic complexity of the area would make characterization prohibitively difficult, and further evaluation was deferred.

A question then arose concerning the compatibility of a repository with the testing of nuclear weapons--the primary purpose of the NTS. A task group formed to evaluate this issue determined in 1978 that a repository located in other than the southwest portion of the NTS might be incompatible with weapons testing. At that time the program refocused on the area in and around the southwestern corner of the NTS, which subsequently was named the Nevada Research and Development Area (NRDA). The entire area then being evaluated included land controlled by the Bureau of Land Management west and south of the NRDA and a portion of the Nellis Air Force Range west of the NRDA.

In August 1978, a preliminary list of potential sites in and near the southwestern part of the NTS was compiled. The areas initially considered were Calico Hills, Skull Mountain, Wahmonie, Yucca Mountain, and Jackass Flats. Of these five areas, Calico Hills, Wahmonie, and Yucca Mountain were considered the most attractive locations for preliminary borings and geophysical testing.

The Calico Hills location was known to contain argillite. It was of particular interest because a geophysical survey showed that granite might occur approximately 1,600 feet below the surface. The first exploratory hole for waste-disposal studies at the NRDA was drilled in 1978 in an attempt to confirm the existence of granite beneath the Calico Hills. Drilling was discontinued at a depth of 3,000 feet without reaching granite (Maldonado et al., 1979). Additional geophysical surveys indicated that the argillite at Calico Hills is probably very complex structurally, comparable with that at Syncline Ridge (Hoover et al., 1982). Because the granite was considered too deep and the argillite appeared too complex, further consideration of the Calico Hills was suspended in the spring of 1979.

Concurrent with drilling at Calico Hills, geophysical studies and surface mapping conducted at Wahmonie indicated that the granite there may not be large enough for a repository, that any granite within reasonable depths may contain deposits of precious metals, and that faults in the rock may allow vertical movement of ground water (Hoover et al., 1982; Smith et al., 1981). For these reasons, Wahmonie was eliminated from consideration in the spring of 1979.

Surface mapping of Yucca Mountain indicated the existence of a generally undisturbed structural block large enough for a repository. In 1978, the first exploratory hole drilled at Yucca Mountain confirmed the presence of thick, highly sorptive units of tuff (Spengler et al., 1979). Because tuff previously had not been considered as a potential host rock for a repository, a presentation was made to the National Academy of Sciences (NAS) Committee for Radioactive Waste Management in September 1978 to solicit its views on the potential advantages and disadvantages of tuff as a repository host rock. The NAS committee supported the concept of investigating tuff as a potential host rock, and the USGS subsequently pointed out the considerable advantages of locating a repository in the unsaturated zone. After comparing the results of preliminary exploration at Calico Hills, Wahmonie, and Yucca Mountain, the USGS recommended that attention be focused on Yucca Mountain. A technical peer-review group supported the DOE's decision to concentrate exploration efforts on the tuffs of Yucca Mountain (DOE, 1980b).

Because the foregoing process of selecting Yucca Mountain for early exploration was not highly structured, a more thorough, formal analysis was begun in 1980 to evaluate whether Yucca Mountain was indeed appropriate for further exploration. This analysis was conducted in a manner compatible with the area-to-location phase of site screening described in the national siting plan (DOE, 1982b), which was used by the DOE before the passage of the Act and the formulation of the guidelines. Details of the formal analysis are presented by Sinnock and Fernandez (1984). In brief, this formal decision analysis evaluated 15 potential locations and concluded that Yucca Mountain was indeed the preferred location. Several potentially suitable horizons were identified in the saturated and unsaturated zones. Therefore, the DOE identified Yucca Mountain as a potentially acceptable site in February 1983.

1.2.4 NOMINATION OF SITES FOR CHARACTERIZATION

The guidelines, in 10 CFR Part 960.3, require the DOE to implement the following six-part decision process in selecting sites for nomination from among the potentially acceptable sites:

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

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

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

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

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

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

Section 1.3 presents the results of evaluating the nine potentially acceptable sites against the disqualifying conditions of the guidelines (step 1) and explains how the DOE has grouped the potentially acceptable sites by geohydrologic setting (step 2). Chapter 2 begins with a detailed description of the geohydrologic setting in which the Richton Dome site is located and provides the basis for the identification of a preferred site in that geohydrologic setting (step 3). Chapter 6 evaluates the site against the guidelines and presents the findings required in steps 4 and 5. Chapter 7 provides a comparative evaluation of the sites proposed for nomination (step 6).

Having issued the final EAs, the DOE will formally nominate five sites as suitable for characterization. The Secretary of Energy will then recommend three of these sites to the President as candidate sites for characterization. The Secretary's recommendation is presented and documented in a separate report that is being issued simultaneously with this environmental assessment.

1.2.5 FINAL STEPS IN THE SITE-SELECTION PROCESS

After the President approves the sites recommended by the Secretary, characterization activities will begin at those sites. If site characterization reveals new information that shows that a site is unsuitable for development as a repository under the guidelines, the DOE will eliminate that site from further consideration and take steps to reclaim the site and to mitigate any significant adverse impacts caused by site characterization. In the event that a site is eliminated from further consideration during characterization, the DOE does not expect to substitute another site for characterization.

After characterization is completed, the DOE will again evaluate each site against the guidelines, prepare an environmental impact statement, and recommend one site to the President for the first repository. The President may then recommend the site to the Congress. At this point, the Governor or the legislature of the host State may submit to the Congress a notice of disapproval that can be overridden only by a joint resolution of both Houses of the 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 the notice of disapproval is overridden, then, as prescribed by the Act, the site designation is effective, and the DOE will proceed to file an application with the NRC to obtain a construction authorization for a repository at that site.

1.3 EVALUATION OF POTENTIALLY ACCEPTABLE SITES AGAINST THE DISQUALIFYING CONDITIONS OF THE GUIDELINES AND GROUPING INTO GEOHYDROLOGIC SETTINGS

1.3.1 EVALUATION AGAINST THE DISQUALIFYING CONDITIONS

Having evaluated the nine potentially acceptable sites against the disqualifying conditions in the guidelines, the DOE has found no evidence to support a finding that any site is disqualified. Details of this analysis are contained in Chapter 6, and a summary of findings for each disqualifying condition is presented in Section 2.3.

1.3.2 DIVERSITY OF GEOHYDROLOGIC SETTINGS AND TYPES OF HOST ROCK

Sections 960.3-1-1 and 960.3-1-2 specify that, to the extent practicable, sites recommended as candidate sites for characterization shall be located in different geohydrologic settings and shall have different types of host rock. This guideline-mandated diversity of geohydrologic settings and host rocks is consistent with similar requirements in the NRC's rule governing the disposal of high-level radioactive waste, 10 CFR Part 60. This requirement will protect against the possibility that future investigations might reveal a generic deficiency in a given rock type or within a given regional geohydrologic environment. Such deficiencies might lead to the disqualification of sites in that setting or rock type. If one rock type or geohydrologic environment were viewed initially as the most favorable for a repository, site nomination and recommendation might be dominated by sites in that type of host rock or geohydrologic environment. If later analyses revealed an unacceptable weakness in either the host rock or in the characteristics of the geohydrologic environment, all candidate sites might have to be eliminated. This could leave the program with no viable alternatives available without lengthy additional site exploration.

The guidelines (Part 960.2) define "geohydrologic setting" as a system of geohydrologic units located within a geologic setting. They further define "geohydrologic unit" as an aquifer, a confining unit, or a combination of aquifers and confining units comprising a framework for a reasonably distinct geohydrologic system. A "geologic setting" encompasses thousands to hundreds of thousands of square miles and is characterized by general similarities in physiography, stratigraphy, structural style, and ground-water flow.

For the intents and purposes of the analyses contained in this environmental assessment, the term "geohydrologic setting" refers to a large and relatively distinct major geohydrologic province of the United States commonly identified and accepted in the technical literature. Such a geohydrologic province has recognizable distinct geologic, hydrologic, and geochemical characteristics and boundaries that distinguish it from other geohydrologic settings.

1.3.2.1 Geohydrologic classification system

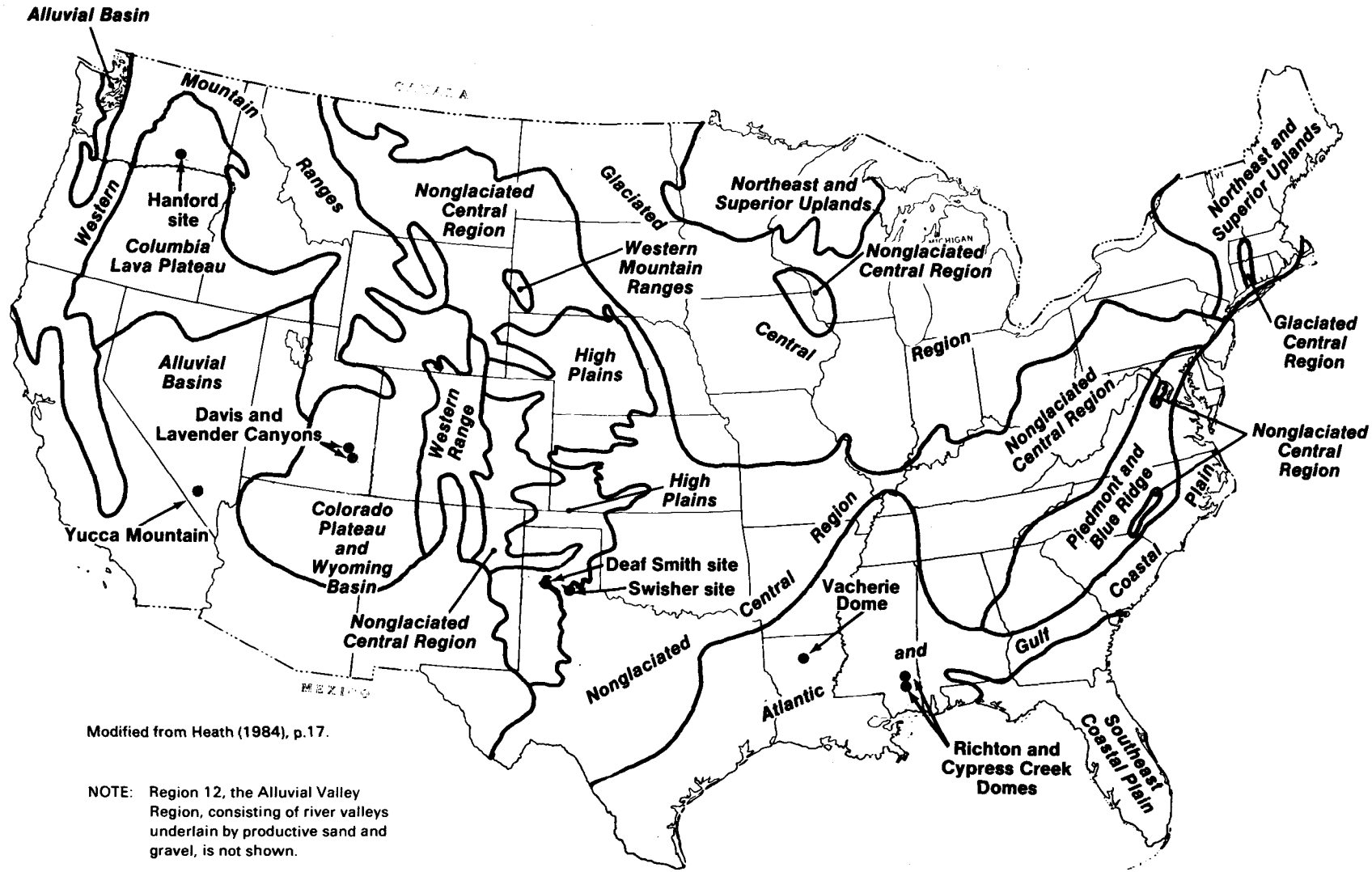
In a report entitled "Ground-Water Regions of the United States" (Heath, 1984), the USGS presents a classification that meets these broad criteria for geohydrologic settings. The USGS applied a logical set of criteria for classifying major geohydrologic regions that considers aquifers and confining units of the system, the nature of water-bearing openings in the rocks, the composition of the rocks, the water-transmitting and water-storage properties of the rocks, and the nature and location of recharge and discharge areas. These characteristics are also those that relate to repository performance (ground-water pathways, rates of radionuclide migration, and other factors important to waste isolation). Therefore, these general criteria appear suitable for application to this guideline requirement.

The USGS classification resulted in the delineation of 12 geohydrologic regions in the contiguous United States (see Figure 1-2). The specific rationale for the delineation and characteristics of each region is described in Heath's report.

It is within the framework of the USGS geohydrologic regions that the nine potentially acceptable sites were examined and classified as to their particular geohydrologic setting. In addition to the general criteria used in the USGS classification, other considerations were used to further subdivide the regions on the basis of tectonic activity, geologic structure, subbasins within the regions, and so on. Accordingly, the DOE has determined that the nine sites fall within the following five distinct geohydrologic settings (the name of the region within which each geohydrologic setting is located is listed in parentheses):

Geohydrologic setting	Site
Columbia Plateau (Columbia Lava Plateau)	Reference repository location as on the Hanford Site, Washington
Great Basin (Alluvial Basins)	Yucca Mountain, Nevada
Permian Basin (High Plains)	Deaf Smith County and Swisher County, Texas
Paradox Basin (Colorado Plateau and Wyoming Basin)	Lavender and Davis Canyons, Utah
Gulf Coastal Plain (Atlantic and Gulf Coastal Plain)	Vacherie Dome, Louisiana; Cypress Creek Dome and Richton Dome, Mississippi

The fundamental distinguishing characteristics associated with these settings as they relate to waste isolation are briefly described below. More-specific details on the characteristics of each of the geohydrologic settings are presented in Section 2.1.



Modified from Heath (1984), p.17.

NOTE: Region 12, the Alluvial Valley Region, consisting of river valleys underlain by productive sand and gravel, is not shown.

Figure 1-2. Geohydrologic regions of the contiguous United States.

1.3.2.2 Distinct differences among the geohydrologic settings and host rocks

The major distinguishing differences among the five geohydrologic settings of the nine potential repository sites are summarized below.

The Hanford and the Yucca Mountain sites are clearly unique in terms of the host rock, the geologic conditions, and the hydrologic conditions that make up the geohydrologic setting. The Hanford site is located within the Pasco Basin, which is a subunit of the Columbia Lava Plateau geohydrologic setting as defined by Heath (1984). It is underlain by a thick, extensive sequence of rocks composed entirely of basalt lava flows in the lower part and of increasing amounts of interbedded, sedimentary deposits in the upper part. Aquifers generally are in the upper parts of the lava flows and in the interbeds. Ground-water drainage is to the Columbia River or its tributaries.

The Yucca Mountain site is located in a region composed of alternating sequences of block-faulted mountains and alluvium-filled valleys of the Alluvial Basins geohydrologic setting as defined by Heath. Yucca Mountain is a typical small fault-block mountain in this region and is composed entirely of volcanic rocks called tuff. The site is in the relatively dry unsaturated welded zone, well above the water table. This is a unique geohydrologic setting in comparison with the other sites, which are all situated well below the water table. The Hanford site will rely principally on the interaction of the low permeability of the dense basalts, the ion-exchange characteristics of the host rock, and a long ground-water flow path for waste isolation. The Yucca Mountain site will rely principally on a very low water flux through unsaturated rocks in a very arid environment, the natural ability of this type of system to exclude flowing or standing water from the repository, and the sorption characteristics of the minerals in the host rock.

The salt-site settings are also clearly distinguishable from one another, but perhaps not as obviously as the nonsalt sites. The first distinction among the salt settings is between salt domes and bedded salt. Although both bedded and dome salt have salt as a host rock, the properties of the two types of salt are quite different, and the hydrologic framework of salt differs greatly from setting to setting. Bedded salt occurs as sedimentary layers of salt and impurities and is typically bounded by aquifers above or below the salt units or both. The domes are anomalous piercements of the thick unconsolidated to semiconsolidated sedimentary clays, silts, and sands that make up the Atlantic and Gulf Coastal Plain, as defined by Heath. The domes are surrounded by aquifers at different depths. Thus, the geohydrologic conditions around the domes are distinctly different from that of bedded salt.

The pathways and mechanisms by which radionuclides might reach the accessible environment are also quite different for bedded and dome salt because of their fundamental structural and stratigraphic differences. Salt domes originated from thick beds of deeply buried salt. When sediments were deposited on these salt beds, the salt was forced upward, forming a dome. Some domes have risen as much as 20,000 feet above their source rock. The salt rock was intensely deformed and "kneaded" during this intrusive rise of the salt dome; as a result, nearly all of the water originally contained in the salt was squeezed out. Consequently, salt domes contain less water than

salt beds. In addition, and largely because of the different mode of formation, the following differences between the two types of salt rock are noteworthy:

- Because of its higher water content, bedded salt has a lower strength than dome salt.
- At equal depths of burial, bedded salt has lower geothermal temperatures than dome salt.
- Bedded salt tends to have a faster rate of creep than dome salt.
- Bedded salt has a more variable chemical composition than dome salt.
- Bedded salt has a simpler structure than salt domes.

Some of the most important of the above factors affecting waste isolation at salt sites are related to the chemical composition and configuration of the host rock. All salt sites would rely primarily on the extremely low permeability of the salt and the isolation of the host rock from surrounding aquifers. One significant potential failure mechanism in salt that can affect ground-water flow is the dissolution of the salt in ground water, whether initiated by inadvertent human intrusion or by unexpected salt deformation. The nature and the relative importance of this failure mechanism differ significantly for bedded and dome salt in their respective geohydrologic environments. For example, at salt domes dissolution would occur along the flanks by ground water from surrounding sedimentary strata. The dissolution of bedded salt could be induced by laterally migrating dissolution fronts, inter-salt-bed sedimentary aquifers, or vertically circulating water in fault zones.

Finally, although the Paradox Basin in Utah and the Permian Basin in Texas are both bedded-salt settings, they also have significant differences that warrant considering them as separate and distinct geohydrologic settings. The bedded-salt sites in Swisher and Deaf Smith counties, Texas, are located in the High Plains setting as defined by the USGS. This setting is underlain by relatively horizontal bedded sedimentary rocks that are capped by the partially unconsolidated sands, gravels, and clays of the Ogallala Formation. The geohydrologic system is dominated by the High Plains aquifer (the Ogallala Formation). Other aquifers, such as the Triassic Dockum Group, occur in deeper strata, but they produce poor-quality water in comparison with the Ogallala.

The bedded-salt sites of Davis Canyon and Lavender Canyon, Utah, on the other hand, are located in the Paradox Basin, which is a subsetting of the Colorado Plateau and the Wyoming Basin and is characterized by a broad uplifted plateau consisting of gently folded sedimentary sandstones, shales, carbonates, and evaporites. The stratigraphic sequence includes a few low-yield aquifers that generally contain poor-quality water. Ground water generally flows toward drainage systems in deeply dissected canyons of the region. Other specific differences include the following:

- Because of overburden and tectonic stresses, the Paradox Basin salt deposits have been structurally deformed into anticlines and synclines

(thickened and thinned zones) much more than the Permian Basin salt deposits have.

- The recharge and discharge patterns of ground water in the two settings are expected to be significantly different.

- The age, stratigraphic sequence, depositional history, and mineral composition of the salts and interbeds in two settings are different.

- The elevation, climate, and physiography of the two settings are significantly different.

- The ground-water system of the Paradox Basin sites is dominated by a deep aquifer well below the repository level, of low yield and poor water quality, whereas the ground-water system at the Permian Basin sites is dominated by a shallow productive aquifer well above the repository level.

On the basis of the criteria and known site characteristics presented above, the DOE has concluded that the nine potentially acceptable sites lie within five distinctly different geohydrologic settings, as indicated, and four distinctly different types of host rock (basalt, welded tuff, bedded salt, and dome salt).

REFERENCES FOR CHAPTER 1

American Physical Society, 1978. "Report to the American Physical Society by the Study Group on Nuclear Fuel Cycles and Waste Management," Reviews of Modern Physics, Vol. 50, No. 1, Part II.

Anderson, R. E., D. H. Eargle, and B. O. Davis, 1973. Geologic Hydrologic Summary of Salt Domes in Gulf Coast Region of Texas, Louisiana, Mississippi, and Alabama, U.S. Geological Survey, Open-File Report USGS-4339-2.

Bechtel Group, Inc., 1984. Visual Aesthetics Study: Gibson Dome Area, Paradox Basin, Utah, ONWI-454, Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, Ohio.

BNI and LETCO (Bechtel National, Inc. and Law Engineering Testing Company), 1980. Summary Characterization and Recommendation of Study Areas for the Gulf Interior Region, ONWI-18, Prepared for Office of Nuclear Waste Isolation, Battelle, Memorial Institute, Columbus, Ohio.

Brunton, G. D., and W. C. McClain, 1977. Geological Criteria for Radioactive Waste Repositories, Y/OWI/TM-47, Office of Waste Isolation. Oak Ridge, Tenn.

Comptroller General of the United States, 1979. The Nation's Nuclear Waste--Proposals for Organization and Siting, EMD-79-77, General Accounting Office, June 21, 1979.

DOE (U.S. Department of Energy), 1980a. Final Environmental Impact Statement--Management of Commercially Generated Radioactive Waste, DOE/EIS-0046-F, Washington, D.C.

DOE (U.S. Department of Energy), 1980b. Nevada Nuclear Waste Storage Investigations, 1979 Peer Review Summaries and Related Documentation, NVO-196-16, Nevada Operations Office, Las Vegas, Nev.

DOE (U.S. Department of Energy), 1981. NWTS Program Criteria for Mined Geologic Disposal of Nuclear Waste: Site Performance Criteria, DOE/NWTS-33(2), Office of NWTS Integration, Battelle Memorial Institute, Columbus, Ohio.

DOE (U.S. Department of Energy), 1982a. Program Objectives, Functional Requirements, and System Performance Criteria, NWTS 33(1), Office of NWTS Integration, Battelle Memorial Institute, Columbus, Ohio.

DOE (U.S. Department of Energy), 1982b. National Plan for Siting High-Level Radioactive Waste Repositories and Environmental Assessment, DOE/NWTS-4, DOE/EA-151, Office of NWTS Integration, Battelle Memorial Institute, Columbus, Ohio.

DOE (U.S. Department of Energy), 1983. "Proposed General Guidelines for Recommendation of Sites for Nuclear Waste Repositories," Federal Register, Vol. 48, p. 5670, February 7, 1983.

DOE (U.S. Department of Energy), 1984a. "General Guidelines for Recommendation of Sites for the Nuclear Waste Repositories; Final Siting Guidelines," 10 CFR Part 60, Federal Register, Vol 49, p. 47714, December 6, 1984.

DOE (U.S. Department of Energy), 1984b. Identification of Sites Within the Palo Duro Basin, Volume 1, "Palo Duro Location A," DOE/CH-(1); Volume 2 "Palo Duro Location B," DOE/CH-(2); and Volume 3, "Responses to Comments," DOE/CH-(3), Washington, D.C.

DOE (U.S. Department of Energy), 1985. Mission Plan for the Civilian Radioactive Waste Management Program, Vols. I, II, and III, DOE/RW-0005, Washington, D.C.

EPA (U.S. Environmental Protection Agency), 1979. Alternative Disposal Concepts for High-Level and Transuranic Radioactive Waste Disposal, ORP/CSD 79-1, Washington, D.C.

Gephart, R. E., R. C. Arnett, R. G. Baca, L. S. Leonhart, and F. A. Spane, Jr., 1979. Hydrologic Studies Within the Columbia Plateau, Washington: An Integration of Current Knowledge, RHO-BWI-ST-5, Rockwell Hanford Operations, Richland, Wash.

Heath, R. C., 1984 Ground-Water Regions of the United States, U.S. Geological Survey, Water Supply Paper 2242.

Hoover, D. L., and J. N. Morrison, 1980. Geology of the Syncline Ridge Area Related to Nuclear Waste Disposal, Nevada Test Site, Nye County, Nevada, USGS-OFR-80-842, U.S. Geological Survey, Denver, Colo.

Hoover, D. L., M. P. Chornack, K. H., Nervick, and M. M. Broker, 1982. Electrical Studies at the Proposed Wahmonie and Calico Hills Nuclear Waste Sites, Nevada Test Site, Nye County, Nevada, USGS-OFR-82-466, U.S. Geological Survey, Denver, Colo.

Interagency Review Group, 1979. Report to the President by the Interagency Review Group on Nuclear Waste Management, NTIS Report TID 29442, U.S. Department of Energy, Washington, D.C.

International Atomic Energy Agency, 1977. Site Selection Factors for Repositories of Solid High-Level and Alpha Bearing Wastes in Geologic Formations, Technical Report No. 177, Vienna, Austria.

Johnson, K. S., 1976. Evaluation of Permian Salt Deposits in the Texas Panhandle and Western Oklahoma for Underground Storage of Radioactive Wastes, Y/OWI/SUB-4494/1, Office of Waste Isolation, Oak Ridge, Tenn.

Johnson, K. S., and S. Gonzales, 1978. Salt Deposits in the United States and Regional Geologic Characteristics Important for Storage of Radioactive Waste, Y/OWI/SUB-7414/1, Office of Waste Isolation, Oak Ridge, Tenn.

Maldonado, F., D. C. Muller, and J. N. Morrison, 1979. Preliminary Geologic and Geophysical Data of the UE25a-3 Exploratory Drill Hole, Nevada Test Site, Nevada, USGS-1543-6, U.S. Geological Survey, Denver, Colo.

Myers, C. W., and S. M. Price (eds.), 1981. Subsurface Geology of the Cold Creek Syncline, RHO-BWI-ST-14, Rockwell Hanford Operations, Richland, Wash.

Myers, C. W., et al., 1979. Geologic Studies of the Columbia Plateau: A Status Report, RHO-BWI-ST-4, Rockwell Hanford Operations, Richland, Wash.

NAS-NRC (National Academy of Sciences-National Research Council), 1957. The Disposal of Radioactive Waste on Land, Report of the Committee on Waste Disposal, Division of Earth Sciences, Publication 519, Washington, D.C.

NAS-NRC (National Academy of Sciences-National Research Council), 1970. Disposal of Solid Radioactive Wastes in Bedded Salt Deposits, Committee on Radioactive Waste Management, Washington, D.C.

NAS-NRC (National Academy of Sciences-National Research Council), 1978. Geologic Criteria for Repositories for High-Level Radioactive Waste, Washington, D.C.

NUS Corporation, 1978. Nongeologic Criteria for Radioactive Waste Repositories (draft), Y/OWI/SUB-77/16504/10, Office of Nuclear Waste Isolation, Oak Ridge, Tenn.

ONWI (Office of Nuclear Waste Isolation), 1982a. Evaluation of Area Studies of the U.S. Gulf Coast Salt Dome Basins: Location Recommendation Report, ONWI-109, Battelle Memorial Institute, Columbus, Ohio.

ONWI (Office of Nuclear Waste Isolation), 1982b. Summary Characterization and Recommendation of Study Areas for the Paradox Basin Region, ONWI-36, Battelle Memorial Institute, Columbus, Ohio.

ONWI (Office of Nuclear Waste Isolation), 1982c. Paradox Area Characterization Summary and Location Recommendation Report, ONWI-291, Battelle Memorial Institute, Columbus, Ohio.

ONWI (Office of Nuclear Waste Isolation), 1983a. Regional Summary and Recommended Study Areas for the Texas Panhandle Portion of the Permian Basin, ONWI-28, Battelle Memorial Institute, Columbus, Ohio.

ONWI (Office of Nuclear Waste Isolation), 1983b. Permian Basin Location Recommendation Report, DOE/CH/10140-2, U.S. Department of Energy, Washington, D.C.

Pierce, W. G., and E. I. Rich, 1962. Summary of Rock Salt Deposits in the United States as Possible Storage Sites for Radioactive Waste, Bulletin 1148, U.S. Geological Survey, Washington, D.C.

Ponce, D. A., and W. F. Hanna, 1982. Preliminary Appraisal of Gravity and Magnetic Data at Syncline Ridge, Western Yucca Flat, Nevada Test Site, Nye County, Nevada, USGS-OFR-82-931, U.S. Geological Survey, Denver, Colo.

Rockwell, 1980. Identification of Candidate Sites Suitable for a Geologic Repository in Basalt Within Hanford, RHO-BWI-LD-24, Rockwell Hanford Operations, Richland, Wash.

Schneider, K. J., and A. M. Platt (eds.), 1974. High-Level Radioactive Waste Management Alternatives, BNL-1900, Battelle Northwest Laboratories, Richland, Wash.

Sinnock, S., and J. A. Fernandez, 1984. Location Performance Objectives for the NNWSI Area-to-Location Screening Activity, SAND82-0837, Sandia National Laboratories, Albuquerque, N.M.

Smith, C., H. P. Ross, and R. Edquist, 1981. Interpreted Resistivity and IP Section Line W1, Wahmonie Area, Nevada Test Site, Nevada, USGS-OFR-81-1350, U.S. Geological Survey, Denver, Colo.

Spengler, R. W., D. C. Muller, and R. B. Livermore, 1979. Preliminary Report on the Geology and Geophysics of Drill Hole UE25a-1, Yucca Mountain, Nevada Test Site, USGS-OFR-79-1244, U.S. Geological Survey, Denver, Colo.

Woodward-Clyde Consultants, 1980. Site Locality Identification Study: Hanford Site, two volumes, RHO-BWI-C-62, Rockwell Hanford Operations, Richland, Wash.

Woodward-Clyde Consultants, 1981. Study To Identify a Reference Repository Location for a Nuclear Waste Repository on the Hanford Site, two volumes, RHO-BWI-C-107, Rockwell Hanford Operations, Richland, Wash.

STATUTES AND REGULATIONS

Nuclear Waste Policy Act of 1982. Public Law 97-425, 42 USC 10101-10226, 1983.

10 CFR Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories," Code of Federal Regulations, Title 10, Part 60.

10 CFR Part 960, "General Guidelines for the Recommendation of Sites for the Nuclear Waste Repositories," Code of Federal Regulations, Title 10, Part 960.

40 CFR Part 191, "Environmental Standards for the Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes," Code of Federal Regulations, Title 40, Part 191.

Chapter 2

SITE SELECTION PROCESS - GULF COAST SALT DOME BASIN

As discussed in Section 1.2.2.1, site screening activities have identified Vacherie, Cypress Creek, and Richton Domes within the Gulf Coast Salt Dome Basin as acceptable salt sites for further study as potential nuclear waste repository sites.

The Vacherie Dome site is located on the Webster/Bienville Parish line in Louisiana, approximately 55 kilometers (34 miles) southeast of Shreveport, Louisiana. The Cypress Creek and Richton Dome sites are located in Perry County, Mississippi, approximately 32 kilometers (20 miles) southeast and 30 kilometers (18 miles) east of Hattiesburg, Mississippi, respectively.

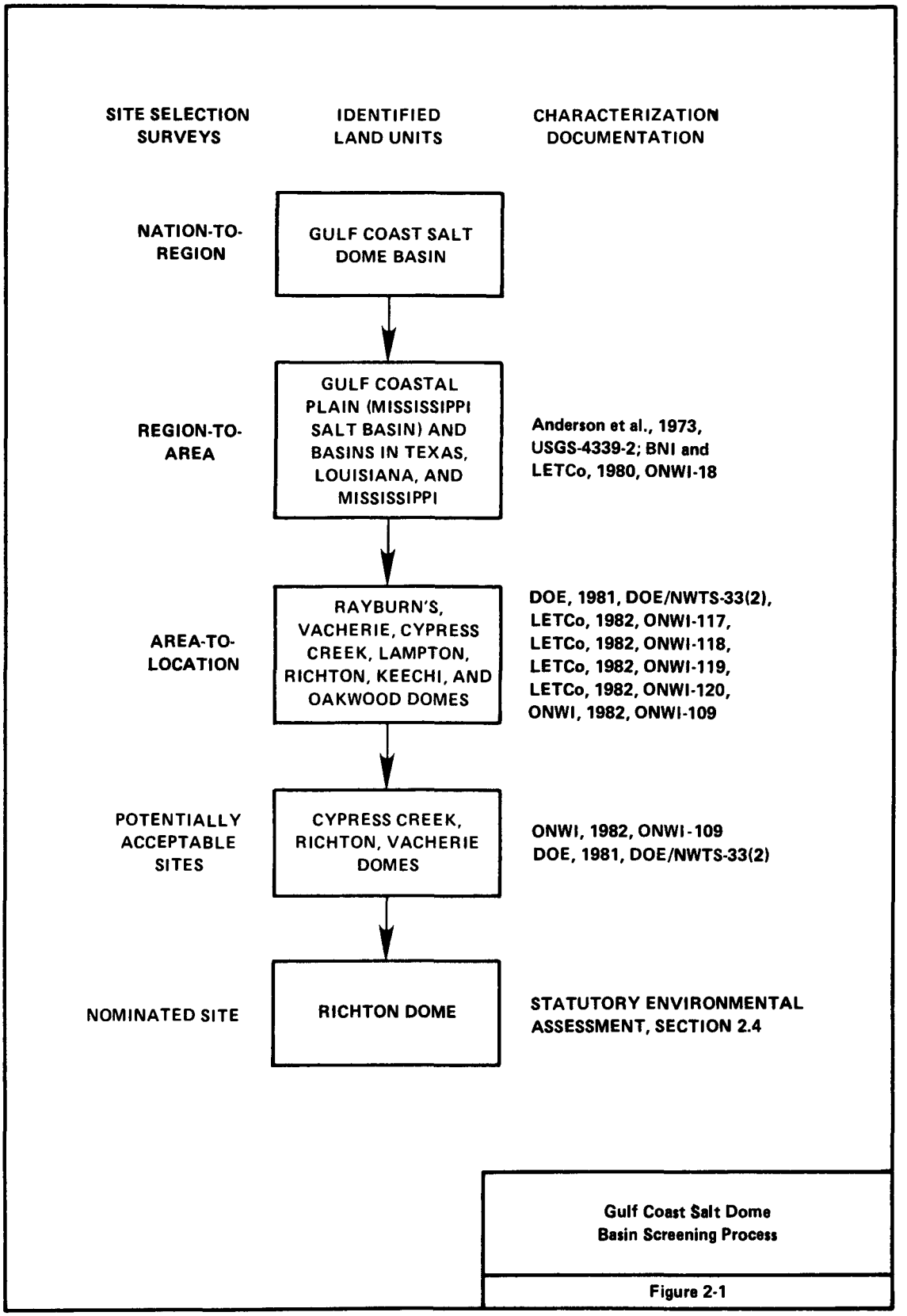
This chapter describes the process and analyses used to identify and select the preferred site(s) from among the salt domes of the Gulf Coast Salt Dome Basin (Figure 2-1). Section 2.1 describes the geohydrologic setting of the region; Section 2.2 describes how potentially acceptable sites were identified; Section 2.3 summarizes an evaluation of the identified sites against explicit disqualifying conditions set forth in U.S. Department of Energy (DOE) "General Guidelines for Recommendation of Sites for Nuclear Waste Repositories" (DOE, 1984, 10 CFR Part 960); and Section 2.4 presents a comparative evaluation of the three salt domes and identifies the salt dome being nominated for site characterization.

2.1 GEOHYDROLOGIC SETTING

Screening studies of the Gulf Coast region have been completed through the Regional and Area phases. As a result of these studies, Vacherie Dome in the Northern Louisiana Salt Basin, and Richton and Cypress Creek Domes in the Mississippi Salt Basin were identified as potentially acceptable sites for further study; sites in the East Texas Salt Basin were deferred from further consideration. Similarities in the geologic history and geologic characteristics of the Mississippi and Northern Louisiana Salt Basins allow a determination to be made that Richton, Vacherie, and Cypress Creek Domes all occupy the same geohydrologic setting (Figure 2-2). "Geohydrologic setting" is defined in 10 CFR 960.2 as a system of geohydrologic units located within a geologic setting. "Geohydrologic unit" is further defined as an aquifer, a confining unit, or a combination of aquifers and confining units comprising a framework for a reasonably distinct geohydrologic system. "Geologic setting" refers to the geologic, hydrologic, and geochemical systems of the region in which a geologic repository operations area is or may be located.

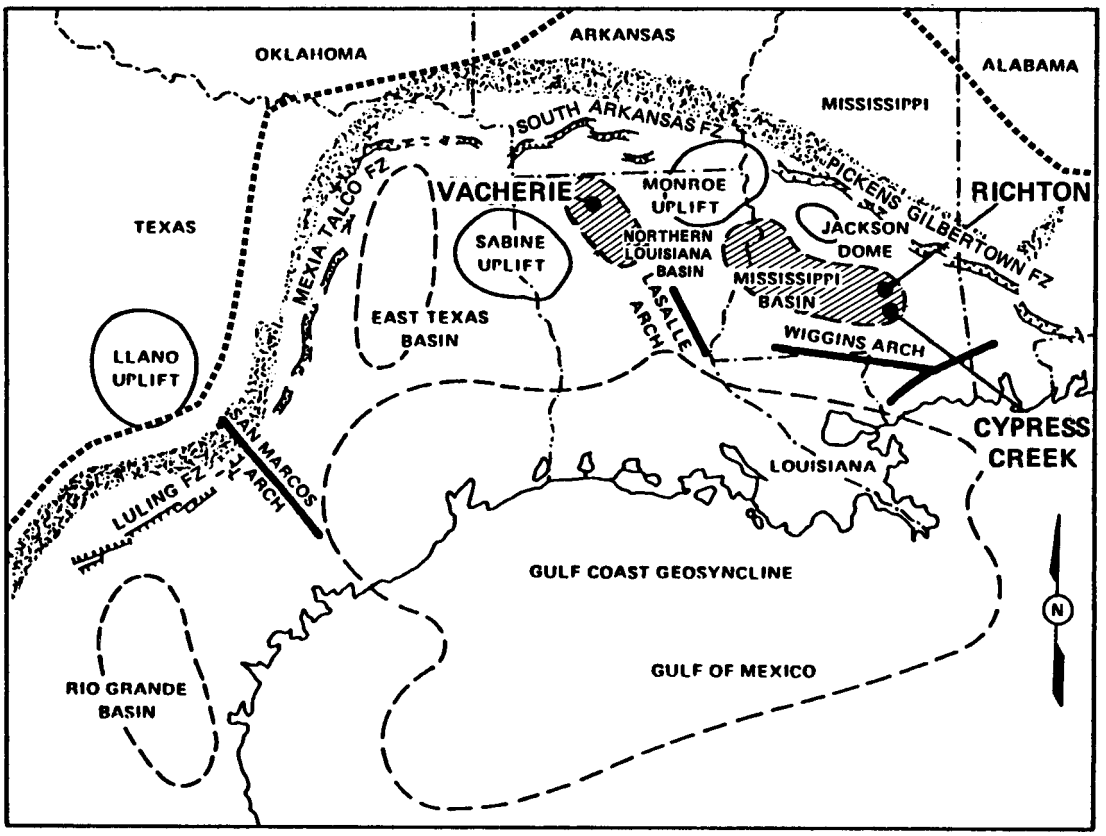
Although local variations in geologic and hydrologic characteristics can be described, the rationale for consideration of the Northern Louisiana and the Mississippi Salt Basins as one setting has been described in a position paper prepared by the Salt Repository Project Office (Neff, 1984) and summarized as follows:

- Both salt basins lie within the same physiographic province (McGuinness, 1963)
- Both salt basins lie within the same structural province (Halbouty, 1979)
- Both salt basins lie within the same ground-water province (Meinzer, 1939; Halbouty, 1979)
- Both salt basins exhibit the structure of interior basins formed by similar processes during the Triassic Period as part of the Gulf Coast geosyncline (Seni and Jackson, 1983)
- Confined aquifers in both basins are recharged where they are exposed to the north and discharge to the south into the Gulf of Mexico (Meinzer, 1939)



Gulf Coast Salt Dome Basin Screening Process

Figure 2-1



Explanation

Edge of Gulf Coast Salt Dome Basin

Boundary of Gulf Coastal Plain Physiographic Province

FZ Fault Zone

Scale

0 100 200 Km

0 100 200 Mi

The Gulf Coast Region Showing the Locations of Candidate Salt Domes and Major Structural Features

Source: Halbouty, 1979, p. 15

Figure 2-2

- Surface aquifers contain good supplies of potable waters and the deeper aquifers are progressively saline (sodium chloride type) with depth (Meinzer, 1939)

- Growth histories for salt domes have resulted in development of similar internal conditions and material properties (inferred from Seni and Jackson [1983]).

2.2 IDENTIFICATION OF THE POTENTIALLY ACCEPTABLE SITES

Potentially acceptable salt dome sites were identified using a succession of surveys. In each phase of the identification process, studies were conducted to evaluate land units against established criteria, resulting in selection of a smaller number of domes for more detailed inspection in the following phase. The first survey and screening step, the National Survey (Section 1.2.1), identified the Gulf Coast as one of four large regions of the United States containing salt deposits (Anderson et al., 1973). Further region-to-area and area-to-potentially-acceptable-site screening studies resulted in the identification of Vacherie, Cypress Creek, and Richton Domes as potentially acceptable sites.

The decision as to which successively smaller land units represented the most promising land areas for further study was made using those criteria at each screening step that best provided a means of differentiation. The DOE/NWTS-33(2) criteria (DOE, 1981), which include geologic, hydrologic, geochemical, demographic, environmental, and socioeconomic factors, were formally established in 1981. These same basic criteria had been considered by many investigators since the 1950s (NAS-NRC, 1957, 1970; Brunton and McClain, 1977; Brunton et al., 1978; NUS, 1978; ONWI, 1980, ONWI-33(2)) for nuclear waste storage sites. Table 2-1 lists the criteria and factors from DOE/NWTS-33(2) (DOE, 1981).

Those criteria that provided the principal basis for distinguishing preferences among the alternatives at each of the screening steps are designated in Table 2-1 with an "X". Not all criteria and screening factors were used at <u>each</u> step of the screening process, although all factors were applied at some stage in the overall process. However, not all criteria provided a clear differentiation between sites (salt domes) based on information available at different stages in the process.

2.2.1 <u>Region-to-Area Screening</u>

Regional surveys defined the number of salt domes available for consideration, eliminated domes with obvious suitability flaws, and established technical criteria similar to those in DOE/NWTS-33(2) (DOE, 1981). Regional surveys conducted to obtain geologic and environmental characterization information for the Gulf Coast were based on a review of existing data obtained primarily from published scientific reports and journal articles (LETCo, 1981, ONWI-106). Additional geologic data sources included geologic maps; drilling records from oil, gas, and mineral exploration programs; and records of earthquake occurrences and intensities. For the environmental characterization surveys, supplemental data sources included topographic maps and State and Federal agency reports (BNI, 1980, ONWI-67). No field activities were conducted during regional screening.

Within the three Gulf Coast Salt Basins including portions of Texas, Louisiana, and Mississippi and the adjacent offshore area (Figure 2-2), more than 500 salt domes have been identified. An initial screening by the U.S. Geological Survey (USGS) eliminated offshore salt domes as possible geologic repository sites because "siting in offshore salt structures would add unnecessary complications to a plan that requires assurance of a dry repository, including conventional shafts, conventional access, continuously reliable utilities, etc." (Anderson et al., 1973, p. 5). This reduced the number of potential domes in the Gulf Coast Salt Dome Basin to 263 onshore domes.

Table 2-1. National Waste Terminal Storage (NWTS) Screening Factors

Criteria and Screening Factors[a]	Region-to-Area	Area-to-Potentially-Acceptable-Site
Criterion I[b]. Site Geometry		
1. Minimum Depth	X	X
2. Thickness and Lateral Extent	X	X
Criterion II. Geohydrology		
1. Geohydrological Regime/Aquifer Characterization		
2. Hydrologic Regime, Modeling Surface/Subsurface		
3. Geohydrologic Regime/Shaft Seals/Flow Rates		
4. Subsurface Dissolution Rates		X
Criterion III. Geochemistry		
1. Chemical Interactions/ Radionuclide Retardation		
Criterion IV. Geologic Characteristics		
1. Stratigraphy Characterization		
2. Host Rock/Stress Phenomena		
3. Undue Hazards to Repository Personnel		
Criterion V. Tectonic Environment		
1. Tectonic Element Evaluation		
2. Quaternary Faults		X
3. Quaternary Igneous Activity		
4. Uplift/Subsidence Rates		
5. Seismicity/Ground Motion/Credible Earthquake		
Criterion VI. Human Intrusion		
1. Exploration History/Use	X	X
2. Ownership and Control		
Criterion VII. Surface Characteristics		
1. Surficial Hydrologic System/ Characteristics		X
2. Surface Topographic Features		
3. Meteorological Phenomena		
4. Industrial, Transportation, and Military Installations and Operations		
Criterion VIII. Demography		
1. Population Density/Urban Proximity	X	
2. Risk to Population		
Criterion IX. Environmental Protection		
1. Potential Environmental Impacts		X
2. Air, Water, Land-Use Conflicts	X	X
3. Consideration of Normal and Extreme Environmental Conditions		
Criterion X. Socioeconomic Impacts		
1. Social/Economic Impacts		X
2. Transportation, Access, Utility		

(a) For a full statement of each criterion and factors considered, see DOE, 1981, DOE/NWTS-33(2).

(b) See Table 2-3 for evaluation of domes using these differentiating factors.

X = Denotes a differentiating factor.

The USGS next evaluated the 263 onshore domes using screening criteria of (1) maximum depth to the top of the salt dome less than 610 meters (2,000 feet) below the ground surface, and (2) lack of previous use of the dome by industry for gas storage or the production of oil, salt, or sulfur. The results of this screening identified 36 domes as being "potentially acceptable" for development as a repository, and identified another 94 domes that were worthy of further study (Anderson et al., 1973, USGS-4339-2).

The Department of Energy then completed regional screening studies of 124 of the 130 onshore salt domes identified by USGS studies within the Northeast and South Texas, Northern Louisiana, and Mississippi Basins (Figure 2-2) and one dome identified by Kreitler et al. (1978) in Texas, for a total of 125 domes. Six of the 130 domes recommended by the USGS are located in the Texas Coastal Basin and were not included in the OWI screening. The following criteria were used to evaluate the 125 domes for this regional screening step (BNI and LETCo, 1980, ONWI-18, p. 63):

- Dome depth of less than 915 meters (3,000 feet)
- Dome cross-sectional (horizontal slice) area of greater than 405 hectares (1,000 acres) in lateral extent, plus a surrounding 152-meter (500-foot) salt barrier zone
- No prior history of use of dome by industry for hydrocarbon production, storage, or mineral-related use.

Although 11 of the 125 domes studied were found to satisfy these three criteria, 3 of the 11 domes were eliminated after additional regional literature study for the following reasons: Brooks Dome, in Texas, is located under Lake Palestine; Mt. Sylvan Dome, in Texas, is near the Tyler urban area and airport; and Boggy Creek Dome, in Texas, is beneath the Neches River (BNI and LETCo, 1980, ONWI-18, p. 64; NUS, 1978, Y/OWI/SUB-77/16504/10, p. 3-50 and 3-51). Table 2-2 lists all of the 125 Gulf Coast salt domes studied and indicates the screening factors which eliminated all but 8 of the domes from further study.

Subsequently, one of the eight domes, the Palestine Dome in Texas, was also eliminated from further consideration when information became available which indicated an extensive history of brining operations and subsequent collapse of overdome strata (ONWI, 1982, ONWI-109, p. 101). Hence the regional screening studies in the Gulf Coast identified seven domes as suitable for Area Phase study: Keechi and Oakwood Domes in the Northeast Texas Basin; Rayburn's and Vacherie Domes in the North Louisiana Basin; and Richton, Lampton, and Cypress Creek Domes in the Mississippi Basin.

2.2.2 Area-to-Potentially-Acceptable-Site Screening

Studies were conducted to further characterize and discriminate between the seven domes identified by the regional screening studies. Environmental, socioeconomic, and geologic factors were evaluated, but within a more restricted geographic area and with a greater degree of detail than in the regional studies.

Geologic field work conducted during this phase included the following: (1) drilling deep holes (up to several thousand feet deep) to assess the properties of the subsurface formations and the characteristics of ground-water aquifers and aquitards; (2) geologic surface mapping to assess tectonic stability and fault occurrence; and (3) geophysical surveys conducted to help determine the geometry of underlying sedimentary formations, caprock and salt stock, and other structures. Environmental and socioeconomic studies included literature surveys of data obtained from local experts and institutions such as universities and local, State, and Federal agencies. The scope of these area environmental studies included descriptions of the water resources; air quality; demographic, socioeconomic, and land-use characteristics; and ecosystems.

Table 2-2. Salt Domes Investigated in the Gulf Coast Salt Dome Basin and Recommended Domes for Further Study During Area Characterizations

Number	Dome	Recommended	Reason For Not Being Considered
	NORTHEAST AND SOUTH TEXAS BASINS		
1	Bullard	no	D
2	PALESTINE	yes	-
3	Brooks	no	N
4	Grand Saline	no	A
5	Steen	no	D
6	Butler	no	G
7	Whitehouse	no	D
8	KEECHI	yes	-
9	Palangana	no	B
10	Mt. Sylvan	no	J
11(a)	Gyp Hill	no	D
12	East Tyler	no	F
13	OAKWOOD	yes	-
14	Hainesville	no	F
15(a)	Piedras Pintas	no	L
16	Bethel	no	D
17	Boggy Creek	no	O
18	Day	no	H
19	Brushy Creek	no	H
20	Kittrell	no	H
21	La Rue	no	H
22	Concord	no	E
23(a)	Moca	no	H
24(a)	Dilworth Ranch	no	H
25	Elkhart	no	H
26(a)	Pescadito	no	H
	NORTH LOUISIANA BASIN		
27	RAYBURNS	yes	-
28	Kings	no	D
29	Winnfield	no	D
30	Cedar Creek	no	D
31	VACHERIE	yes	-
32	Drakes	no	D

(a) South Texas Basin Domes

Table 2-2. Salt Domes Investigated in the Gulf Coast Salt Dome Basin and Recommended Domes for Further Study During Area Characterizations
(Page 2 of 4)

Number	Dome	Recommended	Reason For Not Being Considered
33	Gibsland	no	F
34	Protho	no	M
35	Prices	no	D
36	Arcadia	no	F
37	Minden	no	L
38	Bistineau	no	D
39	Coochie Brake	no	C
40	Chestnut	no	D
41	Milam	no	I
42	Chester	no	I
43	Sikes	no	I
44	Packton	no	I
45	Castor Creek	no	D
	MISSISSIPPI BASIN		
46	McIntosh	no	A
47	RICHTON	yes	-
48	Crowville	no	D
49	Tatum	no	K
50	LAMPTON	yes	-
51	Petal	no	F
52	Gilbert	no	D
53	Hazelhurst	no	D
54	Arm	no	D
55	McLaurin	no	D
56	Richmond	no	D
57	Bruinsburg	no	D
58	Byrd	no	D
59	Leedo	no	D
60	Raleigh	no	D
61	McBride	no	D
62	County Line	no	D
63	Moselle	no	D
64	Sardis Church	no	D
65	Dont	no	D
66	Dry Creek	no	D
67	Centerville	no	D
68	D'Lo	no	D

Table 2-2. Salt Domes Investigated in the Gulf Coast Salt Dome Basin and Recommended Domes for Further Study During Area Characterizations
(Page 3 of 4)

Number	Dome	Recommended	Reason For Not Being Considered
69	Eminence	no	D
70	Midway	no	D
71	New Home	no	D
72	Oakley	no	D
73	Oakvale	no	D
74	Ruth	no	D
75	Walnut Bayou	no	D
76	Monticello	no	D
77	Allen	no	D
78	Prentiss	no	D
79	Carmichael	no	I
80	Bothwell	no	I
81	South Tallulah	no	H
82	Edwards	no	H
83	Caseyville	no	H
84	Kola	no	H
85	Carson	no	H
86	Utica	no	H
87	Coleman	no	H
88	Hervey	no	H
89	Wesson	no	H
90	Kings	no	H
91	Halifax	no	H
92	Glass	no	H
93	Ashwood (Somerset)	no	H
94	Newellton	no	H
95	Singer	no	H
96	Vicksburg	no	H
97	Eagle Bend	no	H
98	Galloway	no	H
99	Learned	no	H
100	North Tallulah	no	H
101	Brownsville	no	H
102	Oakridge	no	H
103	Newman	no	H
104	Duck Port	no	H
105	Sunrise	no	H
106	Snake Bayou	no	H
107	Foules	no	H
108	Glazier	no	H

Table 2-2. Salt Domes Investigated in the Gulf Coast Salt Dome Basin and Recommended Domes for Further Study During Area Characterizations
(Page 4 of 4)

Number	Dome	Recommended	Reason For Not Being Considered
109	Heidleberg	no	H
110	Gwinville	no	H
111	South Carolton	no	H
112	Burns	no	H
113	Yellow Creek	no	H
114	Eucutta	no	H
115	Laurel	no	H
116	Valley Park	no	H
117	Rufus	no	H
118	Ovette	no	H
119	Hiwanee	no	H
120	Baxterville	no	H
121	Ellisville	no	H
122	Grange	no	H
123	CYPRESS CREEK (New Augusta)	yes	-
124	Hubbard	no	I
125	Zion Hill Church	no	D

Key to Reason for Not Being Considered Further

A Brine production
B Brine and sulfur production
C Economic--held in reserve
D Less than 405 hectares (1,000 acres) + 153 meters (500 feet) barrier
E Less than 405 hectares (1,000 acres) + 153 meters (500 feet) barrier and more than 915 meters (3,000 feet) deep
F LPG storage
G LPG storage, too small
H More than 915 meters (3,000 feet) deep
I More than 915 meters (3,000 feet) deep and less than 405 hectares (1,000 acres) + 153 meters (500 feet) barrier
J Near an urban area and airport
K Nuclear test site and less than 405 hectares (1,000 acres) + 153 meters (500 feet) barrier
L Petroleum production
M Petroleum production and too small
N Under a lake
O Under a major river.

Source: BNI and LETCo, 1980, ONWI-18.

A description of the geologic and environmental studies conducted during area characterization is provided in the geologic area characterization reports (LETCo, 1982, ONWI-117, 118, 119, 120) and the environmental area characterization reports (BNI, 1982, ONWI-192, 193, 194). A comparative evaluation of the seven domes based on the criteria in DOE/NWTS-33(2) is summarized in ONWI (1982, ONWI-109). DOE/NWTS-33(2)(DOE, 1981) screening factors used in the differentiation of the seven salt domes are presented in Table 2-3.

During the Area-to-Potentially-Acceptable-Site screening studies, a new repository size criterion was developed which required that potential geologic repositories be able to accommodate 74,844 metric tons (82,500 tons) of high-level waste. The new criterion meant that the domes were required to have a horizontal cross-sectional area greater than 607 hectares (1,500 acres). Additionally, a 244-meter (800-foot) buffer zone (perimeter pillar) was adopted (ONWI, 1982, ONWI-109, p. 41; Stearns-Roger Services Inc., 1981, ONWI-283, pp. 3-31 ff.).

The size requirement, and the results of the more detailed area studies supporting application of the DOE/NWTS-33(2) criteria, eliminated Keechi, Rayburn's, and Lampton Domes from further consideration. Thus, at the conclusion of the area characterization screening studies, Oakwood, Vacherie, Richton, and Cypress Creek Domes remained as sites deemed favorable for further study.

After a period of further analysis and review of the area characterization study data, Oakwood Dome was deferred from further consideration by the DOE since it was judged to be much less favorable than the other three domes because of its significant history of petroleum exploration. Approximately 36 holes have penetrated the Oakwood Dome salt, some to proposed repository level, and many of the holes have been further whipstocked beneath the salt overhang. These borings were judged to have the potential for reducing the site's hydrologic integrity and isolation characteristics. Locations of these deep boreholes have not been well documented, and the ability to adequately seal the whipstocked holes is a problem (ONWI, 1982, ONWI-109, p. 59).

The evaluations, based on the narrowing process described above, led to the conclusion that Vacherie, Cypress Creek, and Richton Domes met the minimum DOE/NWTS-33(2) requirements established as screening factors and were suitable for further study. The geographic location of these sites in Louisiana and Mississippi are shown in Figures 2-3 and 2-4, respectively.

Passage of the "Nuclear Waste Policy Act" (NWPA) (42 USC Sections 10101-10226) in December 1982 established a new process for nomination and recommendation of sites for characterization. Additional studies conducted after the Area-to-Potentially-Acceptable-Site screening studies to further evaluate the three salt domes and their regional environment did not identify any additional data which would alter the potential suitability of these domes (Ertec, 1983, ONWI-484). Subsequently, in accordance with Section 116(a) of NWPA, the DOE sent letters to the governors and legislatures of Louisiana and Mississippi in February 1983, to formally identify the Vacherie, Cypress Creek, and Richton Domes as potentially acceptable sites for the planning and development of the nation's first geologic nuclear waste repository.

2.3 DISQUALIFICATION EVALUATION OF THE POTENTIALLY ACCEPTABLE SITES

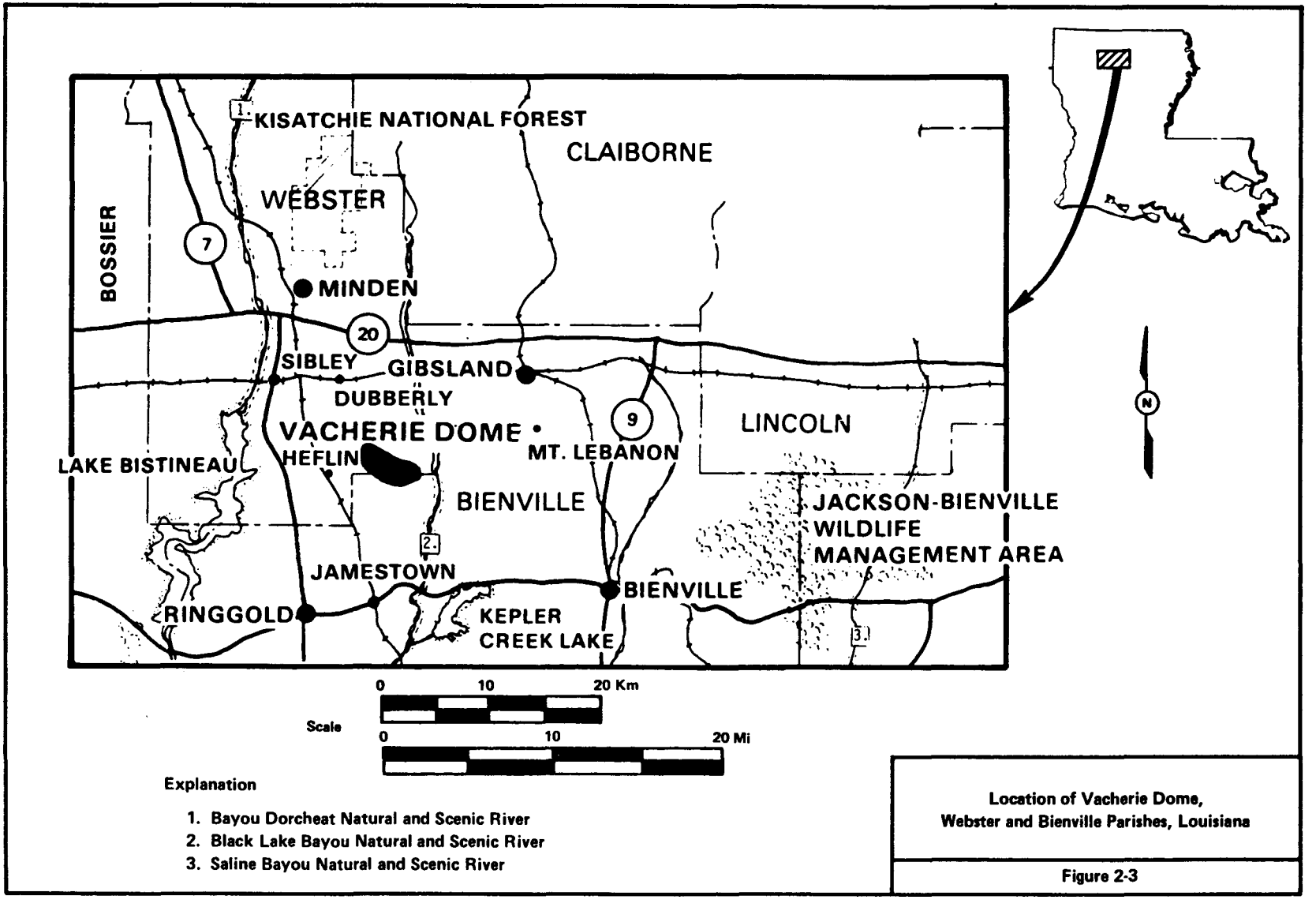
From among the nine potentially acceptable sites in several media identified nationwide during screening studies (Section 1.2.1), the DOE is required to nominate at least five sites as suitable for further site characterization (NWPA, Section 112[b]). The first step in the nominating process, as required by 10 CFR 960.3-2-2, is to evaluate each potentially acceptable site against the disqualifying conditions specified in the Technical Siting Guidelines of 10 CFR 960.4-2 and 10 CFR 960.5-2.

Table 2-3. Evaluation of Domes Considering Differentiating Factors

	Siting Criteria[a]	Richton	Vacherie	Cypress Creek	Oakwood	Keechi	Rayburn's	Lampton
1.0	Site Geometry							
	Minimum Depth	Acceptable	Acceptable	Acceptable	Acceptable	Eliminated	Eliminated	Acceptable
	Lateral Extent (with 800-ft buffer zone)	More Favorable	Acceptable	Acceptable	Acceptable	Eliminated	Eliminated	Eliminated
2.0	Geohydrology							
	Subsurface Dissolution Rates	Acceptable	Less Favorable	Less Favorable	Less Favorable	Acceptable	Less Favorable	Acceptable
5.0	Tectonic Environment							
	Quaternary Faults	Acceptable	Acceptable	Acceptable	Less Favorable	Less Favorable	Acceptable	Acceptable
6.0	Human Intrusion							
	Resources	Acceptable	Acceptable	Less Favorable	Less Favorable	Less Favorable	Less Favorable	Acceptable
	Exploration History	Acceptable	Acceptable	Acceptable	Less Favorable	Acceptable	Less Favorable	Acceptable
7.0	Surface Characteristics							
	Surficial Hydrological System	Acceptable	Less Favorable	Less Favorable	Less Favorable	Less Favorable	Acceptable	Less Favorable
9.0	Environmental Protection							
	Potential Environmental Impacts	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Less Favorable
	Air, Water, and Land-Use Conflicts	Less Favorable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Less Favorable
10.0	Socioeconomic Impacts							
	Social/Economic Impacts	Less Favorable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable

(a) These siting criteria are a subset of those given in Table 2-1 (DOE, 1981, DOE/NWTS-33(2)). Only those which differentiated between the domes are included.

Source: ONWI, 1982, ONWI-109

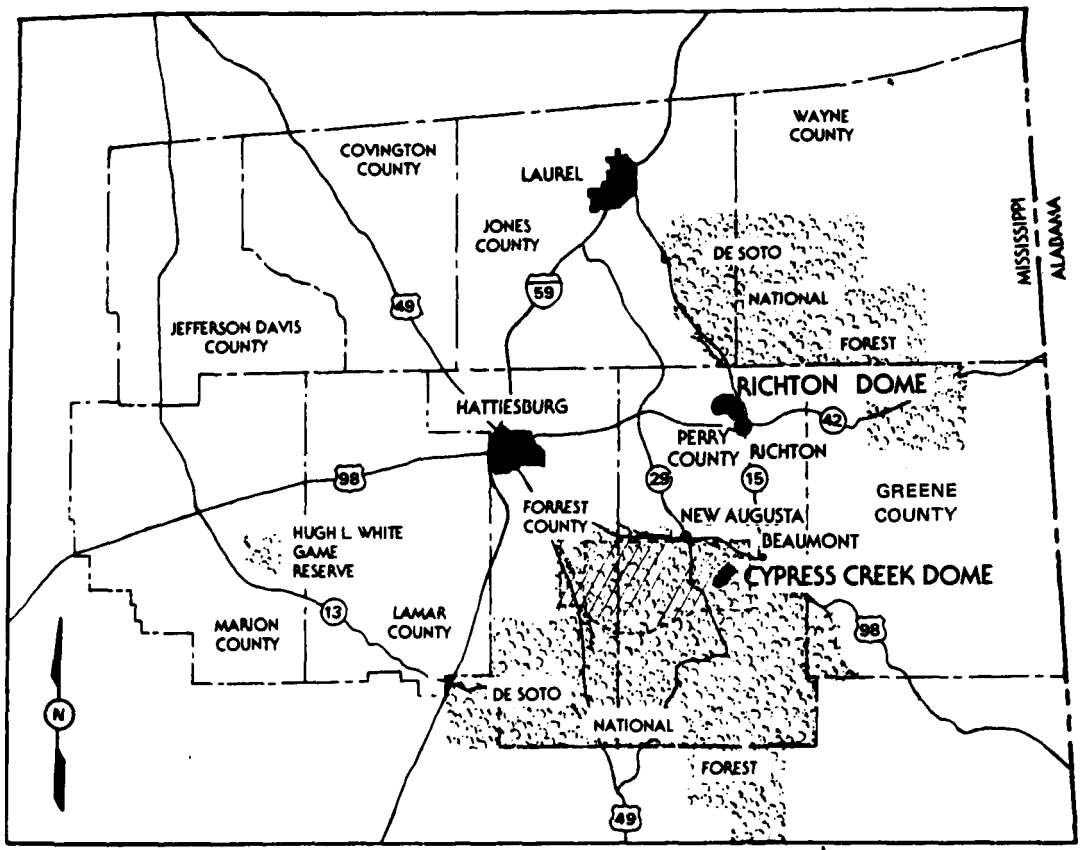


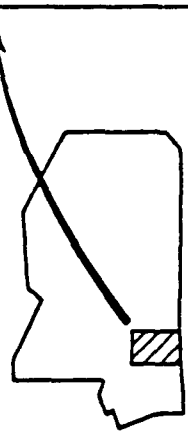
Explanation

1. Bayou Dorcheat Natural and Scenic River
2. Black Lake Bayou Natural and Scenic River
3. Saline Bayou Natural and Scenic River

Location of Vacherie Dome,
Webster and Bienville Parishes, Louisiana

Figure 2-3





Explanation

- Highways
- County lines
- National Forest, State Game Reserve
- Camp Shelby Military Reservation

Scale

0 10 20 Km

0 10 20 Mi

Location of Richton and Cypress Creek Domes, Perry County, Mississippi

Figure 2-4

Among many other requirements, passage of the NWPA mandated the preparation of several regulatory standards and guidelines, including the following:

- "General Guidelines for Recommendation of Sites for Nuclear Waste Repositories" (the Siting Guidelines, 10 CFR Part 960) by the DOE
- "Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes" (40 CFR Part 191) by the U.S. Environmental Protection Agency (EPA)
- "Disposal of High-Level Radioactive Wastes in Geologic Repositories, Technical Criteria" (10 CFR Part 60) by the U.S. Nuclear Regulatory Commission (NRC).

A disqualifying condition is defined in 10 CFR 960.2 as a condition that, if present at a site, would eliminate that site from further consideration. A site may be disqualified at any time during the siting process if the evidence supports a finding by the DOE that a disqualifying condition exists, or if the qualifying condition of any System or Technical Guideline cannot be met (10 CFR 960.3-1-5).

The evaluation of site information against the explicit disqualifying conditions set forth in 10 CFR 960.4 and 10 CFR 960.5 Technical Guidelines is summarized in Table 2-4. Based on the data and analysis, no evidence was found to disqualify any of the identified potentially acceptable salt dome sites as possible repository sites. Therefore, the Vacherie, Richton, and Cypress Creek Domes were determined to be suitable candidate sites for possible subsequent nomination for further site characterization studies.

2.4 COMPARATIVE EVALUATION OF POTENTIALLY ACCEPTABLE SITES WITHIN THE GEOHYDROLOGIC SETTING, AND SELECTION OF THE PREFERRED SITE

This section compares the three potentially acceptable sites, Richton Dome, Cypress Creek Dome, and Vacherie Dome, in the Gulf Coast Salt Dome geohydrologic setting and concludes that the Richton Dome site is the preferred site. The guideline findings for the three sites show that there are very few differences among the sites. The Richton Dome site was found to be the preferred site for the postclosure guidelines and the preclosure ease and cost of siting, construction, operation, and closure guidelines. The much larger Richton Dome allows considerable flexibility in locating the repository within the dome while maintaining the largest salt perimeter to ensure isolation and worker safety. Evidence of near-surface collapse features that may have resulted from dissolution during the Quaternary Period are present at both the Vacherie and Cypress Creek Dome sites but not at the Richton Dome site.

The Vacherie Dome site was found to be preferred for the preclosure radiological safety and preclosure environment, socioeconomic and transportation guidelines. This is because of the greater distance to populated areas from Vacherie Dome and the environmental impacts associated with the presence of the De Soto National Forest on or near the Richton Dome and Cypress Creek Dome sites.

Consistent with the Siting Guidelines (10 CFR Part 960), the DOE has placed primary importance on the postclosure repository performance. Since the Richton Dome site is preferred for both the postclosure guidelines and the preclosure ease and cost of siting, construction, operation, and closure, it has been selected as the overall preferred site in the Gulf Coast Salt Dome geohydrologic setting. A small margin of preference exists for the Richton Dome site over the Vacherie Dome site, while the Cypress Creek Dome site is clearly the least preferred of the three sites.

A key step in the nomination of sites as suitable for characterization, Section 960.3-2-2-2 of DOE General Guidelines for Recommendation of Sites for Nuclear Waste Repositories (10 CFR Part 960) requires, for those geohydrologic settings that contain more than one potentially acceptable site, that "the preferred site shall be selected on the basis of a comparative evaluation of all potentially acceptable sites in that setting." This evaluation shall consider the distinguishing characteristics displayed by the potentially

Table 2-4. Summary of Rationale For Not Disqualifying the Potentially Acceptable Gulf Coast Salt Dome Basin Sites[a]

Disqualifying Condition			Present Rationale for Not Disqualifying		
Guideline	Statement Synopsis	EA Section Reference	Vacherie Dome, Louisiana	*Cypress Creek Dome,* Mississippi	*Richton Dome,* Mississippi
Geohydrology 960.4-2-1(d)	Pre-waste-emplacement ground-water travel time less than 1,000 years.	6.3.1.1	Estimated ground-water travel time through undisturbed host rock greatly exceeds 1,000 years.		
Erosion 960.4-2-5(d)	Any portion of underground facility less than 200 meters deep.	6.3.1.5	Upper level of conceptual two-level repository design is at a depth of 678 meters (2,224 feet).	Upper level of conceptual two-level repository design is at a depth of 642 meters (2,106 feet).	Conceptual repository design at depth of 646 meters (2,120 feet).
Dissolution 960.4-2-6(d)	Active dissolution likely to result in a loss of waste isolation within first 10,000 years after closure.	6.3.1.6	Caprock formation indicates possible past dissolution of salt stock; however, within an estimated rate of 0.1 to 0.5 meters (0.3 to 1.6 feet) in 10,000 years, it is extremely unlikely that a dissolution front will result in a loss of waste isolation.	Caprock formation indicates past dissolution of salt stock. Estimated dissolution rate of between 0.07 and 1.2 meters (0.2 and 3.9 feet) in 10,000 years is extremely unlikely to cause a hydraulic interconnection of the repository and the geohydrologic system during the period of interest.	Estimated maximum rate of dissolution is 0.6 meters (2 feet) over 10,000 years, which is insignificant compared to the minimum 244-meter (800-foot) buffer zone, and thus will not result in a hydraulic connection between the repository and the surrounding geohydrologic units.
Tectonics 960.4-2-7(d)	Based on geologic records, the nature and rates of fault movement or other ground motion are believed to be such that a loss of waste isolation is likely to occur.	6.3.1.7	*The relative stability of the geologic setting during the Quaternary period is illustrated by the lack of evidence for Quaternary fault movement; absence of historical seismicity in geologic setting; the low frequency and magnitude of seismicity in the region around the geologic setting; slow, long-term uplift rates; and a lack of igneous activity. The net result of these processes is a slow rate of change within the geologic setting that should not adversely affect waste isolation.*		
Human Interference 960.4-2-8-1(d)(1)	Previous subsurface activities have created significant pathways between the projected underground facility and the accessible environment.	6.3.1.8	Ten boreholes are located near the site, but the only borehole penetrating the potential repository horizon is the DOE's Smith No. I borehole. No solution or conventional mining, or underground storage has been identified.	*Five boreholes penetrate the repository* design level around the dome periphery and three produce hydrocarbons. Isolation of these boreholes from repository working by a 15-to 30-meter (49- to 98-foot) salt buffer zone is contemplated. No known subsurface mining has occurred.	*Numerous shallow drill holes are located* over the top of and adjacent to the dome and three boreholes are known to *penetrate the salt formation. The area* characterization DOE MRIG-9 borehole is approximately 244 meters (800 feet) shallower than the design horizon and the two Shell-Masonite petroleum exploration wells enter the salt stock well below the repository level. No indication of underground resource extration, solution mining, or underground storage within the dome has been found.
960.4-2-8-1(d)(2)	Ongoing or future recovery of mineral resources outside the controlled area would lead to an inadvertant loss of *waste isolation.*		Development of water or possible hydrocarbon resources is not expected to affect the waste isolation characteristics of the salt.		
Population Density and Distribution 960.5-2-1(d)(1)	Repository surface facility located in a highly populated area.	6.2.1.2	Minden, LA, the nearest highly populated *area, is 16 km (10 mi) from the site.*	Hattiesburg/Petal, MS, the nearest highly populated area, is 25 km (15 mi) from the site.	Hattiesburg/Petal, MS, the nearest highly populated area, is 25 km (15 mi) from the site.
960.5-2-1(d)(2)	Repository surface facility located adjacent to a 1.6-kilometer-by-1.6-kilometer (1-mile-by-1-mile) area having a population of 1,000 or more individuals.		*No such populations are located adjacent* to repository surface facility.	*No such populations are located adjacent* to repository surface facility.	*No such populations are located adjacent* to repository surface facility; the town of Richton, MS, is located 3.2 km *(2.0 mi) from the proposed surface* facility.
960.5-2-1(d)(3)	Inability of the DOE to develop an emergency preparedness plan that meets DOE and NRC regulatory requirements.		Compliance is expected: The NRC has not issued 10 CFR Part 60, Subpart 1, "Emergency Planning Criteria;" the DOE has developed emergency preparedness programs for its other similar rural facilities per DOE Order 5500.3 (DOE, 1981).		

Table 2-4. Summary of Rationale For Not Disqualifying the Potentially Acceptable Gulf Coast Salt Dome Basin Sites[a]
(Page 2 of 2)

Disqualifying Condition			Present Rationale for Nondisqualification		
Guideline	Statement Synopsis	EA Section Reference	Vacherie Dome, Louisiana	Cypress Creek Dome, Mississippi	Richton Dome, Mississippi
Offsite Installations and Operations 960.5-2-4(d)	Atomic energy defense activities in proximity and which are expected to conflict irreconcilably with a repository.	6.2.1.5	No atomic energy defense activities are located in proximity to the sites.		
Environmental Quality 960.5-2-5(d)(1)	Environmental quality of affected area could not be adequately protected, or projected environmental impact could not be mitigated to an acceptable degree.	6.2.1.6	The quality of the environment in the affected area can be adequately protected, and projected environmental impacts can be mitigated to an acceptable degree, taking into account programmatic, technical, social, economic, and environmental factors.		
960.5-2-5(d)(2)	Location of restricted area or support facilities within boundaries of a national park, wildlife refuge, wilderness preservation area, or wild and scenic river.	6.2.1.6	No part of the sites is located within the specified disqualifying areas.		
960.5-2-5(d)(3)	Presence of restricted area or support facilities would conflict irreconcilably with previous designated resource-preservation use of a national park, wildlife refuge, wilderness preservation area, wild and scenic river or forest, or any comparable or significant State-protected resource area.	6.2.1.6	No irreconcilable conflicts identified with the dedicated resource preservation use of any Federal- or State-protected resource areas at time of NWPA enactment; site located 12 km from Kisatchie National Forest, the the nearest dedicated Federal land.	Repository located in a portion of the De Soto National Forest in which multiple uses are permitted and thus will not conflict irreconcilably with the previously designated resource preservation use of the National Forest.	No irreconcilable conflict identified with the dedicated resource preservation use of any Federal- or State-protected areas; site located 4 km from DeSoto National Forest, the nearest dedicated Federal Land.
Socioeconomic Impacts 960.5-2-6(d)	Repository would significantly degrade the quality or reduce the quantity of water from major sources of offsite supplies, and such impacts cannot be compensated or mitigated by reasonable measures.	6.2.1.7	Local ground-water resources at all sites are adequate to meet repository needs; no surface water will be withdrawn or consumed. Potential water-quality effects are expected to be negligible.		
Rock Characteristics 960.5-2-9(d)	Repository activities predicted to cause significant risk to health and safety of personnel.	6.3.3.2	Potential hazards to personnel during repository construction, operation, and closure consist of gas pockets, excavation instability, brine pockets, water inflow, and dust; such potential hazards have either not been found to date at the sites can readily be mitigated by proven mine safety and engineering practices.		
Hydrology 960.5-2-10(d)	Based upon expected ground-water conditions, engineering measures beyond reasonably available technology will be required for exploratory shaft or repository.	6.3.3.3	Saturated water-bearing units occur over the domes. Engineering measures within currently available technology to mitigate these conditions during shaft drilling and construction include ground freezing, dewatering, and other accepted water control measures.		
Tectonics 960.5-2-11(d)	Based on expected nature and rates of fault movement or ground motion, engineering measures beyond reasonably available technology will be required for exploratory shaft or repository.	6.3.3.4	Nature and rates of ground motion expected at the sites are not likely to require engineering measures beyond reasonably available technology to construct, operate, or close the exploratory shaft or repository.		

[a] Based on the U.S. Department of Energy and U.S. Nuclear Regulatory Commission concurred final General Guidelines for recommendation of sites for nuclear waste repositories (10 CFR Part 960) (DOE, 1984).

acceptable sites within the setting and the related postclosure and preclosure guidelines, placing primary significance on the postclosure guidelines.

Because three potentially acceptable sites (Cypress Creek, Richton, and Vacherie Salt Domes) were identified in the Gulf Coast Salt Dome Basin geohydrologic setting (Section 2.2) and are not presently disqualified based on specific 10 CFR Part 960 disqualifying conditions (Section 2.3), this section describes the comparative evaluation procedure leading to the selection of one as the preferred Gulf Coast Salt Dome site to be subsequently nominated for site characterization by the Secretary of Energy.

As specified in 10 CFR 960.3-2-2-2, the basis for this comparative evaluation of the three potentially acceptable Gulf sites is the qualifying conditions, considering, on balance, the favorable and potentially adverse conditions for all postclosure and preclosure Technical Guidelines for which the evidence shows distinguishing characteristics among the three sites. Specifically, fifteen favorable or potentially adverse conditions and three subconditions of one of the favorable conditions within ten technical guidelines discriminate among the three potentially acceptable Gulf sites (Table 2-5). Four of these technical guideline conditions are from the postclosure repository performance group; the remaining discriminating technical guideline conditions are from the preclosure repository performance groups. The findings for other technical guideline conditions did not distinguish among the sites.

In the following paragraphs, the potentially acceptable Vacherie, Cypress Creek, and Richton Dome sites are compared using the discriminating favorable and potentially adverse conditions summarized by technical guidelines and aggregated according to the hierarchy of guideline information groups, with decreasing order of importance as specified in 10 CFR 960.3-1-5:

1. Postclosure repository performance
2. Preclosure radiological safety
3. Preclosure environment, socioeconomics, and transportation
4. Preclosure ease and cost of siting, construction, operation, and closure.

Whether each discriminating technical guideline condition is present or not present for each of the three potentially acceptable Gulf sites is presented by technical guideline groups in Table 2-5.

2.4.1 Evaluation of Gulf Coast Salt Dome Basin Postclosure Discriminating Technical Guidelines

Postclosure repository guidelines specified in 10 CFR Part 960, Subpart C, which form one of the four guideline groups, include a System Guideline and eight Technical Guidelines. This subpart of the guidelines specifies the characteristics, processes, and events that may affect the long-term performance of the repository after waste emplacement and repository closure and which must be considered in evaluating and comparing potential sites. The objective of the postclosure waste containment and isolation System Guideline (10 CFR 960.4-1) is to ensure that, by means of natural and engineered barriers, the health and safety of the public will be protected until the radioactivity in the nuclear wastes has diminished to safe levels. These are the considerations most important in ensuring the long-term protection of the health and safety of the public. The eight Technical Guidelines included under this postclosure System Guideline have numerous qualifying, favorable, potentially adverse, and disqualifying conditions related to geohydrology (10 CFR 960.4-2-1); geochemistry (10 CFR 960.4-2-2); rock characteristics (10 CFR 960.4-2-3); climatic changes (10 CFR 960.4-2-4); erosion (10 CFR 960.4-2-5); dissolution (10 CFR 960.4-2-6); tectonics (10 CFR 960.4-2-7); and human interference (natural resources, 10 CFR 960.4-2-8-1, and site ownership and control, 10 CFR 960.4-2-8-2).

Table 2-5. Summary of Technical Guidelines Which Provide the Basis for Discriminating Among the Potentially Acceptable Gulf Coast Salt Dome Basin Sites[a]

Discriminating Guidelines		EA Section Reference	Site Conditions		
Guideline	Condition[b]		Vacherie Salt Dome, Louisiana	Cypress Creek Dome, Mississippi	Richton Salt Dome, Mississippi
	Postclosure Discriminating Guidelines				
Rock Characteristics 960.4-2-3(b)(1)	+A host rock that is sufficiently thick and laterally extensive to allow significant flexibility in selecting the depth, configuration, and location of the underground facility to ensure isolation	6.3.1.3	NP[c]	NP	P
Dissolution 960.4-2-6(b)	+No evidence that the host rock within the site was subject to significant dissolution during the Quaternary Period	6.3.1.6	NP	NP	P
Human Interference 960.4-2-8-1(c)(2)	-Evidence of subsurface mining or extraction for resources within the site if this could affect waste containment or isolation	6.3.1.8	NP	P	NP
960.4-2-8-2(c)	-Projected land-ownership conflicts that cannot be successfully resolved through voluntary purchase-sell agreements, nondisputed agency-to-agency transfers of title or Federal condemnation proceedings	6.2.1.1	NP	P	NP
	Preclosure Radiological Safety Discriminating Guidelines				
Population Density and Distribution 960.5-2-1(c)(1) and (2)	-High residential, seasonal, or daytime population density within the projected site boundaries	6.2.1.2	NP	P	NP
	-Proximity of the site to highly populated areas or to areas having at least 1,000 individuals in an area 1 mile by 1 mile as defined by the most recent decennial count of the U.S. census		NP	NP	P
Site Ownership and Control 960.5-2-2(c)	-Projected land-ownership conflicts that cannot be successfully resolved through voluntary purchase-sell agreements, nondisputed agency-to-agency transfers of title, or Federal condemnation proceedings	6.2.1.3	NP	P	NP
	Environment, Socioeconomic, and Transportation Discriminating Guidelines				
Environmental Quality 960.5-2-5(c)(3)	-Proximity to, or projected significant adverse environmental impacts of the repository or its support facilities on a component of the National Park System, the National Wildlife Refuge System, National Wild and Scenic Rivers System, the National Wilderness Preservation System, or National Forest Land	6.2.1.6	NP	P	P
Socioeconomics 960.5-2-6(c)(1)	-Potential for significant repository-related impacts on community services, housing supply and demand, and the finances of state and local government agencies in the affected area	6.2.1.7	NP	P	NP
Transportation 960.5-2-7(b)(1)(i, iii, v), (b)(2), (c)(1), and (c)(4)	+Availability of access routes from local existing highways and railroads to the site which have any of the following characteristics:	6.2.1.8			
	(i) Such routes are relatively short and economical to construct as compared to access routes for other comparable siting options.		P	P	NP
	(iii) Cuts, fills, tunnels, or bridges are not required.		P	NP	NP
	(v) Such routes bypass local cities and towns		P	P	NP
	+Proximity to local highways and railroads that provide access to regional highways and railroads and are adequate to serve the repository without significant upgrading or reconstruction	6.2.1.8	P	P	NP
	-Access routes to existing local highways and railroads that are expensive to construct relative to comparable siting options		NP	NP	P
	-Any local condition that could cause the transportation-related costs, environmental impacts, or risk to public health and safety from waste transportation operations to be significantly greater than those projected for comparable siting options		NP	P	NP

Table 2-5. Summary of Technical Guidelines Which Provide the Basis for Discriminating Among the Potentially Acceptable Gulf Coast Salt Dome Basin Sites[a]
(Page 2 of 2)

Discriminating Guidelines		EA Section Reference	Site Conditions		
Guideline	Condition[b]		Vacherie Salt Dome, Louisiana	Cypress Creek Dome, Mississippi	Richton Salt Dome, Mississippi
Ease and Cost of Siting, Construction, Operation, and Closure Discriminating Guidelines					
Surface Characteristics 960.5-2-8(b)(2)	+Generally well-drained terrain	6.3.3.1	P	NP	P
Rock Characteristics 960.5-2-9(b)(1) and (c)(1)	+A host rock that is sufficiently thick and laterally extensive to allow significant flexibility in selecting the depth, configuration, and location of the underground facility	6.3.3.2	NP	NP	P
	-A host rock that is suitable for repository construction, operation, and closure, but is so thin or laterally restricted that little flexibility is available for selecting the depth, configuration, or location of an underground facility		P	P	NP

Note: For favorable conditions, a P is desirable and an NP undesirable. For potentially adverse conditions, a P is undesirable and an NP is desirable.

(a) Based on the U.S. Department of Energy final General Guidelines for recommendation of sites for nuclear waste repositories (10 CFR Part 960) (DOE, 1984).
(b) In this column, a favorable condition is preceded by a "+" sign and a potentially adverse condition by a "-" sign. The sequence of conditions for each guideline is the same as in 10 CFR Part 960.
(c) Explanation of symbols:
"P" means that the available evidence suggests that the site is likely to meet this favorable or potentially adverse condition, and that the site will meet the condition to a considerable degree. The letter is an abbreviation for the word "present."
"NP" means that the site is not likely to meet this favorable or potentially adverse condition. The letters are an abbreviation for the words "not present."

As shown in Table 2-5 and discussed below, three of the eight postclosure Technical Guidelines, rock characteristics (10 CFR 960.4-2-3), dissolution (10 CFR 960.4-2-6), and human interference (10 CFR 960.4-2-8), contain a favorable or potentially adverse condition which, when applied to the potentially acceptable Cypress Creek, Richton, and Vacherie Salt Dome repository sites, discriminated among them.

2.4.1.1 Rock Characteristics (10 CFR 960.4-2-3)

The qualifying condition for the rock characteristics Technical Guideline (10 CFR 960.4-2-3) requires that the present and expected characteristics of the host rock and surrounding units be able to accommodate the thermal, chemical, mechanical, and radiation stresses expected to be induced by repository construction, operation, and closure and by expected interactions among the waste, host rock, ground water, and engineered components. A favorable condition under this guideline is a host rock that is sufficiently thick and laterally extensive to allow significant flexibility in selecting the depth, configuration, and location of the underground facility and thereby ensure isolation.

Characteristically, salt dome formations are extensive in depth (vertically) but may be limited in lateral extent (horizontally) by dome geometry. Although engineering calculations and conceptual repository designs show that each of the three potentially acceptable Gulf Salt Dome sites has sufficient salt mass to allow flexibility in selecting the depth, configuration, and location of the subsurface repository facilities, for the same given conservative design requirements, only the Richton Salt Dome site has a host rock lateral extent at the proposed repository depth that permits flexibility in siting a single-level repository design while maintaining an adequate salt perimeter buffer for isolation. Both the Vacherie and Cypress Creek Salt Dome sites require multiple-level repository designs to accommodate the same waste inventory. Thus, for the favorable rock characteristics guideline condition 10 CFR 960.4-2-3(b)(1), based upon the geologic data and conceptual engineering designs, the Richton Dome site is more favorable than either the Vacherie or Cypress Creek Dome site because its greater host rock lateral extent at the proposed repository depth (1) is expected to provide the largest buffer zone between the repository underground operations area and the edge of the salt dome, and (2) will allow considerable flexibility in selecting the depth, configuration, and location of the underground facility to ensure isolation.

2.4.1.2 Dissolution (10 CFR 960.4-2-6)

The qualifying condition for the dissolution Technical Guideline (10 CFR 960.4-2-6) requires (1) that a repository site shall be located such that any subsurface rock dissolution will not be likely to lead to radionuclide releases greater than specified allowable limits; and (2) that, for predicting the likelihood of dissolution, evidence of dissolution within the geologic setting during the Quaternary Period must be considered. The favorable condition under this guideline specifies that the site should exhibit no evidence that the host rock within the site was subject to significant dissolution during the Quaternary Period.

The presence of caprock at each of the three domes indicates past dissolution during dome formation. Based on existing geologic data for the Vacherie, Cypress Creek, and Richton Dome repository sites, the projected rate of future dissolution would not cause loss of isolation (i.e., hydraulic interconnection between the repository and adjacent aquifers within the next 10,000 years). However, both the Vacherie and Cypress Creek Dome sites show evidence of near-surface collapse features that may be the result of localized dissolution during the late Tertiary or Quaternary Periods. Further site studies are needed to determine the specific cause, age, and extent of these collapse features. However, the data indicate that no such features are present at the Richton Dome site. Thus, for the dissolution guideline condition 10 CFR 960.4-2-6(b), based on the geologic evidence, the Richton Dome site is more favorable than either the Vacherie or the Cypress Creek Dome site.

2.4.1.3 Human Interference (10 CFR 960.4-2-8)

The qualifying condition for the human interference (natural resources) Technical Guideline (10 CFR 960.4-2-8-1) requires that a repository site be located such that the presence of natural resources at or near the site, including ground water suitable for crop irrigation or human consumption without treatment, will not be likely to give rise to interference activities by future generations that would lead to radionuclide releases greater than specified allowable limits. A potentially adverse condition specified under this guideline is evidence of subsurface mining or extraction for resources within the site if the mining or extraction could affect waste containment or isolation.

Available mineral exploration and well-drilling records (for purposes other than repository characterization) indicate that this potentially adverse condition is present at the Cypress Creek Dome site and is not present at the Vacherie or Richton Dome sites. Specifically, seven hydrocarbon drill holes penetrate the Cypress Creek Dome, five of which pass through the salt stock to various completion depths below the level of proposed repository workings. Three of these wells are presently producing oil and gas. Although each of these deeper holes represents a potential pathway to the accessible environment and will require special consideration in repository design and construction, modeling results indicate that a loss of waste isolation is unlikely even if any of these wells were to become a center of dissolution. Although numerous hydrocarbon exploration wells have been drilled within 10 kilometers (6.2 miles) of the Vacherie Dome flank, no recorded evidence exists that any drill holes, shafts, or other excavations have penetrated the Vacherie Dome repository horizon for any purpose other than repository site evaluations since the discovery of the dome in 1921. Similarly, at the Richton Dome site, no recorded evidence exists since the discovery of the underlying salt formation in 1944 that any holes, shafts, or other excavations penetrate the proposed repository horizon, although some shallow sulfur exploration holes exist from the 1940s and deep petroleum exploration wells have been drilled near the dome, including a well that grazed the salt stock at repository depth.

Therefore, for the potentially adverse human interference guideline condition 10 CFR 960.4-2-8-1(c)(2), based upon resource extraction evidence, the Vacherie and Richton Dome sites are more favorable than the Cypress Creek Dome site because of the lack of evidence of subsurface mining or extraction for resources within the site that could affect waste containment or isolation.

The purpose of the postclosure guideline on site ownership and control (10 CFR 960.4-2-8-2) 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 the NRC (10 CFR Part 60), is to obtain ownership and surface and subsurface rights to land and minerals within the controlled area of the repository. A similar guideline on site ownership is provided for the preclosure period. The purpose of the preclosure guideline is to ensure that surface and subsurface activities during repository operation will not be likely to lead to radionuclide releases greater than those allowed by applicable regulations. The DOE has determined that the necessary land area and controls are the same for both the postclosure and preclosure periods at the three sites in this geohydrologic setting.

Whichever site is selected, the DOE must obtain ownership and surface and subsurface rights before commencing preclosure activities; there is therefore no basis for distinguishing among the sites on their site ownership and control status at the beginning of the postclosure period. Therefore, even though there are differences in the findings for the potentially adverse condition all sites are ranked equally on this guideline.

2.4.1.4 Gulf Coast Site Postclosure Guidelines Preference

As shown in Table 2-5, based on data available prior to site characterization, the three postclosure guidelines which discriminate among the three sites indicate the Richton Dome site

is expected to be a more favorable Gulf Salt Dome Basin repository site than the Cypress Creek Dome or Vacherie Dome sites, primarily because of Richton Dome's greater ability to ensure compliance with the postclosure guidelines:

- Greater flexibility in selecting the repository depth, configuration and location attributable to a larger areal extent of the host rock (10 CFR 960.4-2-3)
- Lack of geologic features indicating significant dissolution in the Quaternary Period. (In contrast, significant features such as structural collapse of the overburden have been observed at the other dome sites [10 CFR 960.4-2-6].)
- Absence of previous subsurface mining or resource extraction within the site that could affect containment or isolation (10 CFR 960.4-2-8-1).

The Vacherie Dome site is expected to be a less favorable repository site when compared against the postclosure guidelines because of both (1) its limited lateral extent of host rock at the proposed repository depth, which will necessitate a multiple-level repository concept, and (2) the presence of a potential Quaternary Period dissolution feature.

The Cypress Creek Dome site is expected to be the least favorable repository site when compared against all three discriminating postclosure guideline conditions because of its

- Limited lateral extent of host rock at the proposed repository depth, necessitating a multiple-level repository concept to maintain the same buffer to ensure isolation (10 CFR 960.4-2-3)
- Presence of a potential Quaternary Period host rock dissolution feature at the site (10 CFR 960.4-2-6)
- Presence of producing hydrocarbon drill holes through the host rock repository level that potentially could affect waste containment and isolation (10 CFR 960.4-2-8-1).

2.4.2 Evaluation of Gulf Coast Salt Dome Basin Preclosure Discriminating Technical Guidelines

The preclosure repository guidelines specified in 10 CFR Part 960, Subpart D, include three System Guidelines and eleven Technical Guidelines. Subpart D of the guidelines specifies the factors to be considered in evaluating and comparing sites based on expected repository performance before closure. The Technical Guidelines in Subpart D set forth qualifying, favorable, potentially adverse, and, in seven guidelines, disqualifying conditions on which to base the suitability of a site relative to the three preclosure System Guidelines.

2.4.2.1 Preclosure Radiological Safety Guideline Group

This guideline group focuses on compliance with applicable safety requirements specified in various DOE, NRC, and EPA regulations relating to any projected radiological exposures of the general public and releases of radioactive materials to restricted and unrestricted areas during repository operation and closure. The preclosure radiological safety guideline group includes population density and distribution (10 CFR 960.5-2-1), site ownership and control (10 CFR 960.5-2-2), meteorology (10 CFR 960.5-2-3), and offsite installations and operations (10 CFR 960.5-2-4). As shown in Table 2-5 and discussed below, the preclosure radiological safety guidelines include three guideline conditions which, when applied to the potentially acceptable Cypress Creek, Richton, and Vacherie Dome sites, discriminate among them.

2.4.2.1.1 Population Density and Distribution (10 CFR 960.5-2-1). The qualifying condition for the population density and distribution Technical Guideline (10 CFR 960.5-2-1) requires that the repository site be located such that, during repository operation and closure, the expected average radiation dose to members of the public within any highly populated area will not be likely to exceed a small fraction of the allowable limits, and the expected radiation dose to any member of the public in an unrestricted area will not be likely

to exceed allowable limits. One potentially adverse condition specified under this guideline is a high residential, seasonal, or daytime population density within the projected site boundaries.

Demographic data indicate that this potentially adverse condition is not present at the Vacherie or Richton Dome sites but is present at the Cypress Creek Dome site. The Vacherie Dome site boundaries lie primarily within commercial forestland having a low population density. No activities that would cause significant seasonal or daytime in-migration within the projected site boundaries have been identified. Residential and daytime populations exist within the projected Richton Dome controlled area boundaries; however, the estimated number of persons within this area does not constitute a high population density. High seasonal and daytime population densities associated with Camp Shelby Military Reservation activities exist within the projected Cypress Creek Dome site boundaries.

Therefore, for the potentially adverse population density and distribution guideline condition 10 CFR 960.5-2-1(c)(1), based upon the evidence, the Vacherie and Richton Dome sites are more favorable than the Cypress Creek Dome site because of the lower residential, seasonal, and daytime population densities within the projected controlled area boundaries of these two sites.

A second potentially adverse condition specified under the population density and distribution guideline (10 CFR 960.5-2-1[c][2]) is the proximity of a site to highly populated areas, or to areas having at least 1,000 individuals in an area 1.6 kilometers by 1.6 kilometers (1 mile by 1 mile) as defined by the most recent decennial count of the U.S. census.

Demographic data indicate that this second potentially adverse condition is not present at either the Vacherie or Cypress Creek Dome sites but is present at the Richton Dome site. The highly populated area closest to the Vacherie Dome site is Minden, Louisiana (1980 population of 15,084), which is located 16 kilometers (10 miles) from the site. Given the low regional population density (3 persons per square mile) of the region, the nearest concentration of at least 1,000 individuals in a 1.6-kilometer-by-1.6-kilometer (1-mile-by-1-mile) area is the town of Sibley, Louisiana (1980 population of 1,200) which is 10 kilometers (6.2 miles) from the site. The nearest highly populated area and the nearest area having the specified population density to the Cypress Creek Dome site is the town of Richton, Mississippi (1980 population of 1,200) located 20 kilometers (12 miles) away. The restricted area for a repository at Richton Dome site is approximately 3.2 kilometers (2.0 miles) from the town of Richton. The controlled area boundary for the Richton site lies near the corporation boundary of the town of Richton, which has a 1.6-kilometer-by-1.6-kilometer (1-mile-by-1-mile) area, and thus is the nearest area having the specified population density in proximity to the Richton Dome site.

Therefore, for the potentially adverse population density and distribution guideline condition 10 CFR 960.5-2-1(c)(2), based upon the data, the Vacherie Dome and Cypress Creek Dome sites are more favorable than the Richton Dome site because they are farther from highly populated areas and areas having 1,000 persons in a 1.6-kilometer-by-1.6-kilometer (1-mile-by-1-mile) area.

Based on the above findings for the two discriminating potentially adverse conditions for the population density and distribution guideline 10 CFR 960.5-2-1, the Vacherie Dome site is more favorable for this guideline than the Richton Dome and the Cypress Creek Dome sites, because of its greater distance from highly populated areas compared to the Richton Dome site and its lower residential, seasonal, and daytime population densities within the projected controlled area boundaries than the Cypress Creek Dome site.

2.4.2.1.2 Site Ownership and Control (10 CFR 960.5-2-2). This preclosure site ownership and control guideline is similar to the postclosure site ownership and control guideline (10 CFR 960.4-2-8-2). The DOE has determined that the necessary land area and controls are the same for both the preclosure and postclosure periods. Because the DOE must obtain ownership and surface and subsurface rights before commencing preclosure, the preclosure and not the postclosure site ownership and control guideline was analyzed to determine if there was a basis for discriminating between the three sites.

The qualifying condition for the site ownership and control Technical Guideline (10 CFR 960.5-2-2) requires that a repository site be located on land for which the DOE can obtain, in accordance with the requirements of 10 CFR Part 60, ownership, surface and subsurface rights, and control of access that are required so that surface and subsurface activities during repository operation and closure will not likely cause radionuclide releases to an unrestricted area greater than specified allowable limits. A potentially adverse condition specified under this guideline consists of projected land ownership conflicts that cannot be resolved successfully through voluntary purchase-sell agreements, nondisputed agency-to-agency transfers of title, or Federal condemnation proceedings.

Land ownership information indicates that this potentially adverse condition is not present at either the Vacherie or Richton Dome site; however, it is present at the Cypress Creek Dome site. The Vacherie and Richton Dome sites are located on privately owned land for which the DOE can negotiate voluntary purchase-sell agreements, or, if necessary, obtain ownership rights by condemnation. On the other hand, the Cypress Creek Dome site is located within the De Soto National Forest on lands owned by the Federal Government, the State of Mississippi, and private owners. In addition, there is a potential conflict with the present use of the Federal land because of the presence of Camp Shelby. The DOE can negotiate voluntary purchase-sell agreements or use condemnation to obtain title to private and State lands. However, an agency-to-agency transfer of title for the land will not be adequate at the Cypress Creek Dome site and Congressional action will be required to transfer National Forest land to DOE control. In addition, the Mississippi National Guard has been granted use of the Camp Shelby lands until 1989, through a lease agreement with the U.S. Forest Service.

Therefore, for the potentially adverse site ownership and control guideline condition 10 CFR 960.5-2-2(c), based on available evidence, the Vacherie Dome and Richton Dome sites are more favorable repository sites than the Cypress Creek Dome site because of the present U.S. Forest Service jurisdiction over large portions of the site and the requirement for Congressional action to transfer control of National Forest lands for the repository from the U.S. Forest Service to the DOE.

2.4.2.1.3 Preclosure Radiological Safety Guidelines - Gulf Coast Site Preference. As shown in Table 2-5, based on the data available prior to site characterization as discussed above, each of the three guideline conditions for the population density and distribution and site ownership and control Technical Guidelines which discriminate among the three Gulf sites indicates that the Vacherie Dome site is expected to be a more favorable Gulf Salt Dome Basin repository site than either the Cypress Creek Dome or Richton Dome sites, primarily because of these two factors:

- Greater distance to populated areas and nearby population density characteristics (10 CFR 960.5-2-1)

- Presence at the Cypress Creek Dome site of projected land ownership conflicts that cannot be successfully resolved through voluntary agreements or legal proceedings (10 CFR 960.5-2-2).

The Richton Dome site is less favorable when compared against the preclosure radiological safety guideline grouping because of demographic factors related to its proximity to the town of Richton. The Cypress Creek Dome site is less favorable compared against the preclosure radiological safety guideline grouping because of seasonal and daytime population density fluxes that occur nearby at Camp Shelby and the potential National Forest land conveyance procedures that may be required.

2.4.2.2 Environment, Socioeconomics, and Transportation Guideline Group

The second preclosure guideline group - environment, socioeconomics, and transportation - includes conditions related to environmental quality (10 CFR 960.5-2-5) and socioeconomic impacts (10 CFR 960.5-2-6) in areas potentially affected by a repository, and to the transportation (10 CFR 960.5-2-7) of waste to a repository site. This guideline group focuses on adequately protecting the public and the environment during repository siting, construction,

operation, closure, and decommissioning from the hazards posed by the disposal of radioactive waste. As shown in Table 2-5 and discussed below, the environmental, socioeconomics, and transportation guidelines include five guideline conditions and three subconditions which, when applied to the potentially acceptable Vacherie Dome, Cypress Creek Dome, and Richton Dome sites, discriminate among them.

2.4.2.2.1 Environmental Quality (10 CFR 960.5-2-5). The qualifying condition for the environmental quality Technical Guideline (10 CFR 960.5-2-5) requires, in part, that the site shall be located so that the quality of the environment in the affected area during this and future generations will be adequately protected during repository siting, construction, operation, closure, and decommissioning, and that projected environmental impacts in the affected area can be mitigated to an acceptable degree taking into account programmatic, technical, social, economic, and environmental factors.

A potentially adverse condition specified under the environmental quality Technical Guideline 10 CFR 960.5-2-5(c)(3) is the proximity to, or projected significant adverse environmental impacts by the repository or its support facilities on, a component of the National Park System, the National Wildlife Refuge System, and the National Wild and Scenic Rivers System, the National Wilderness Preservation System, or National Forest land.

Land ownership and environmental impact data indicate that this potentially adverse condition is not present at the Vacherie Dome site but is present at the Cypress Creek Dome and Richton Dome sites. The Cypress Creek Dome site is located within the boundaries of the De Soto National Forest and could conflict with the present use of such lands for the Camp Shelby Military Reservation and the De Soto Military Operations Area. The dedicated Federal land closest to the Vacherie Dome site is the Kisatchie National Forest, located about 12 kilometers (7 miles) from the site. The area potentially affected by the repository and its support facilities does not extend into these dedicated lands, and proposed site characterization and repository activities would not impact on or conflict with the designated uses of the forest. De Soto National Forest is the dedicated Federal land closest to the Richton Dome site. Locating the proposed repository at this site would require the upgrading of both Mississippi State Route 15 and the abandoned Illinois-Central-Gulf rail line along those segments that pass through the western edge of the forest. The presence of these repository support facilities is in proximity to National Forest Land.

Therefore, for the potentially adverse environmental quality guideline condition 10 CFR 960.5-2-5(c)(3), based on land ownership and environmental impact evidence, the Vacherie Dome site is a more favorable site than the Cypress Creek Dome or Richton Dome sites because of (1) Cypress Creek Dome's proximity to a National Forest, and potential land-use conflicts associated with locating a repository within the boundaries of a National Forest and (2) the proximity of the Richton Dome site repository support facilities to the De Soto National Forest.

Based on the above findings for the discriminating favorable and potentially adverse conditions for the environmental quality guideline 10 CFR 960.5-2-5, the Vacherie Dome site is more favorable when compared against this guideline than either the Richton Dome or Cypress Creek Dome sites because of the Vacherie Dome site's expected ability to meet applicable environmental regulations and the remoteness of the site or projected environmental impacts to a significant national protected resource.

2.4.2.2.2 Socioeconomics (10 CFR 960.5-2-6). The qualifying condition for the socioeconomics Technical Guideline (10 CFR 960.5-2-6) requires, in part, that the site shall be located such that any significant adverse social or economic impacts induced in communities and surrounding regions by repository siting, construction, operation, closure, and decommissioning can be offset by reasonable mitigation or compensation. A potentially adverse condition specified under this guideline is potential for significant repository-related impacts on community services, housing supply and demand, and the finances of State and local government agencies in the affected area.

Available population data, projected work-force requirements, and locations where the workers and their families might live indicate that this potentially adverse condition is present at the Cypress Creek Dome site but is not present at the Richton Dome and Vacherie Dome sites. In-migration for the town of New Augusta is projected to be 40 percent over a 5-year period when the peak of construction in-migration is reached for a repository constructed at the Cypress Creek Dome site, 37 percent for the town of Richton over a 4-year period for the peak construction in-migration at the Richtone Dome site, and 17 percent over a 5-year period for the town of Heflin at the Vacherie Dome site. While the construction in-migration growth rate for New Augusta and Richton is similar, the fact that the town of New Augusta is approximately half the size of Richton suggests that impacts to New Augusta could be greater because of its projected inability to respond to changes of this magnitude. Although services and housing are expected to be adequate in the general regions surrounding all of the sites, a conservative approach considered the potential for greater impacts on New Augusta and the potentially adverse condition was taken for the Cypress Creek Dome site. Therefore, for the potentially adverse socioeconomic guideline condition (10 CFR 960.5-2-6[c][1]), based on the evidence, the Vacherie Dome and the Richton Dome sites are more favorable than the Cypress Creek Dome site.

Based on the above findings for the discriminating potentially adverse condition of the socioeconomics guideline (10 CFR 960.5-2-6), the Vacherie Dome and Richton Dome sites are more favorable for this guideline than the Cypress Creek Dome site.

2.4.2.2.3 Transportation (10 CFR 960.5-2-7). The qualifying condition for the Transportation Technical Guideline (10 CFR 960.5-2-7) requires, in part, that (1) a repository be located such that the access routes to be constructed from existing local highways and railroads to the site can be designed and constructed using reasonably available technology, and (2) transportation operations be conducted without causing an unacceptable risk to the public or unacceptable environmental impacts. One subcondition specified under a favorable condition of the Transportation Guideline (10 CFR 960.5-2-7[b][1][i]) is the availability of access routes that are relatively short and economical to construct. In application of this guideline, short and economical means less than 10 miles and less than $10 million. At the Richton Dome site, the access railroad required is 42 kilometers (26 miles) at a cost of $16 million. For the Cypress Creek and Vacherie Dome sites, the access railroads are 8 kilometers (5 miles) and 5.6 kilometers (3.5 miles) at a cost of $6 million and 2.4 million, respectively. Thus, the Cypress Creek and Vacherie Dome sites meet the subcondition 10 CFR 960.5-2-7(b)(1)(i) and the Richton Dome site does not.

Another subcondition (10 CFR 960.5-2-7[b][1][iii]) is the availability of access routes for which cuts, fills, tunnels, or bridges are not required. The need for significant cuts and fills is minimal at all three sites, but 1 truck bridge and 16 rail bridges will be required for access to the Richton Dome site, and 1 rail bridge will be required for access to the Cypress Creek Dome site. No bridges are required for access to the Vacherie Dome site. Thus, the Vacherie Dome site meets the subcondition 10 CFR 960.5-2-7(b)(1)(iii) and the Richton Dome and the Cypress Creek Dome sites do not.

Another subcondition (10 CFR 960.5-2-7[b][1][v]) is that such routes bypass local cities and towns. The rail access route to the Richton Dome site passes through the town of Laurel. None of the rail or road access routes to the Cypress Creek Dome or Vacherie Dome sites passes through a town. Thus, the Cypress Creek Dome and the Vacherie Dome sites meet the subcondition 10 CFR 960.5-2-7(b)(1)(v) and the Richton Dome site does not.

A favorable condition listed under this guideline is the proximity to local highways and railroads that provide access to regional highways and railroads and are adequate to serve the repository without significant upgrading or reconstruction.

Transportation data indicate that this favorable condition is present at the Vacherie Dome and Cypress Creek Dome sites but not at the Richton Dome site. New and upgraded highway and railroad requirements for representative access routes from local highways and railroads to each site are 14 kilometers (9 miles) of highways and 5.8 kilometers (3.5 miles) of railroads for the Vacherie Dome site; 6.6 and 8 kilometers (4.1 and 5 miles), respectively, for

the Cypress Creek Dome site; and 42 and 43 kilometers (26 and 27 miles), respectively, for the Richton Dome site. Therefore, for the favorable transportation guideline condition 10 CFR 960.5-2-7(b)(2), based on the evidence, the Vacherie Dome and Cypress Creek Dome sites are more favorable than the Richton Dome site because they are closer to local highways and railroads that provide access to regional transportation networks and are adequate to serve a repository without significant upgrading or reconstruction.

A potentially adverse condition specified under the transportation Technical Guideline 10 CFR 960.5-2-7(c)(1) is access routes to existing local highways and railroads that are expensive to construct compared to comparable siting options. In application of this guideline condition, a cost of truck or rail access routes greater than $10 million is considered expensive. At the Richton Dome site, the rail access route may cost up to $16 million. At the Cypress Creek Dome and the Vacherie Dome sites, all access routes are less than $10 million. Therefore, for the potentially adverse transportation guideline 10 CFR 960.5-2-7(c)(1), based on the evidence, the Vacherie Dome and Cypress Creek Dome sites are more favorable than the Richton Dome site because access routes are not expensive to construct except at the Richton Dome site.

A potentially adverse condition specified under the transportation Technical Guideline 10 CFR 960.5-2-7(c)(4) is any local condition that could cause transportation-related costs, environmental impacts, or risk to public health and safety from waste transportation operations to be significantly greater than those projected for other comparable siting options. In application of this guideline condition, proximity to a bombing range, extreme cost, or impacting the environmental and aesthetic qualities of pristine land are examples of local conditions that would be considered potentially adverse. The Cypress Creek Dome site is near the Camp Shelby training and military operations area. The Richton Dome and Vacherie Dome sites do not possess any of the attributes mentioned above. Therefore, for the potentially adverse transportation guideline 10 CFR 960.5-2-7(c)(4), based on the evidence, the Richton Dome and Vacherie Dome sites are more favorable than the Cypress Creek Dome site because of ongoing military activities, including the use of live ammunition, near the Cypress Creek Dome site.

Based on the above findings for the discriminating favorable and potentially adverse conditions for the transportation guideline (10 CFR 960.5-2-7), the Vacherie Dome site is more favorable when compared against this guideline than are the Cypress Creek and Richton Dome sites because the Cypress Creek and Richton Dome sites are farther from adequate highways and railroads, thus requiring more expensive construction and upgrading to provide adequate access to the existing regional and national transportation systems.

2.4.2.2.4 Environment, Socioeconomics, and Transportation Guidelines - Gulf Site Preference. As shown in Table 2-5, based on evidence available prior to site characterization, the five preclosure environmental quality, socioeconomic impacts, and transportation Technical Guideline conditions that discriminate among the three Gulf sites indicate that the Vacherie Dome site is expected to be a more favorable Gulf Salt Dome Basin repository site than the Cypress Creek Dome and Richton Dome sites, primarily because of its

- Relatively large distance to nearest dedicated Federal land (10 CFR 960.5-2-5), such as National Forests
- Proximity to local highways and railroads that will not require significant upgrading to provide adequate access to regional and national transportation systems (10 CFR 960.5-2-7).

The Cypress Creek Dome and Richton Dome sites are less favorable repository sites than the Vacherie Dome site when compared against the preclosure environment, socioeconomics, and transportation guidelines because of the less-favorable sites' locations and the creation of potential land-use conflicts within the De Soto National Forest. In addition, the Richton Dome site is less favorable because of the greater distance of local highway and railroad access construction required to link the site to the regional and national transportation networks.

2.4.2.3 Ease and Cost of Siting, Construction, Operation, and Closure Guideline Group

The third preclosure guideline group - ease and cost of siting, construction, operation, and closure - includes conditions related to the surface characteristics of a site (10 CFR 960.5-2-8) and the characteristics of the host rock and surrounding strata (10 CFR 960.5-2-9). These guidelines serve to demonstrate that repository siting, construction, operation, and closure are technically feasible on the basis of reasonably available technology, and that associated costs are reasonable compared to other available and comparable siting options. As shown in Table 2-5 and discussed below, this guideline group includes three guideline conditions under two separate guidelines which, when applied to the three sites, discriminate among them.

2.4.2.3.1 Surface Characteristics (10 CFR 960.5-2-8). The qualifying condition for the surface characteristics Technical Guideline (10 CFR 960.5-2-8) requires, in part, that the site be located such that surface characteristics and conditions of surface-water systems and terrain meet the specified requirements for repository siting, construction, operation, and closure. To receive a favorable condition when compared against this guideline, a site must have generally well-drained terrain.

Site data indicate that this favorable condition is present at the Vacherie Dome and Richton Dome sites but not at the Cypress Creek Dome site. Specifically, the soils at the Vacherie Dome and Richton Dome sites are well drained, and the topographic relief is such that most excess runoff is drained by small tributaries. However, at the Cypress Creek Dome site, the alluvial soils are poorly drained and swampy conditions exist. Therefore, for the favorable surface characteristics guideline condition 10 CFR 960.5-2-8(b)(2), based upon the evidence, the Vacherie Dome and Richton Dome sites are more favorable than the Cypress Creek Dome site, given the natural drainage characteristics of each site.

Based on the above findings for the discriminating favorable and potentially adverse condition for the surface characteristics guideline 10 CFR 960.5-2-8, the Richton Dome and Vacherie Dome sites are more favorable for this guideline than the Cypress Creek Dome site. The Vacherie Dome and Richton Dome sites generally are better drained than Cypress Creek Dome site.

2.4.2.3.2 Rock Characteristics (10 CFR 960.5-2-9). The qualifying condition for the rock characteristics Technical Guideline (10 CFR 960.5-2-9) requires, in part, that the site be located such that the thickness and lateral extent and the characteristics and composition of the host rock will be suitable for accommodation of the underground facility; and that repository construction, operation, and closure will not cause undue hazard to personnel. A favorable condition specified under this guideline is a host rock sufficiently thick and laterally extensive to allow significant flexibility in selecting the depth, configuration, and location of the underground facility.

Similar to the postclosure rock characteristics discriminator 10 CFR 960.4-2-3(b)(1), discussed in Section 2.4.1.1, available geologic data and conceptual engineering designs indicate that this favorable condition is present at the Richton Dome site but not at the Vacherie Dome and Cypress Creek Dome sites. Although engineering calculations and conceptual repository designs show that each of the potentially acceptable Gulf Coast Salt Domes has a sufficient salt mass to allow flexibility in selecting the depth, configuration, and location of the subsurface repository facilities, for the same given conservative design requirements, only the Richton Dome site has a host rock lateral extent at the proposed repository depth that permits flexibility in siting a single-level repository design while maintaining an adequate buffer for isolation. This constraint results in some limitations in selecting an optimum depth, configuration, and location of the subsurface repository facilities at the Vacherie Dome and Cypress Creek Dome sites to minimize hazards and maximize worker safety during repository construction, operation, and closure. Therefore, for the favorable rock characteristics guideline condition 10 CFR 960.5-2-9(b)(1), based upon the evidence, the Richton Dome site is a more favorable site than the Vacherie Dome or Cypress Creek Dome sites because its greater host rock lateral extent at the proposed repository depth will permit more flexibility in selecting the repository depth, configuration, and location of the underground facility.

A related potentially adverse condition specified under the rock characteristics guideline 10 CFR 960.5-2-9(c)(1) is a host rock that is suitable for repository construction, operation, and closure, but is so thin or laterally restricted that little flexibility is available for selecting the depth, configuration, or location of an underground facility. As discussed in the previous paragraph, the salt at Richton Dome provides more than adequate thickness and lateral extent for placement of the underground repository facility, whereas the Vacherie Dome and Cypress Creek Dome sites have significant lateral restrictions. Therefore, for the potentially adverse rock characteristics guideline condition 10 CFR 960.5-2-9(c)(1), based on the evidence, the Richton Dome site is more favorable than either the Vacherie Dome or Cypress Creek Dome sites because the Richton Dome site has a greater areal extent of host rock available for selecting the depth, configuration, and location of an underground facility.

Based on the above findings for the discriminating favorable and potentially adverse conditions for the rock characteristics guideline 10 CFR 960.5-2-9, the Richton Dome site is more favorable for this guideline than either the Cypress Creek Dome or Vacherie Dome sites. The Richton Dome site has greater lateral extent at the proposed repository horizon than the other two domes, and this will allow more flexibility to ensure worker safety during repository construction, operation, and closure.

2.4.2.3.3 Ease and Cost of Siting, Construction, Operation, and Closure - Gulf Coast Site Preference. As shown in Table 2-5, based on data available prior to site characterization, the three preclosure surface characteristics and rock characteristics Technical Guideline conditions that discriminate among the three Gulf sites indicate that the Richton Dome site is expected to be a more favorable Gulf Salt Dome Basin repository site than the Vacherie Dome and Cypress Creek Dome sites, primarily because of its

- Greater lateral extent of host rock, which permits flexibility in subsurface repository location and configuration (10 CFR 960.5-2-9)
- To a lesser extent, its favorable site natural surface-water drainage patterns (10 CFR 960.5-2-8).

The Vacherie Dome and Cypress Creek Dome sites are less favorable repository sites than the Richton Dome site when all are compared against the preclosure ease and cost of siting, construction, operation, and closure guidelines because the Richton Dome site has a better natural drainage system, and a less restrictive areal extent of host rock.

2.4.3 Preferred Gulf Coast Salt Dome Basin Site

The findings from the comparative evaluation of the postclosure and preclosure guidelines are summarized and the results of additional analyses which were performed to assist in the selection of the preferred Gulf Coast Salt Dome Basin site are presented in the following paragraphs. The comparative evaluation results from the Section 2.4.1 postclosure discriminating technical guidelines and the Section 2.4.2 preclosure discriminating technical guidelines are summarized in Table 2-6.

Section 2.4.1.4 and Table 2-6 clearly indicate that, based on postclosure repository performance, the Richton Dome site is the preferred site within the Gulf Coast Salt Dome Basin. Section 2.4.2 and Table 2-6 show that the Richton Dome site is also the preferred site for the preclosure ease and cost of siting, construction, operation, and closure guideline group.

The Vacherie Dome site is considered the preferred site, according to Section 2.4.2 and Table 2-6, for the preclosure radiological safety and preclosure environment, socioeconomics, and transportation guideline groups. The Cypress Creek Dome site is less preferred than either the Richton Dome site or the Vacherie Dome site for all four of the postclosure and preclosure guideline groups.

Because none of the three Gulf Coast Salt Dome Basin sites is preferred for all four guideline groups, additional analyses were required to aggregate the findings of

Table 2-6. Summary of Findings Based on Discriminating Guidelines Among the Potentially Acceptable Gulf Coast Salt Basin Sites

	Finding	
	Less Favorable	More Favorable
Postclosure Discriminating Guidelines		
Rock Characteristics 960.4-2-3	Vacherie Cypress Creek	Richton
Dissolution 960.4-2-6	Vacherie Cypress Creek	Richton
Human Interference 960.4-2-8	Cypress Creek Vacherie	Richton
Overall Postclosure Performance	Cypress Creek Vacherie	Richton
Preclosure Radiological Safety Discriminating Guidelines		
Population Density and Distribution 960.5-2-1	Richton Cypress Creek	Vacherie
Site Ownership and Control 960.5-2-2	Cypress Creek	Richton Vacherie
Overall Preclosure Radiological Safety	Richton Cypress Creek	Vacherie
Preclosure Environment, Socioeconomic and Transportation Discriminating Guidelines		
Environmental Quality 960.5-2-5	Cypress Creek Richton	Vacherie
Socioeconomic 960.5-2-6	Cypress Creek	Vacherie Richton
Transportation 960.5-2-7	Richton	Vacherie Cypress Creek
Overall Preclosure Environment, Socioeconomic and Transportation	Richton Cypress Creek	Vacherie
Preclosure Ease and Cost of Siting, Construction, Operation, and Closure Discriminating Guidelines		
Surface Characteristics 960.5-2-8	Cypress Creek	Richton Vacherie
Rock Characteristics 960.5-2-9	Vacherie Cypress Creek	Richton
Overall Preclosure Ease and Cost of Siting Construction, Operation, and Closure	Vacherie Cypress Creek	Richton

Sections 2.4.1 and 2.4.2. The basis to be followed for site comparative evaluation, as specified under 10 CFR 960.3-1-5, includes the following:

1. Site comparison must be based on both the preclosure and postclosure guidelines.

2. Primary significance shall be placed on the postclosure guidelines.

3. Secondary significance shall be placed on the preclosure guidelines.

4. Preclosure guidelines are separated into the following three groups in decreasing order of importance: (1) preclosure radiological safety; (2) environment, socioeconomics, and transportation; and (3) ease and cost of siting, construction, operation, and closure.

As stated above, the Richton Dome site is clearly the preferred Gulf Coast Salt Dome site based on postclosure repository performance. Placing primary significance on postclosure performance would indicate that the Richton Dome site is the overall preferred site. Investigating further, for the Vacherie Dome site to be found "as preferred as" or "more preferred than" the Richton Dome site, a number of conditions would have to be met. Specifically, from Table 2-6:

1. The preclosure radiological safety and environment, socioeconomics, and transportation guideline groups would have to be of equal significance or nearly equal significance to the postclosure group.

2. The ease and cost of siting, construction, operation and closure preclosure guideline group would have to be much less significant than either of the other two preclosure guideline groups.

These particular conditions would seem to violate 10 CFR 960.3-1-5 and items 2 and 3 above, as well as require a significant skewing in the relative importance of the preclosure guideline groups. Because the Cypress Creek Dome site was not preferred for any of the postclosure or preclosure guideline groupings, a similar analysis was not needed. Therefore, the results of this investigation show that while the Richton Dome Site is the preferred Gulf Coast Salt Dome Basin Site, the Vacherie Dome Site is not far behind. The primary reasons for not choosing the Vacherie Dome Site as the "most preferred" site were the limited lateral extent of the host rock, and the presence of a potential dissolution feature at the site. The Cypress Creek Dome site was much less preferred than either the Richton Dome or the Vacherie Dome sites, for the same reasons as the Vacherie Dome site plus the presence of the De Soto National Forest and a terrain that is not generally well-drained.

Based on the available discriminating guideline evidence specified above for each of the three potentially acceptable Gulf Coast Salt Dome Basin sites, and following the comparative evaluation process specified by the 10 CFR Part 960 final General Guidelines for the recommendation of sites for nuclear waste repositories (DOE, 1984), the Richton Dome site is determined to be the preferred site for subsequent site characterization studies in the Gulf Coast Salt Dome geohydrologic setting.

2.5 CHAPTER 2 REFERENCES

2.5.1 References Listed by Author

Anderson, R. Ernest, D. Hoye Eargle, and Beth O. Davis, 1973. Geologic and Hydrologic Summary of Salt Domes in Gulf Coast Region of Texas, Louisiana, Mississippi, and Alabama, U.S. Geological Survey Open-File Report 4339-2, U.S. Department of the Interior, Denver, CO.

Bechtel National, Inc., 1980. Regional Environmental Characterization Report for the Gulf Interior Region and Surrounding Territory, ONWI-67, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Bechtel National, Inc., 1982. Environmental Characterization Report for the Gulf Interior Region, Louisiana Study Area, ONWI-192, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Bechtel National, Inc., 1982. Environmental Characterization Report for the Gulf Interior Region, Mississippi Study Area, ONWI-193, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Bechtel National, Inc., 1982. Environmental Characterization Report for the Gulf Interior Region, Texas Study Area, ONWI-194, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Bechtel National, Inc., and Law Engineering Testing Company, 1980. Summary Characterization and Recommendation of Study Areas for the Gulf Interior Region, ONWI-18, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

BNI, see Bechtel National, Inc.

Brunton, G. D., and W. C. McClain, 1977. Geological Criteria for Radioactive Waste Repositories, Y/OWI/TM-47, prepared for U.S. Department of Energy by Office of Waste Isolation, Union Carbide Corporation, Nuclear Division, Oak Ridge, TN.

Brunton, G. D., R. B. Laughon, and W. C. McClain, 1978, Screening Specifications for Gulf Coast Salt Domes, Y/OWI/TM-48, prepared for U.S. Department of Energy by Office of Waste Isolation, Union Carbide Corporation, Nuclear Division, Oak Ridge, TN.

DOE, see U.S. Department of Energy.

Ertec, Inc., 1983. Midyear FY 83 Richton Dome Screening and Suitability Review, ONWI-484, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Halbouty, Michel T., 1979. Salt Domes - Gulf Region, United States and Mexico, 2nd edn., Gulf Publishing Company, Houston, TX.

Kreitler, Charles W., E. G. Wermund, E. H. Guevara, A. Giles, and G. Fogg, 1978. Preliminary Evaluation of Salt Domes in East Texas for the NWTS Program, U.S. Department of Energy, Washington, DC.

Law Engineering Testing Company, 1981. Geologic Evaluation of Gulf Coast Salt Domes: Overall Assessment of the Gulf Interior Region, ONWI-106, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Law Engineering Testing Company, 1982. Gulf Coast Salt Domes Geologic Area Characterization Report, Vol. I, Introduction, ONWI-117, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Law Engineering Testing Company, 1982. Gulf Coast Salt Domes Geologic Area Characterization Report, Vol. II, East Texas Study Area, ONWI-118, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Law Engineering Testing Company, 1982. Gulf Coast Salt Domes Geologic Area Characterization Report, North Louisiana Study Area, Vol. IV, ONWI-119, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Law Engineering Testing Company, 1982. Gulf Coast Salt Domes Geologic Area Characterization Report, Mississippi Study Area, Vol. VI, ONWI-120, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

LETCO, see Law Engineering Testing Company.

McGuinness, C. L., 1963. The Role of Ground Water in the National Water Situation, U.S. Geological Survey Water-Supply Paper 1800, U.S. Department of the Interior, Washington, DC.

Meinzer, Oscar Edward, 1939. Ground Water in the United States - A Summary of Ground Water Conditions and Resources Utilization of Water From Wells and Springs, Methods of Scientific Investigation and Literature Relating to the Subject, U.S. Geological Survey Water Supply Paper 836-D, U.S. Department of the Interior, Washington, DC.

NAS-NRC, see National Academy of Sciences - National Research Council.

National Academy of Sciences - National Research Council, 1957. The Disposal of Radioactive Wastes on Land, Publication 519, Report of the Committee on Waste Disposal, Division of Earth Sciences, Washington, DC.

National Academy of Sciences - National Research Council, 1970. Disposal of Solid Radioactive Wastes in Bedded Salt Deposits, Committee on Radioactive Waste Management, Washington, DC.

Neff, J. O., 1984. Position Paper on the Geohydrologic Setting of Vacherie, Richton, and Cypress Creek Salt Domes, Salt Repository Project Office, U.S. Department of Energy, Columbus, OH.

NUS Corporation, 1978. Nongeologic Criteria for Radioactive Waste Repositories, Y/OWI/SUB-77/16504/10 (Draft), Office of Waste Isolation, Union Carbide Corporation, Nuclear Division, Oak Ridge, TN.

Office of Nuclear Waste Isolation, 1980. NWTS Criteria for the Geologic Disposal of Nuclear Wastes: Site Qualification Criteria, ONWI-33(2), prepared for the U.S. Department of Energy, Public Draft.

Office of Nuclear Waste Isolation, 1982. Evaluation of Area Studies of the U.S. Gulf Coast Salt Dome Basins: Location Recommendation Report, ONWI-109, Battelle Memorial Institute, Columbus, OH.

ONWI, see Office of Nuclear Waste Isolation.

Seni, Steven J., and M.P.A. Jackson, 1983. "Evolution of Salt Structures, East Texas Diapir Province, Part 1: Patterns and Rates of Halokinesis," American Association of Petroleum Geologists Bulletin, Vol. 67, No. 8, pp. 1245-1274.

Stearns-Roger Services Inc., 1981. Engineering Feasibility Studies for Candidate Salt Domes: National Waste Terminal Storage Repository No. 1, Special Study No. 5, ONWI-283, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

U.S. Department of Energy, 1981. NWTS Program Criteria for Mined Geologic Disposal of Nuclear Waste: Site Performance Criteria, DOE/NWTS-33(2), Office of NWTS Integration, Battelle Memorial Institute, Columbus, OH.

U.S. Department of Energy, 1981. Reactor and Nonreactor Nuclear Facility Emergency Planning, Preparedness, and Response Program for Department of Energy Operations, DOE Order 5500.3, Washington, DC.

U.S. Department of Energy, 1984. "Nuclear Waste Policy Act of 1982; General Guidelines for the Recommendation of Sites for the Nuclear Waste Repositories; Final Siting Guidelines," (10 CFR Part 960), Federal Register, Vol. 49, pp. 47714-47770, Washington, DC, December 6.

2.5.2 Federal Regulations and Statutes

10 CFR Part 60, Disposal of High-Level Radioactive Wastes in Geologic Repositories; Technical Criteria.

10 CFR Part 960, Nuclear Waste Policy Act of 1982; General Guidelines for the Recommendation of Sites for the Nuclear Waste Repositories; Final Siting Guidelines.

40 CFR Part 191, Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes; Final Rule, September 19, 1985.

Nuclear Waste Policy Act of 1982, 42 USC Secs. 10101-10226.

Chapter 3

THE SITE

Chapter 3 summarizes the present information base on the Richton Dome site in Perry County, Mississippi (Figure 3-1). This information is the foundation on which subsequent EA chapters rely for evaluations and assessments mandated by the "Nuclear Waste Policy Act of 1982" (NWPA) (42 USC Sections 10101 et seq.).

This chapter includes a description of the site and the environmental characteristics that may be affected by both site characterization activities and repository development at the site. The information has been developed from reviews of applicable literature and completion of various field surveys conducted during the site selection process described in Chapter 2.

The following terms of reference are used for purposes of discussion of surface features associated with Richton Dome (Figures 3-2 and 4-5).

Study Area generally represents an area whose boundaries extend well beyond the dome. Specific boundaries, which conform to natural features (such as drainage basins or vegetation types) or cultural features (such as State or county lines), are defined within subsections.

Exploratory Shaft Facility is the 28-hectare (68-acre) surface area directly affected by construction and operation of the two exploratory shafts during the site characterization activities.

Dome Area is a projection to the land surface of a contour around the salt dome at a depth of 610 meters (2,000 feet) below mean sea level (MSL). The land area enclosed by this contour at Richton Dome is 2,221 hectares (5,489 acres).

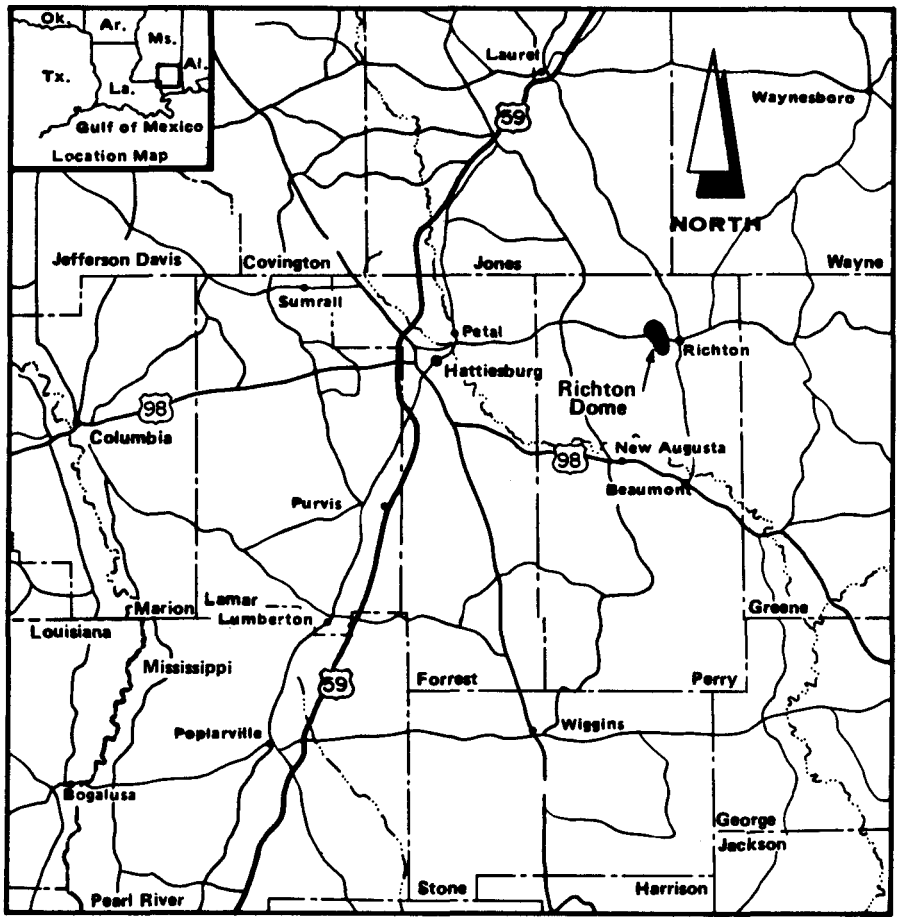
Repository Site means an area that consists of (1) the geologic repository underground operation area of approximately 890 hectares (2,200 acres), (2) a fenced central area (restricted area) of about 165 hectares (407 acres) for support buildings and repository surface facilities, and (3) a controlled area extending outward from the edge of the underground operation area.

Geologic Repository Operations Area (GROA) means a radioactive-waste facility that is part of the geologic repository, including both surface and subsurface areas and facilities where waste-handling activities are conducted.

Restricted Area means any area to which access is controlled by the DOE to protect individuals from exposure to radiation and radioactive materials before repository closure. For the purpose of this EA, the restricted area is the approximately 165-hectare (407-acre) surface area directly affected by site preparation, construction of surface and underground facilities, and repository operations.

Controlled Area means a surface location, to be marked by suitable monuments, extending horizontally no more than 4.8 kilometers (3 miles) (consistent with 40 CFR Part 191) in any direction from the surface projection of the outer boundary of the underground facility, and the underlying subsurface, which has been committed to use as a geologic repository and from which incompatible activities would be prohibited before and after permanent closure. For the purposes of this EA, the controlled area corresponds to the dome area.

Geologic Setting means the geologic, hydrologic, and geochemical systems of the region in which a geologic-repository operations area is or may be located. For the purpose of this assessment, the Mississippi Salt Basin is the geologic setting of the Richton Dome site.



Explanation

- 59 — Highway
- Secondary road
- County line
- State line
- River drainages

Scale

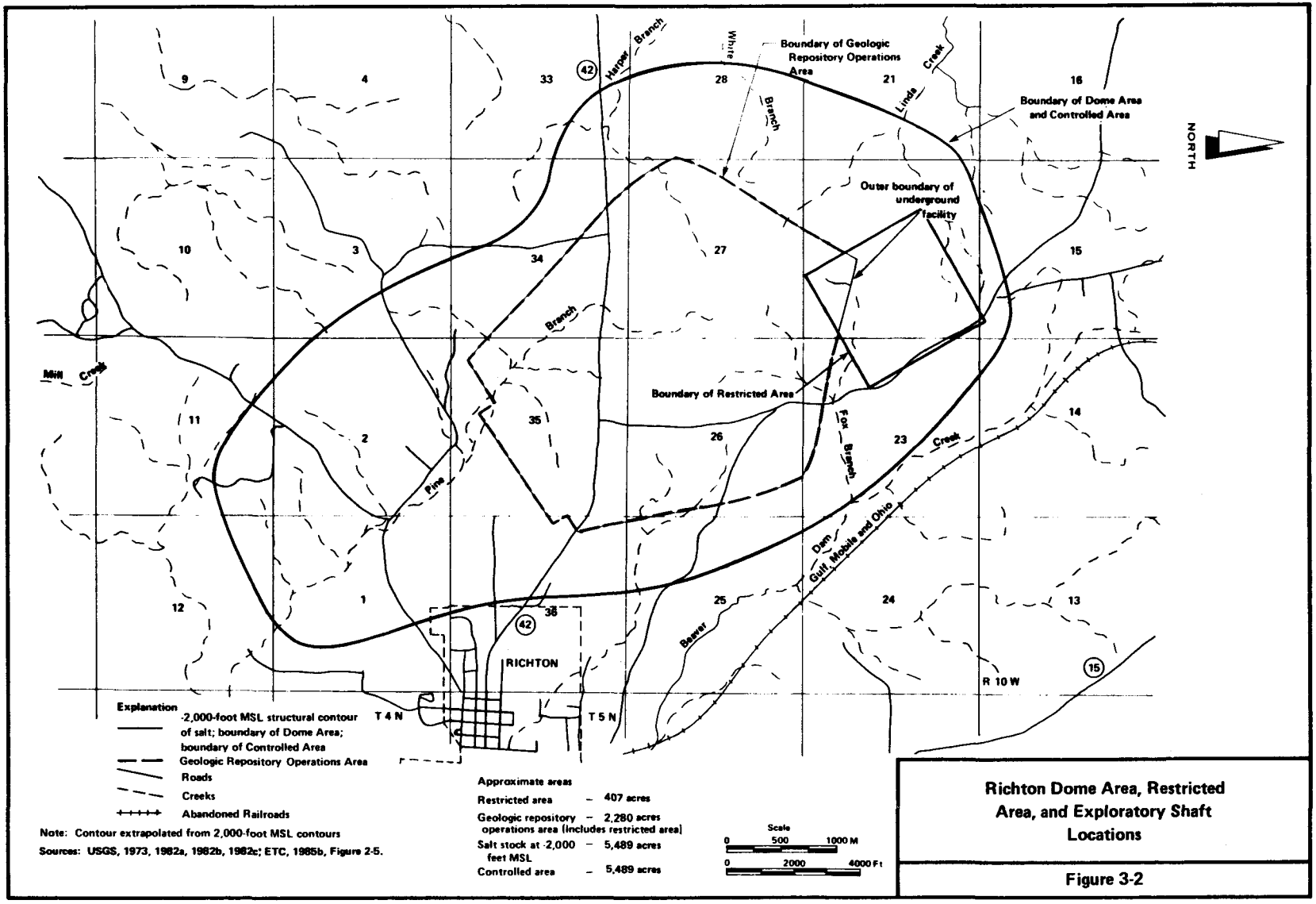
0 20 40 Km

0 10 20 Mi

Location of Richton Dome

Source: USGS, 1972.

Figure 3-1



Richton Dome Area, Restricted Area, and Exploratory Shaft Locations

Figure 3-2

3.1 LOCATION, GENERAL APPEARANCE AND TERRAIN, AND PRESENT USES

The Richton Dome area is located in Perry County, Mississippi, about 30 kilometers (18 miles) east of Hattiesburg and 18 kilometers (11 miles) north-northeast of New Augusta, the county seat (Figure 3-1). The nearest population center is Richton, a town of about 1,200 located approximately 3.2 kilometers (2.0 miles) southeast of the boundary of the restricted area (Figure 3-2).

Several State and Federal highways serve the Richton area. Interstate 59, from New Orleans to Birmingham, Alabama, passes through Hattiesburg. Mississippi State Highway 42, between Hattiesburg and Richton, crosses directly over the dome. Rail access exists at both Hattiesburg and Laurel. A portion of the Illinois Central Gulf line which previously served the town of Richton has been abandoned.

Terrain at the dome area and throughout the Southern Pine Hills is classified as flat to gently rolling (Section 3.2.2). The dome area is drained by tributaries of Bogue Homo and Thompson Creeks, both of which are characterized by meandering channels and broad flood plains. Both creeks flow into the Leaf River, a major tributary of the Pascagoula River. The Pascagoula River drains an area of about 25,000 square kilometers (9,700 square miles), eventually flowing into the Gulf of Mexico.

Principal present uses of the dome area (see Section 3.4.1) are forestry and agriculture. Much of the forest at the repository site has been clear-cut and reseeded since publication of the land-use information contained in the Environmental Area Characterization Report (BNI, 1982, ONWI-193).

3.2 GEOLOGIC CONDITIONS

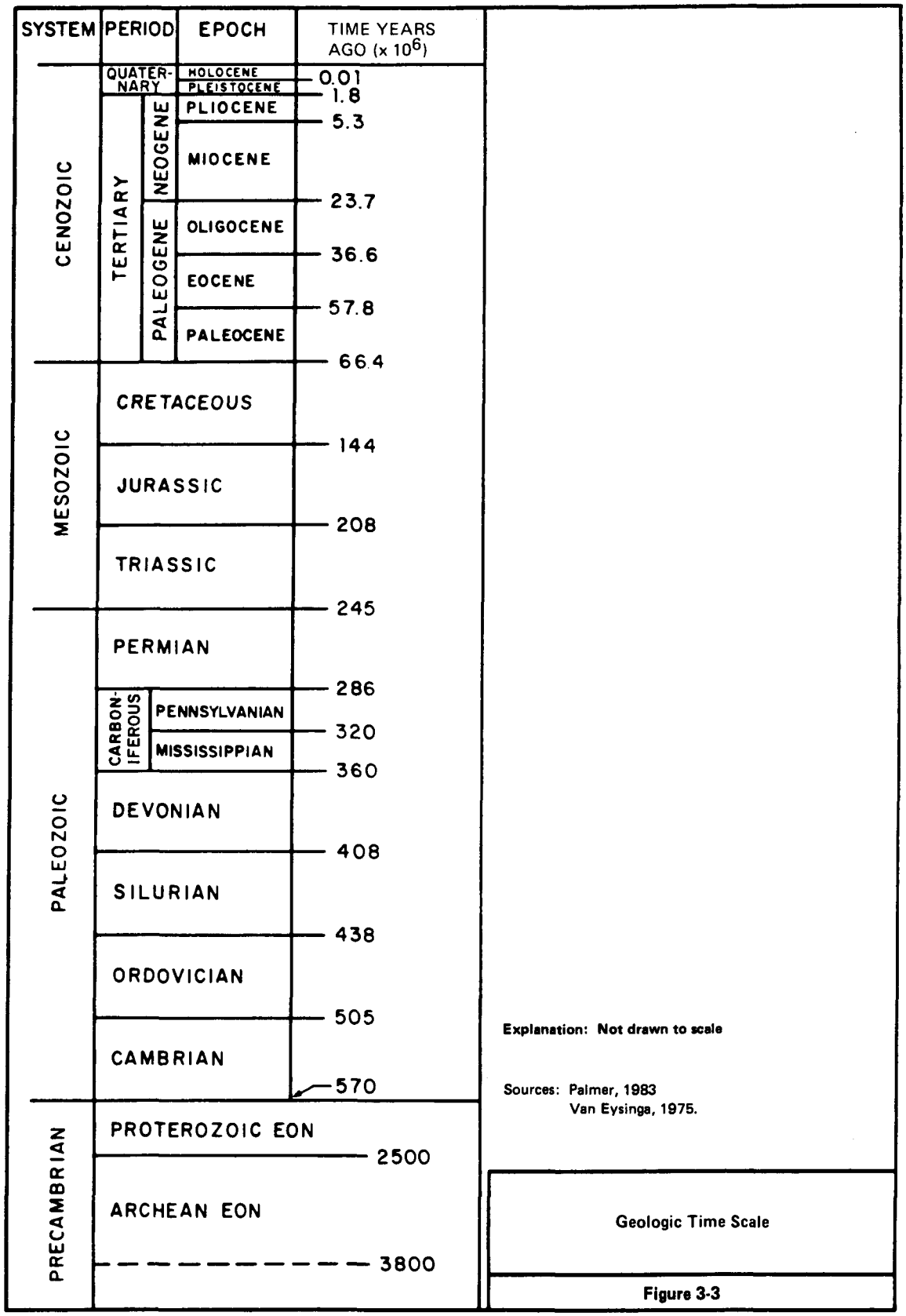
This section provides information on the geologic conditions at Richton Dome and the geologic processes that have acted to produce those conditions. A geologic time scale is presented in Figure 3-3 and geologic terms are defined in the Glossary.

3.2.1 Regional Geology

Richton Dome is located in the southeastern part of the Mississippi Salt Basin (Figure 3-4), a deep, asymmetric, structural depression approximately 400 kilometers (250 miles) long and 100 kilometers (60 miles) wide. This basin is the geologic setting for Richton Dome and is situated on the continental margin of the Gulf Coast Geosyncline, an east-west-trending structural trough filled with Mesozoic and Cenozoic sediments. The Mississippi Salt Basin extends from the Monroe-Sharkey Uplift in northeastern Louisiana across Mississippi to the Mobile Graben in southwestern Alabama (Figure 3-4). In eastern Mississippi, the basin is bounded on the north by the Pickens-Gilbertown Fault System and on the south by the Wiggins Anticline. The salt basin occupies approximately 39,000 square kilometers (15,000 square miles) (Anderson et al., 1973, p. 66). The relatively flat-lying and southward-dipping Mesozoic and Cenozoic sediments are locally disturbed by salt diapirs (salt domes, ridges) and related structural features.

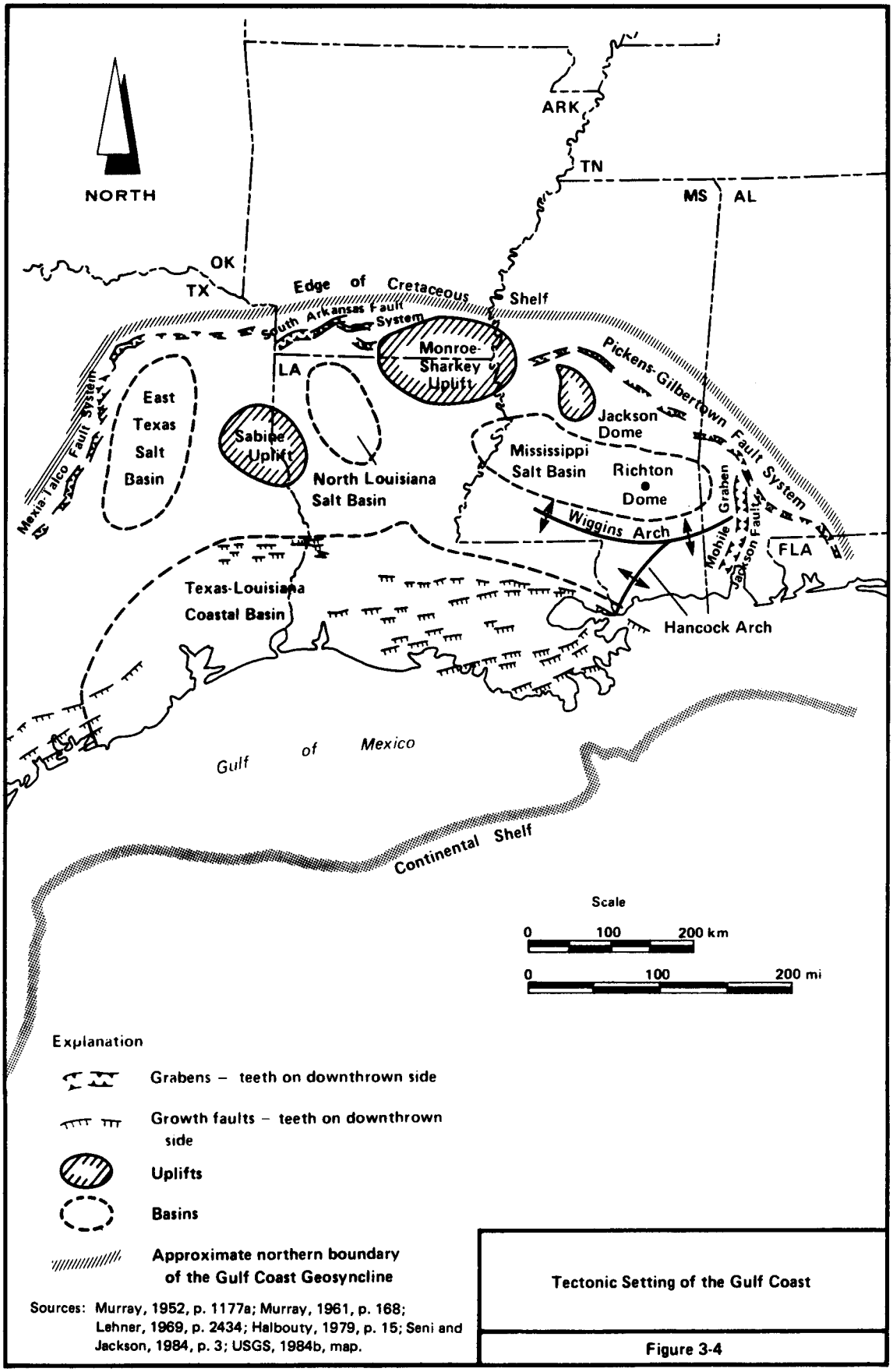
The Mississippi Salt Basin is one of several inland salt basins in Texas, Louisiana, and Mississippi that flank the northern Gulf Coast (Seni and Jackson, 1983, p. 1219) (Figure 3-4). The evolution of these basins within the larger Gulf Coast Geosyncline was initiated by continental rifting during the early Triassic. The rifting that formed the geosyncline was probably the result of a subcrustal thermal anomaly caused by the rise of mantle material (Jackson, 1981, p. 7).

In the Jurassic, a thinned crust consisting of a series of down-dropped fault blocks developed in the continental rift zone. The Gulf of Mexico formed to the south of the geosyncline by sea-floor spreading associated with the thermal anomaly. The rifted area formed a broad, shallow basin that was inundated by marine water. Restricted water circulation in the basin resulted in a thick accumulation of evaporitic salt deposits that constitute the Louann Salt (Jackson, 1981, p. 9).



Geologic Time Scale

Figure 3-3



Sources: Murray, 1952, p. 1177a; Murray, 1961, p. 168; Lehner, 1969, p. 2434; Halbouty, 1979, p. 15; Seni and Jackson, 1984, p. 3; USGS, 1984b, map.

Tectonic Setting of the Gulf Coast

Figure 3-4

By the Late Jurassic, the influence of the thermal anomaly (heat derived from the mantle) on the rift zone within the North American plate diminished (Pindell and Dewey, 1982, pp. 198-207). Along the continental margin of the Gulf Coast Geosyncline, structures such as the Mississippi Salt Basin and intrabasinal ridges formed as a result of differential subsidence of the cooling fault blocks.

Late Jurassic and Cretaceous sedimentation in the Mississippi Salt Basin approximately equaled the rate of basin subsidence. Open-water marine and deltaic sediments were the principal types of deposits formed during this time. It is hypothesized that differential sediment loading induced the mobilization of the Louann Salt. Mobilization of the Louann Salt is theorized to conform to the model of salt flowage proposed by Trusheim (1960), which outlined salt diapirism induced by differential loading of overlying sediments. The ensuing horizontal migration of the Louann Salt resulted in some areas being depleted in salt. These salt-withdrawal basins continued to receive sedimentation and became centers of increased sediment thickness. This process increased the differential sediment loading on the salt until vertical migration of the salt through the overlying sediments (diapirism) occurred and salt domes formed (Kreitler et al., 1981, p. 21). Structural features such as folds, rim synclines, and tension-induced faults were produced by salt movement and developed over and near the domes.

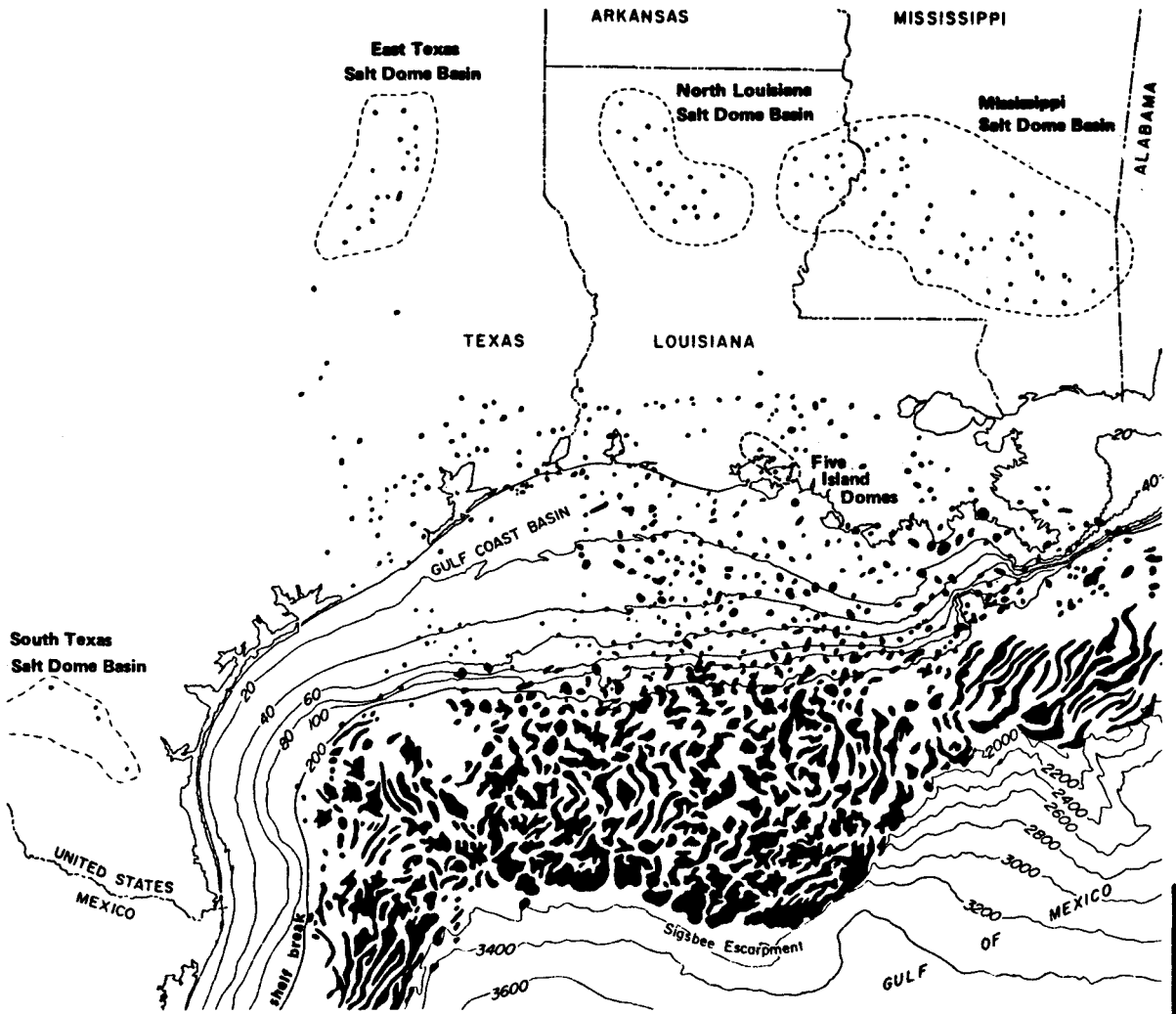
By the end of the Cretaceous, subsidence slowed and the Mississippi Salt Basin filled to near capacity with sediments derived from the adjacent continent. Additional sediments were deposited progressively gulfward, outside the basin, and toward the axis of the larger Gulf Coast Geosyncline (Bornhauser, 1958, p. 343). Sediment loading in the gulf initiated the growth of salt domes southward with time and eventually caused the formation of salt massifs on the continental slope (Figure 3-5). Decreased sedimentation in the Mississippi Salt Basin reduced the rate of sediment loading on the Louann Salt, which led to a reduction of salt movement (diapirism), and the stabilization of existing salt structural features (LETCo, 1982, ONWI-117, pp. 2-15 to 2-17).

By the early Tertiary, subsidence related to crustal cooling had ceased and sediments derived from the adjacent continent continued to be transported progressively gulfward (Ertec, Inc., 1983, ONWI-484, p. 19). As a result, the mechanism of subsidence changed from crustal cooling to sediment loading as thick accumulations of sediments subsequently depressed and downwarped the continental crust. Such further subsidence resulted in deposition of additional Tertiary- to Quaternary-age sediments in the Mississippi Salt Basin. Post-diapiric salt movement continued through middle to late Tertiary. The last areally extensive deposit is the widespread but thin Plio-Pleistocene Citronelle Formation, which was deposited onto older units of Tertiary age (see Section 3.2.3).

Since early Pleistocene (preglacial) time, the Mississippi Salt Basin has undergone uplift in marked contrast to the subsidence that had affected the region since the Triassic (Section 3.2.5.4). Uplift may be the result of crustal loading via a process described by Walcott (1972, p. 1847); the weight of sediments deposited on the continental margin causes subsidence around the center of deposition and uplift on the margins of the depressed area. Throughout the Tertiary, as sediments were deposited in the Gulf Coast Geosyncline, the center of deposition and the associated area of uplift moved gulfward. Thus, by the early Pleistocene, the Mississippi Salt Basin was situated on the uplifting margin of the Gulf Coast Geosyncline (Figure 3-4).

3.2.2 Geomorphology

This section describes the geomorphology of the Richton Dome area and those geomorphic processes operating within the Quaternary that contributed to its development. First, the physiographic setting is presented. Second, estimates of the rates of erosion and incision during the Quaternary are presented. These rates provide a general estimate of erosion rates anticipated at Richton Dome in the future. Finally, climatic fluctuations during the late Pleistocene and projections of future changes are presented.



Explanation

- Salt dome
- Salt massif

Scale
0 50 100 mi
0 100 200 km
Contour interval variable (meters)

Source: Martin, 1978

Distribution of Salt Domes and Salt Massifs in the Gulf Coast

Figure 3-5

3.2.2.1 Physiography

Richton Dome is located within a heavily vegetated area called the Southern Pine Hills physiographic subdivision of the East Gulf Coastal Plain physiographic province (Figure 3-6) (Thornbury, 1965; Fenneman, 1946). The terrain is dissected by wide, flat-bottomed valleys through which tributaries to the Pearl and Pascagoula rivers flow. The land surface near Richton Dome is a gently rolling flatland, with moderate relief that developed by mature dissection of the Miocene-Pleistocene Formations. Alluvial terraces are present in the valleys of the larger streams. Elevations within 8 kilometers (5 miles) of the dome range from 50 to 90 meters (160 to 290 feet) above mean sea level (MSL).

Richton Dome is located beneath the interfluve of Bogue Homo and Thompson Creek (Figure 3-7). Drainage over Richton Dome has been described as radial by previous investigators (LETCo, 1982, ONWI-120, pp. 13-125; Berger and Aghassy, 1982, p. 75). In addition, LETCo (1982, ONWI-120, Vol. VII, p. D-1-43) noted that the intermediate-order streams (second and third) of the area appear to be preferentially oriented in a northwest/southeast direction, parallel to one of the regional major lineament trends.

Further study of the streams in the near-dome area has shown that approximately 86 percent of all second and third order streams flow either southwest or southeast, indicating that radial drainage does not exist or is poorly developed over the near-dome area. Additionally, only 52 percent of the intermediate-order streams have a northwest/southeast orientation, indicating that these streams are not preferentially oriented with the northwest /southeast major lineament mode.

LETCo (1982, ONWI-120, pp. 13-25) noted the importance of lithology to the drainage network, stating, "....drainage courses in the near-dome area are dominantly controlled by variations in lithology." Open dendritic drainage is characteristic of the more sand-rich units exposed at the surface. In contrast, intricate dendritic drainage is characteristic of the silt and clay-rich members of these units.

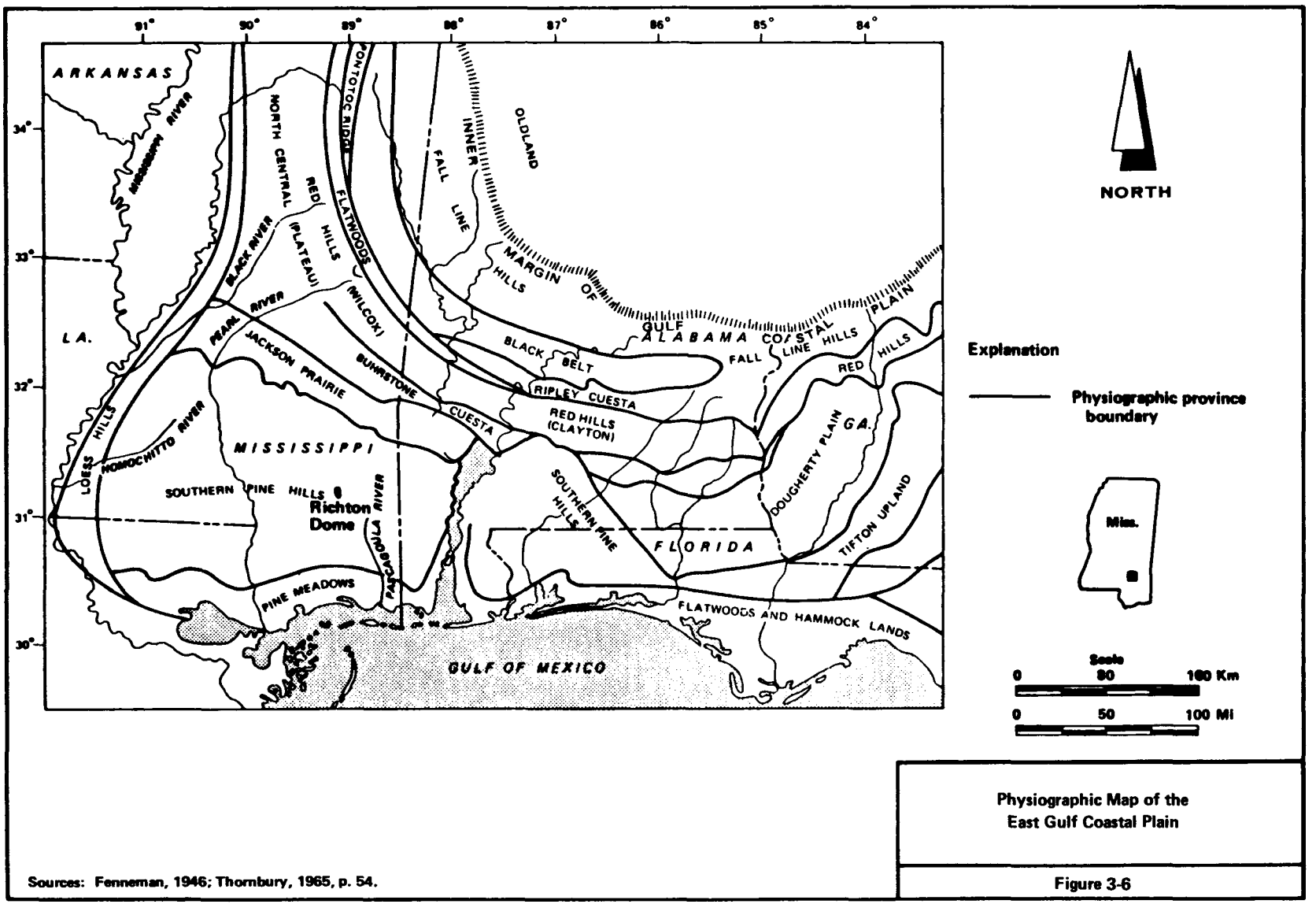
3.2.2.2 Erosional Processes

The erosional processes include both regional denudation and entrenchment of stream channels. Ritter (1978, p. 209) reported regional denudation (the rate of lowering of the earth's surface) rates of 3 to 5 centimeters per 1,000 years (1 to 2 inches per 1,000 years) for the Gulf Coast, based on stream-load sediments. Stream-load data needed for calculation of denudation rates specific to Richton Dome are not available.

Maxwell (1971, p. 91) suggested an average incision (entrenchment) rate of 7 centimeters per 1,000 years (3 inches per 1,000 years) over the last 600,000 years, based on the age and elevation of terraces along the Alabama River. These terraces are located approximately 120 kilometers (75 miles) east of Richton Dome and at similar inland distances and similar elevations as comparable terraces that are adjacent to Richton Dome. In a study at Vacherie Dome, Louisiana, Kolb et al. (1983, ONWI-467, p. 89) estimated Quaternary stream entrenchment rates at that location to be 18 centimeters per 1,000 years (7 inches per 1,000 years).

Ertec, Inc. (1983, ONWI-484, p. 27) estimated the amount of erosion of the Citronelle Formation that has occurred in the vicinity of Richton Dome. Assuming the Citronelle Formation was deposited at sea level, approximately 122 meters (400 feet) of erosion and incision have occurred in the past 1.2 million years. The erosion rate estimated by this method is approximately 10 centimeters per 1,000 years (4 inches per 1,000 years).

The Earth Technology Corporation (1985a) estimated the rate of Quaternary incision at Richton Dome based on the elevation of strath terraces cut into the Citronelle Formation as defined by Werner (1985a, p. 21). The incision rate was calculated by assuming the highest terrace was formed at the beginning of the Quaternary, during the Nebraskan glaciation, and that lower erosional terraces were formed during subsequent glaciations. The incision rate calculated for the entire Quaternary is approximately 3 centimeters per 1,000 years (1 inch per 1,000 years). Although the terraces have not been dated, the similarity of this assumed

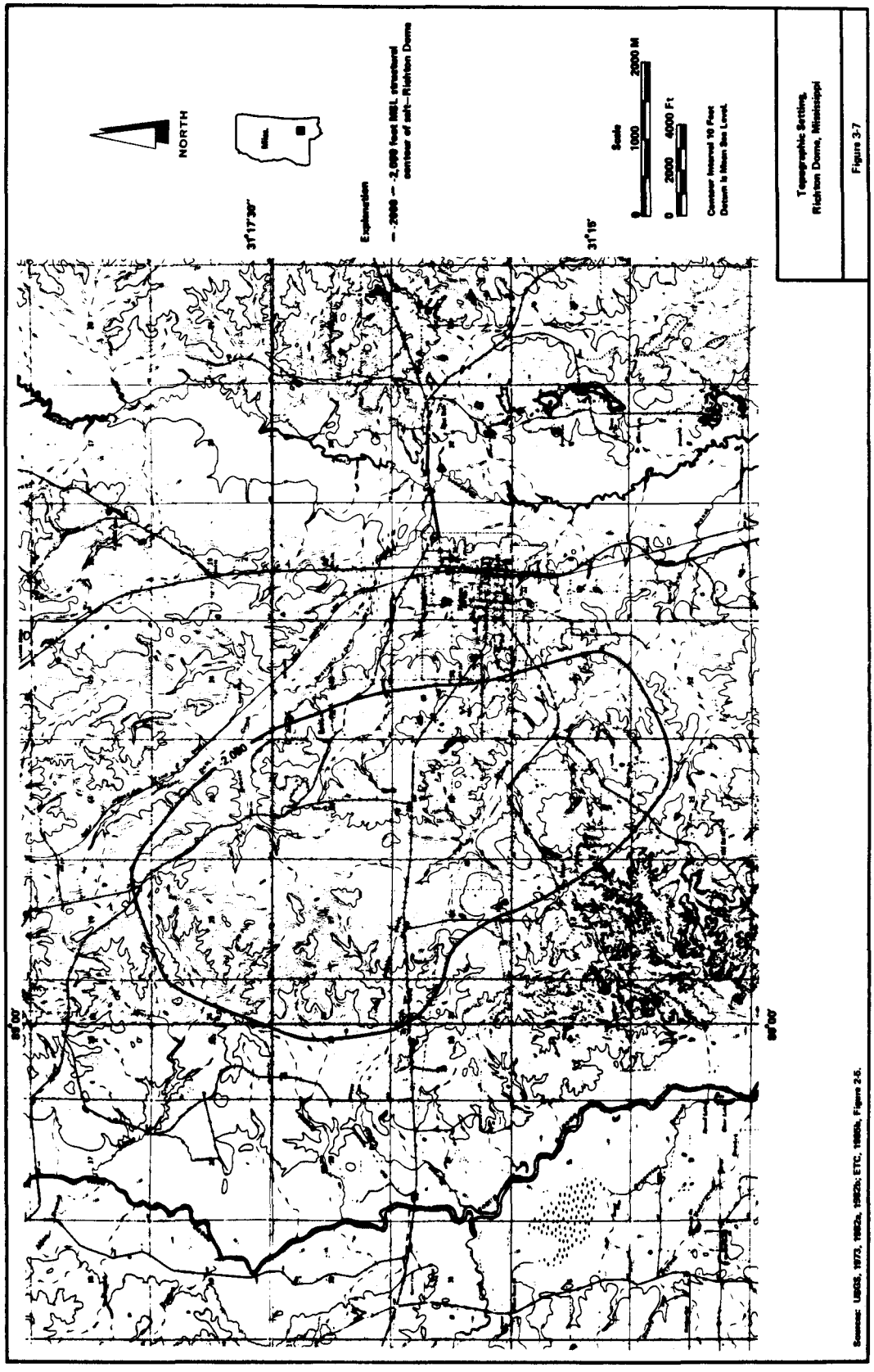


Sources: Fenneman, 1946; Thornbury, 1965, p. 54.

Physiographic Map of the East Gulf Coastal Plain

Figure 3-6

A larger reproduction of this figure appears at the back of this volume.



incision rate with those reported by Maxwell (1971, p. 91), Kolb et al. (1983, ONWI-467, p. 89), and Ertec, Inc. (1983, ONWI-484, p. 27) suggests that it is a reasonable estimate of the site-specific rate of Quaternary incision.

Short-term incision rates can be much greater than the long-term geologic rates because they can be influenced by transitory or episodic conditions that do not persist at any one location for extended periods of time. Specific-gage-height analyses of hydrographs for stream gaging stations located in southern Mississippi (ETC, 1985a) suggest that historical (since the mid-1930s) rates of incision have been as great as 1.4 to 1.9 centimeters per year (0.55 to 0.75 inch per year). The distribution of gaging stations at which such rates have been recorded suggests that this incision may be the response of the streams to either coastward tilting or regional uplift (Section 3.2.5.4.).

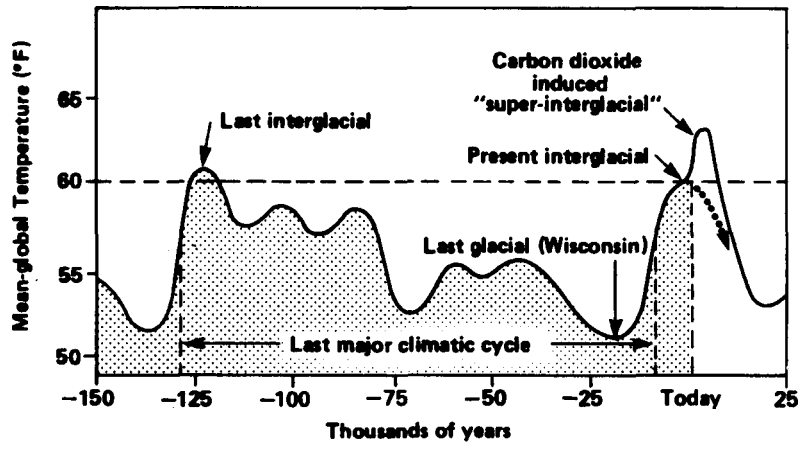
3.2.2.3 Paleoclimatology

The worldwide climate history of the Quaternary Period has been studied with regard to the Pleistocene glacial cycles. These studies have identified climate cycles over the Quaternary, each on the order of 100,000 years in duration, that are best known over the late Quaternary (Imbrie and Imbrie, 1979, pp. 157-173). Details of climate history have been defined over the past 125,000 years (Imbrie and Imbrie, 1979, p. 184). Additionally, temperature histories determined from isotopic and paleontologic analyses of sea bottom cores from the Atlantic and Pacific Oceans indicate that the range of temperatures over the past 125,000 years has been representative of the temperature ranges over the entire Quaternary Period (Frye, 1962).

Trends in global temperature during the late Pleistocene have been studied by Imbrie and Imbrie (1979, p. 186) (Figure 3-8). According to the results of their study, climatic conditions over the past 125,000 years have varied between an interglacial period of global warmth at approximately 75,000 to 125,000 years before present and the cooler temperatures present during the Wisconsinan glaciation at approximately 17,000 to 75,000 years before present. In general, it is expected that climatic conditions over the next 25,000 years, the period forecasted by Imbrie and Imbrie (1979, p. 186) (Figure 3-8), will be similar to those prevailing during the last major climatic cycle that is bracketed by these two temperature extremes. Local geologic and biological evidence of past environmental conditions has not been studied at Richton Dome; however, regional studies provide the framework for understanding the climatic history of the site.

The environmental conditions recorded in sediments from the Atlantic Coastal Plain (Cronin et al., 1981, p. 238) and the Gulf of Mexico (Brunner, 1982, p. 108) since the period of global warmth at 125,000 years before present indicate that the Gulf Coastal Plain was dominated by tropical maritime air masses during this period, with climatic conditions similar to those existing today. Effective precipitation (precipitation minus evapotranspiration) and streamflow were slightly greater than at present. Radiometrically dated coral reef material from the Caribbean (Neumann and Moore, 1975, p. 222) and preserved coastal features along the Gulf Coast (Saucier and Fleetwood, 1970, p. 880) indicate that sea levels have been less than 10 meters (33 feet) above the present sea level.

At the last glacial maximum, the Wisconsinan Laurentide ice sheet reached its maximum extent, reaching to within 1,000 kilometers (600 miles) north of Richton Dome (Bryson and Wendland, 1967, Figure 73). The sea level in the Gulf of Mexico fell approximately 100 to 130 meters (300 to 430 feet) below the present sea level (Poag, 1973, p. 395). Despite such changes, both the paleoecological (e.g., Delcourt, 1980, p. 371) and paleoceanographic (Brunner, 1982, p. 108) records from this period indicate that tropical maritime air masses prevailed in this region even during the period of maximum glaciation, with only a slight cooling in mean annual temperature. These records also indicate that the region underwent a summer drought, with slightly greater effective precipitation during winter than at present because of decreased evapotranspiration losses. The frequency of hurricane activity was probably less than at present because of the cooler ocean surface temperatures (Brunner, 1982, p. 108). However, the frequency of convective storms may have been greater than at present because of the instability resulting from the interaction of polar and tropical air masses.



Note: Based on astronomical theory of climate change, the natural course of future climate (dotted line) would be a cooling trend to full glacial conditions, 23,000 years from now. The warming effect of anthropogenically-derived carbon dioxide, however, may interpose a "super-interglacial," with global temperatures several degrees higher than those experienced during the last million years. If this occurs, the onset of the cooling trend may be delayed to some 2,000 years from now.

Past and Forecasted Climatic Conditions

Source: Imbrie and Imbrie, 1979, p. 186

Figure 3-8

Geomorphic evidence from the Ouachita drainage in Southern Louisiana (Saucier and Fleetwood, 1970, p. 888) suggests that these changes in precipitation resulted in a slight increase in streamflow during the glacial maximum.

The astronomical theories of climatic changes (e.g., Hays et al., 1976, p. 1131) indicate that the earth may undergo a long-term cooling trend 20,000 to 25,000 years from now, which would culminate in a glacial maximum comparable in magnitude to the late Wisconsinan glacial maximum (Imbrie and Imbrie, 1979, p. 186) (Figure 3-8). In the shorter term, a carbon-dioxide-induced global warming may result from the burning of fossil fuels (Hansen et al., 1981, p. 957). Imbrie and Imbrie (1979, p. 186) indicated that this warming could delay the initiation of cooling an estimated 2,000 years.

3.2.3 Stratigraphy

The stratigraphy of Richton Dome is summarized in the following subsections by describing the regional stratigraphy and the site-specific stratigraphy of the sediments over and adjacent to the dome, as well as the caprock and salt stock. A stratigraphic column is presented in Figure 3-9. Table 3-1 summarizes the thickness of the strata in the southeastern part of the Mississippi Salt Basin.

3.2.3.1 Regional Stratigraphy

Richton Dome is located in the southeastern portion of the Mississippi Salt Basin (Figure 3-4). The stratigraphic sequence above the Louann Salt ranges in age from Jurassic to Quaternary. The thick sequence of strata consists of continental shoreline and marine facies, and forms a wedge of gently dipping strata whose northern edge constitutes the margin of the southern Coastal Plain and the continental shelf.

Throughout the Mesozoic and Cenozoic, changes in sea level and position of the shoreline, coupled with the tectonic events described in Section 3.2.1 (Regional Geology), gave rise to a variable stratigraphic sequence. Within each stratigraphic horizon, facies may differ or be absent locally. That is, the composition of beds, members, and formations may change over relatively short distances due to the varying environment of deposition, position of the shoreline, and source of sediments. Some formations, however, are very consistent and continuous over hundreds of kilometers.

In addition to these sedimentological factors, movement of the underlying salt beds (discussed in Section 3.2.5.6) created local variations in the thicknesses of the younger units. Plastic deformation of the salt was caused by pressure differentials resulting from gravitational forces imposed by regional dip and localized thickening of the salt beds. As the salt was undergoing plastic deformation, the sediments overlying the salt were deformed. The sediments deposited on the deformed strata reflect the salt movements by being thicker or thinner relative to sediments over areas of no salt movement (see Section 3.2.5.6, Salt Dome Development and Geometry). Grabens and faults developed above many of the salt domes and salt anticlines in the region. This process of halokinesis (salt movement) influenced sedimentation in the Mississippi Salt Basin from the Late Jurassic through early Tertiary time; its influence on Richton Dome is discussed in Section 3.2.5.6.

3.2.3.2 Site-Specific Stratigraphy

This section describes the Quaternary- and Tertiary-age sediments that overlie and surround Richton Dome (Figure 3-9) to depths well below the proposed repository depth (Section 5.1, Table 5-1), as well as the caprock and salt that constitute the dome.

3.2.3.2.1 Surface Geology. Surface geology at Richton Dome and the surrounding area, as mapped by Brandwein and White (1983, ONWI-298), is presented in Figure 3-10. Four stratigraphic units are exposed in the vicinity of the dome. From youngest to oldest, they are alluvium, terrace deposits, the Citronelle Formation, and the Hattiesburg Formation. Alluvium is common in the stream valleys; these sediments are typically fine-grained sand, silt, and clay, and sandy gravel composed of quartz and chert. Stream terrace deposits consisting of

ERA	SYSTEM	SERIES	GROUP OR STAGE	FORMATION	AGE (MYBP)	THICKNESS (FEET)	LITHOLOGY
CENOZOIC	QUATERNARY	RECENT		ALLUVIUM		0-125	Quartz sand, chert and quartz gravel, and silty clay.
		PLEISTOCENE		CITRONELLE	1.6	0-215	Silty, clayey sand grading into gravel.
	TERTIARY	PLIOCENE		HATTIESBURG	23.7	976-980	Interbedded gravelly sand, sand, silty clay and lignite.
		MIOCENE		CATAHOULA			Silt, clay, fine- to medium-grained sand, gravel, lignite and a marker Heterostegina Zone (Tatum limestone member)
		OLIGOCENE		CHICKASAWHAY		96-117	Argillaceous to sandy limestone, interbedded with clay and marl.
			VICKSBURG	BUCATUNNA		43-76	Clayey sandstone or sandy marl interbedded with lignitic, calcareous clay.
				VICKSBURG LIMESTONES UNDIFF.		61-101	Limestone with associated bentonite, clay shale and clay.
				FOREST HILL/ RED BLUFF-UNDIFF	36.6	42-58	Sandy to silty carbonaceous clay and partially indurated fossiliferous marl.
		EOCENE	JACKSON	YAZOO		122-178	Variably limy, glauconitic, sandy and silty clay, with basal chalky limestone (Ocala Facies)
				MOODYS BRANCH		15-18	Glauconitic, partially indurated and sometimes sandy.
			CLAIBORNE	COCKFIELD		185-224	Limestone, sand streaked, lignitic-bearing clay and silt.
				COOK MOUNTAIN		112-150	Loosely cemented, porous carbonate sand, glauconitic clay shale, and calcarenitic limestone.
				KOSCIUSKO (SPARTA)		151-218	Slightly porous, chalky limestone, well cemented calcarenitic limestone interbedded with glauconitic clay shale. Locally sandy.
				ZILPHA		126-176	Interbedded glauconitic clay shale, chalk, and chalky limestone.
				WINONA		33-80	Clay shale containing chalk or marl lenses.
				TALLAHATTA		223-306	Glauconitic and limy siltstone and claystone interbedded with clay shale.
				MERIDIAN		49-90	Sand with sandy shale and lignitic clay.
		?-	WILCOX	UNDIFF.	57.8	2266-2613	Silty, lignitic shale interbedded with silt, sand, lignitic siltstone, and fine- to medium-grained sandstone.
		PALEOCENE	MIDWAY	PORTERS CREEK		778-870	Shale interbedded with thin lignite beds, silt, siltstone, and fine- to medium-grained argillaceous sandstone.
				CLAYTON	66.4	12-27	Sandy, glauconitic marl, marly chalk, or calcareous clay.
MESOZOIC	CRETACEOUS		SELMA	UNDIFF.		925-1500	Sandy to very argillaceous to pure chalk, containing trace of bentonite and fissile shale.
			EUTAW	UNDIFF.			Fissile, slightly sandy or calcareous, lignitic shale, very fine- to fine-grained, sandstone and calcareous siltstone.
			GULFIAN	UPPER TUSCALOOSA		300-900	Fissile shale, mudstone, and fine- to medium-grained, glauconitic, porous sandstone.
			TUSCALOOSA	MIDDLE TUSCALOOSA		820-1160	Interbedded carbonaceous shale, mudstone, siltstone, and thin, fine-grained sandstone with basal chalk or chalky limestone.
				LOWER TUSCALOOSA	97.5±2.5		Fissile shale, calcareous and glauconitic sandstone, and siltstone with a basal massive, fine- to coarse-grained, conglomerate sandstone.
			WASHITA	DANTZLER		575-1500	Micaceous shale alternating with mudstone, nodular limestone, fine- to medium-grained, lignitic, calcareous or silty sandstone.
			FREDERICKSBURG	WASHITA-FREDERICKSBURG UNDIFF.		1000-1880	Shale, silty mudstone, fine- to medium-grained, silty, carbonaceous sandstone, and pseudo-oolitic, sometimes sandy, limestone.
		COMANCHEAN	TRINITY SUPERGROUP	PALUXY		1000-1450	Fissile shale, lignitic mudstone, and fine- to coarse-grained, argillaceous, carbonaceous, gravel-bearing sandstone.
				MOORINGSPORT		200-1000	Limy shale alternating with mudstone, silty fine-grained sandstone, and pseudo-oolitic anhydrite-bearing limestone.
				FERRY LAKE		160-240	Shale alternating with oolitic limestone and anhydrite
				RODESSA/PINE ISLAND UNDIFF.		750±	Thin anhydrite stringer overlying shale, very fine- to fine-grained, calcareous sandstone and siltstone and pseudo-oolitic limestone.
		COAHUILAN	NUEVO LEON	SLIGO		300	Splintery shale interbedded with fine- to medium-grained, argillaceous sandstone, and occasionally, nodular limestone.
				HOSSTON	144±5	1800-2850±	Very fine- to coarse-grained, calcareous sandstone, sandy carbonaceous shale, and sandy, lignite mudstone.
	JURASSIC	UPPER	COTTON VALLEY	UNDIFF.		2000-2900+	Fine- to medium-grained, silty and calcareous sandstone alternating with mudstone and shale.
			LOUARK	HAYNESVILLE-BUCKNER		1500-3450±	Dense, lithographic limestone, dolomite carbonate, and anhydrite.
				SMACKOVER			Dense, oolitic limestone, finely crystalline limestone, dolomite limestone, and dolomite.
				NORPHLET			Sandy shale and poorly sorted, shaley sandstone.
		LOWER	LOUANN	LOUANN SALT		0-5000±	Coarsely crystalline, halite containing anhydrite inclusions.

Note: ~~~~ Denotes unconformable contact

Sources: Dockery, 1981; LETCo, 1982, ONWI-120, pp. 12-23, 13-140; Palmer, 1983, p. 504.

Stratigraphic Column of the Southeastern Mississippi Salt Basin Richton Dome Area, Mississippi

Figure 3-9

Table 3-1. Thickness of Stratigraphic Sequences in the Southeastern Part of the Mississippi Salt Basin, Richton Dome Area

System	Range in Thickness	
	Meters	Feet (Measured Value)
Quaternary	0 - 105	0 - 340
Tertiary	1,585 - 1,875	5,205 - 6,155
Cretaceous	2,325 - 4,060±	7,630 - 13,330±
Upper Jurassic	1,070 - 1,935±	3,500 - 6,350±
Lower Jurassic	0 - 1,520±	0 - 5,000±

Source: LETCo, 1982, ONWI-120, pp. 12-23, 13-140.

quartzose silt are found at several topographic levels adjacent to the dome in Bogue Homo and Thompson Creek. The Citronelle Formation is exposed on the higher hills over most of the area. The Hattiesburg Formation is exposed on the high ground between drainages (where the Citronelle Formation has been eroded) and in drainages where terrace and alluvial deposits are absent. The contact between the Citronelle and Hattiesburg Formations exhibits relief in excess of 60 meters (200 feet) (Werner, 1985a, pp. 22-24), and is probably erosional.

3.2.3.2.2 Stratigraphy of Dome Area and Adjacent Sediments. Based on data from 70 borings in the immediate dome area, a stratigraphic sequence has been recognized for sediments overlying and adjacent to the Richton Dome. The sequence ranges in age from Plio-Pleistocene to Jurassic and correlates with local (Brandwein and White, 1983, ONWI-298, pp. 3-4) and regional stratigraphy defined in previous investigations. These stratigraphic units (see Figure 3-11) are described below, from youngest to oldest.

Citronelle Formation. The Citronelle Formation is of Plio-Pliocene age and consists of reddish-brown to yellowish-brown, gravelly, coarse- to fine-grained sand with lenses and interbedded silt, silty clay, and clay. A maximum thickness of 66 meters (215 feet) was encountered in Area Characterization borings (LETCo, 1982, ONWI-120, p. 12-79). The Citronelle Formation was deposited in environments ranging from fluviatile to littoral, deltaic, lagoonal, and estuarine (LETCo, 1982, ONWI-120, p. 12-79). The Citronelle Formation unconformably overlies the Hattiesburg and Pascagoula formations.

Hattiesburg and Catahoula Formations (Undifferentiated). The Hattiesburg and Catahoula formations are Miocene in age and consist of about 298 meters (980 feet) of very fine- to coarse-grained sand, clay, and chalky, sandy limestone. The base of the Catahoula Formation is marked by the Heterostegina Zone (or Tatum Limestone), a chalky, sandy limestone, clay, and quartz sand unit (LETCo, 1982, ONWI-120, p. 13-140). These formations were deposited in shallow-marine and fluvial environments (Williams et al., 1966, p. 222).

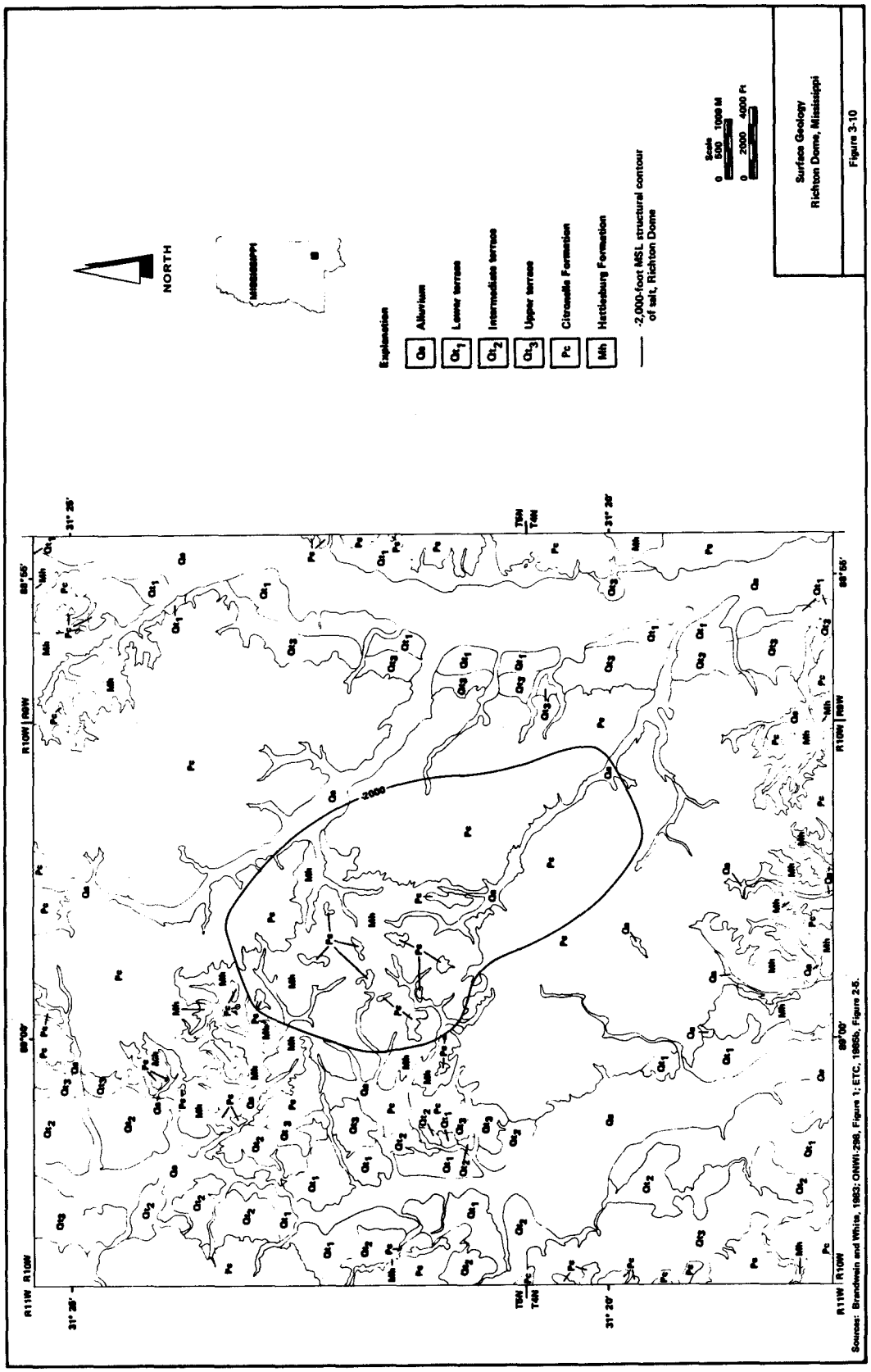
Chickasawhay Formation. The Chickasawhay Formation was deposited during the late Oligocene in a fluctuating, shallow, marginal-marine, estuarine environment (May et al., 1974, p. 101) and is 29 to 35 meters (96 to 117 feet) thick. The formation consists of interbedded clay, fine - to medium-grained sand, and, locally, very sandy limestone that grades into limy sand (LETCo, 1982, ONWI-120, p. 13-140). The Chickasawhay unconformably overlies the Vicksburg Group.

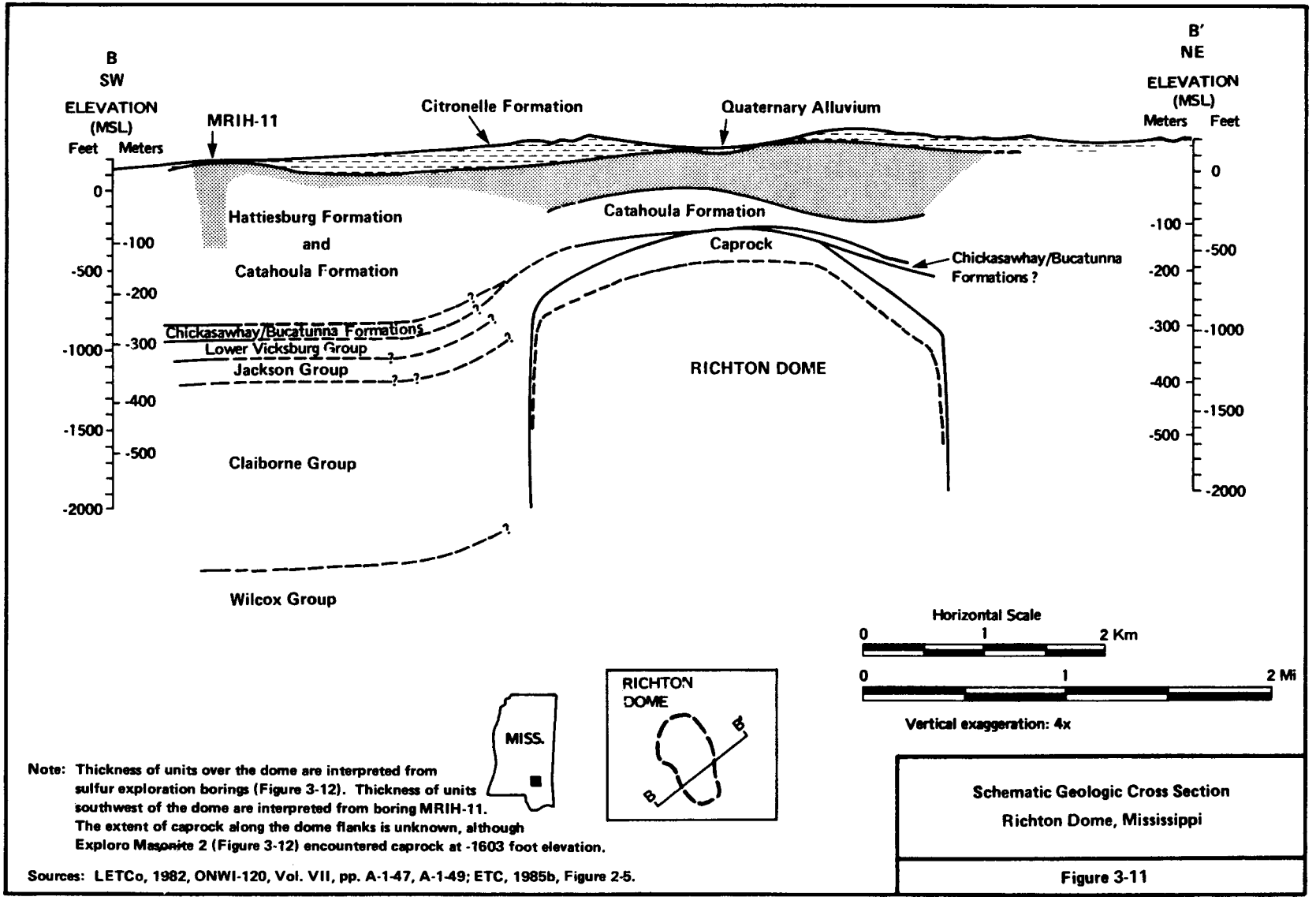
Vicksburg Group. The Bucatunna Formation, Vicksburg Limestone, and the Forest Hill/Red Bluff Formation (undifferentiated) constitute the Vicksburg Group, which was deposited during the early to Middle Oligocene.

The Bucatunna Formation consists of silty to arenaceous, micaceous, carbonaceous, fossiliferous clay, channel sand, and sulfurous clay that were deposited in an estuarine to shallow marine environment (May et al., 1974, p. 92). It is 13 to 23 meters (43 to 76 feet) thick and conformably overlies the Vicksburg Limestone (LETCo, 1982, ONWI-120, p. 13-140).

The Vicksburg Limestone is an informal grouping of the predominantly limestone Byram, Glendon, Mariana, and Mint Springs formations. The limestone was deposited in a shallow marine environment (Rainwater, 1963, p. 103; Murray, 1961, p. 398). The Vicksburg Limestone (undifferentiated) is 18 to 30 meters (61 to 101 feet) thick and consists of crystalline, sandy, glauconitic, locally chalky, or calcarenitic limestone (LETCo, 1982, ONWI-120, p. 13-140).

A larger reproduction of this figure appears at the back of this volume.





Note: Thickness of units over the dome are interpreted from sulfur exploration borings (Figure 3-12). Thickness of units southwest of the dome are interpreted from boring MRIH-11. The extent of caprock along the dome flanks is unknown, although Exploro Masonite 2 (Figure 3-12) encountered caprock at -1603 foot elevation.

Sources: LETCo, 1982, ONWI-120, Vol. VII, pp. A-1-47, A-1-49; ETC, 1985b, Figure 2-5.

Schematic Geologic Cross Section
Richton Dome, Mississippi

Figure 3-11

The Forest Hill Formation has not been recognized at Richton Dome. It is either not present or it cannot be differentiated from the Red Bluff Formation based on lithology (LETCo, 1982, ONWI-120, p. 13-141). The Red Bluff Formation is a shallow marine deposit, approximately 13 to 17 meters (42 to 58 feet) thick around Richton Dome. It consists of interbedded clay, chalky limestone, and minor dolomite (LETCo, 1982, ONWI-120, p. 13-140); it unconformably overlies the Jackson Group.

Jackson Group. The Jackson Group is of late Eocene age and is composed of the Yazoo and Moody's Branch formations.

The Yazoo Formation, a sequence of glauconitic clay, sandy chalky limestone, or chalky, locally sandy marl, underlain by clay or occasionally limy shale, was deposited in an inner neritic environment during a period of marine inundation (Rainwater, 1963, p. 100). It is 37 to 54 meters (122 to 178 feet) thick and conformably overlies the Moody's Branch Formation.

The Moody's Branch Formation is a sequence of calcareous, glauconitic, fossiliferous limestone, sandstone, and marl (Williams et al., 1966, p. 212) deposited in a shallow marine environment. It is 4 to 5 meters (15 to 18 feet) thick and unconformably overlies the Claiborne Group.

Claiborne Group. The Claiborne Group is Eocene in age and consists of the Cockfield, Cook Mountain, Kosciusko, Zilpha, Winona, and Tallahatta formations.

The Cockfield Formation is a regressive sequence deposited in alluvial and marginal marine environments (Rainwater, 1963, p. 98). The formation is 50 to 68 meters (165 to 224 feet) thick and consists of clay and sandy, sometimes chalky or glauconitic limestone, occasionally interbedded with silty, limy, glauconitic shale. The Cockfield Formation conformably overlies the Cook Mountain Formation (LETCo, 1982, ONWI-120, p. 13-140).

The Cook Mountain Formation is a transgressive sequence deposited in a shallow neritic environment (Rainwater, 1963, p. 98) and is approximately 34 to 46 meters (112 to 150 feet) thick (LETCo, 1982, ONWI-120, p. 13-140). The formation consists of chalky, sandy to silty, sometimes crystalline limestone and conformably overlies the Kosciusko Formation (LETCo, 1982, ONWI-120, p. 13-140).

The Kosciusko (Sparta) Formation was deposited during a marine regression and consists of limestone and shale deposited in marginal marine and alluvial environments (Rainwater, 1963, p. 98). The Kosciusko is 46 to 66 meters (151 to 218 feet) thick and consists of interbedded clay, silty, limy shale, and occasionally sandy, chalky limestone and slightly limy siltstone. This formation conformably overlies the Zilpha Formation (LETCo, 1982, ONWI-120, p. 13-140).

The Zilpha Formation consists of interbedded glauconitic, clayey shale and minor limy shale, siltstone, very fine- to coarse-grained sand, and sandy limestone (LETCo, 1982, ONWI-120, p. 13-140). It is a 38- to 51-meter (126- to 170-foot-) thick regressive sequence that is gradational with the underlying Winona Formation.

The Winona Formation consists of marine strata deposited in a shallow, neritic environment (Rainwater, 1963, p. 98) and consists of 10 to 18 meters (33 to 60 feet) of chalky, sandy, clayey limestone interbedded with limy shale or glauconitic siltstone (LETCo, 1982, ONWI-120, p. 13-140). The Winona Formation conformably overlies the Tallahatta Formation.

The Tallahatta Formation, a very shallow marine deposit, is part of the transgressive sequence (Rainwater, 1963, p. 98) that consists of clay; sandy, chalky or silty, limy shale; or limy, glauconitic siltstone. It is 68 to 93 meters (223 to 306 feet) thick and unconformably overlies the Wilcox Group.

Wilcox Group. The Wilcox Group is Eocene-Paleocene in age and is undifferentiated in the vicinity of Richton Dome. A sequence of deltaic sand, shale, and interbedded marine sand and shale, the group is 670 to 766 meters (2,200 to 2,513 feet) thick (LETCo, 1982, ONWI-120, p. 13-140). Shale and clayey beds are usually silty and lignitic or carbonaceous, whereas the sandstone and siltstone units are argillaceous and micaceous (Williams et al., 1966, pp. 205-206). The Wilcox Group conformably overlies the Midway Group.

Midway Group. The Midway Group consists of the Porters Creek and Clayton formations. It was deposited during the Paleocene and marks the base of Tertiary sediments.

The Porters Creek Formation was deposited in a restricted marine environment (Rainwater, 1963, p. 95). Lithologically, the unit consists of clay and clayey shale beds that are silty, micaceous, and lignitic or carbonaceous, and of argillaceous silt and siltstone (Williams et al., 1966, p. 205). The Porters Creek is 237 to 265 meters (778 to 870 feet) thick and conformably overlies the Clayton Formation.

The Clayton Formation was deposited in a shallow, open-sea environment (Rainwater, 1963, p. 10). It consists of 4 to 8 meters (12 to 27 feet) of chalky limestone, clay, and silty shale. The Clayton unconformably overlies the Upper Cretaceous Selma Group.

Between the Midway Group and the Louann Salt is a thick sequence of Cretaceous and Jurassic sedimentary rocks containing chalk, limestone, shale, and sandstone. The total thickness of these strata is approximately 3,000 to 5,800 meters (10,000 to 19,000 feet) (LETCo, 1982, ONWI-120, p. 12-23).

Stratigraphy Over the Dome. The stratigraphic sequence over Richton Dome has been interpreted by Werner (1985a) based on driller's records from 34 sulfur exploration wells. The lithologic units defined have been correlated with lithologies reported in nearby project wells and, hence, with the regional stratigraphic sequence previously described. The lithologies of units over the dome are consistent with lithologic descriptions previously discussed. Werner (1985a) noted that the units over the dome are thin compared with their regional thicknesses. Thinning of units may be the result of differential sedimentation and erosion when deposition occurs over an actively uplifting dome (Section 3.2.5.6).

Werner (1985a) identified the Citronelle and Hattiesburg formations and lithologic units referred to as D, E, F, and G. Unit D was described by drillers as a pyrite-bearing sand and has been correlated with the upper Catahoula Formation. Unit E is defined as a sandy lime, which is correlatable in lithology, stratigraphic position, and contact relationships with the Tatum Limestone member of the Catahoula Formation. Unit F is a sand with shale unit that correlates with the Chickasawhay or Bucatunna formations, or both. Unit G is a thick shale with limestone unit that has been interpreted to be a thinned sequence of the lower Vicksburg Group through the Upper Wilcox Group. Table 3-2 presents a comparison of thicknesses of these units in the regional and in the overdome area.

3.2.3.2.3 Caprock and Salt Stratigraphy. Salt domes consist of a ridge or column of salt known as a salt stock. Caprock is usually, but not always, found on the top and upper portions of salt stocks and has also been reported on the flanks of salt stocks at depths greater than 3,000 meters (10,000 feet) (Murray, 1961, p. 2212). Caprock is composed primarily of anhydrite, but also contains gypsum and calcite, which generally occur in zones.

Table 3-2. Comparison of Regional and Overdome Stratigraphy

Regional Stratigraphy (LETCo, 1982, ONWI-120, p. 13-140) meters (feet)		Overdome Stratigraphy (Werner, 1985a) meters (feet)	
Citronelle Formation	65 (215)	Citronelle Formation	83 (270)
Hattiesburg/Catahoula (Undifferentiated)	297 to 298 (976 to 980)	Hattiesburg Formation Catahoula Formation (Units D and E)	70 to 89 (230 to 620) 143 (467)
Chickasawhay Formation	29 to 35 (96 to 117)	Chickasawhay/Bucatunna (Undifferentiated) (Unit F)	62 (204)
Bucatunna Formation	13 to 23 (43 to 76)		
Vicksburg Group	31 to 48 (103 to 159)	Lower Vicksburg through Upper Wilcox (Unit G)	365 (1,200)
Jackson Group	42 to 60 (137 to 196)		
Claiborne Group	247 to 344 (810 to 1,128)		
Wilcox Group	670 to 766 (2,200 to 2,513)		

Elemental sulfur may be present in minor amounts. The anhydrite in the caprock is usually considered to be an accumulated residuum of relatively insoluble materials that result when a salt stock is subjected to ground-water dissolution (Halbouty, 1979, p. 45). Alternative caprock theories suggest that it may be material precipitated from ground water in sediments adjacent to the dome (Walker, 1974, p. 169) (see Section 3.2.7.2). Werner's (1985b) analysis of the available borehole data indicates that the anhydrite caprock at Richton Dome is residuum.

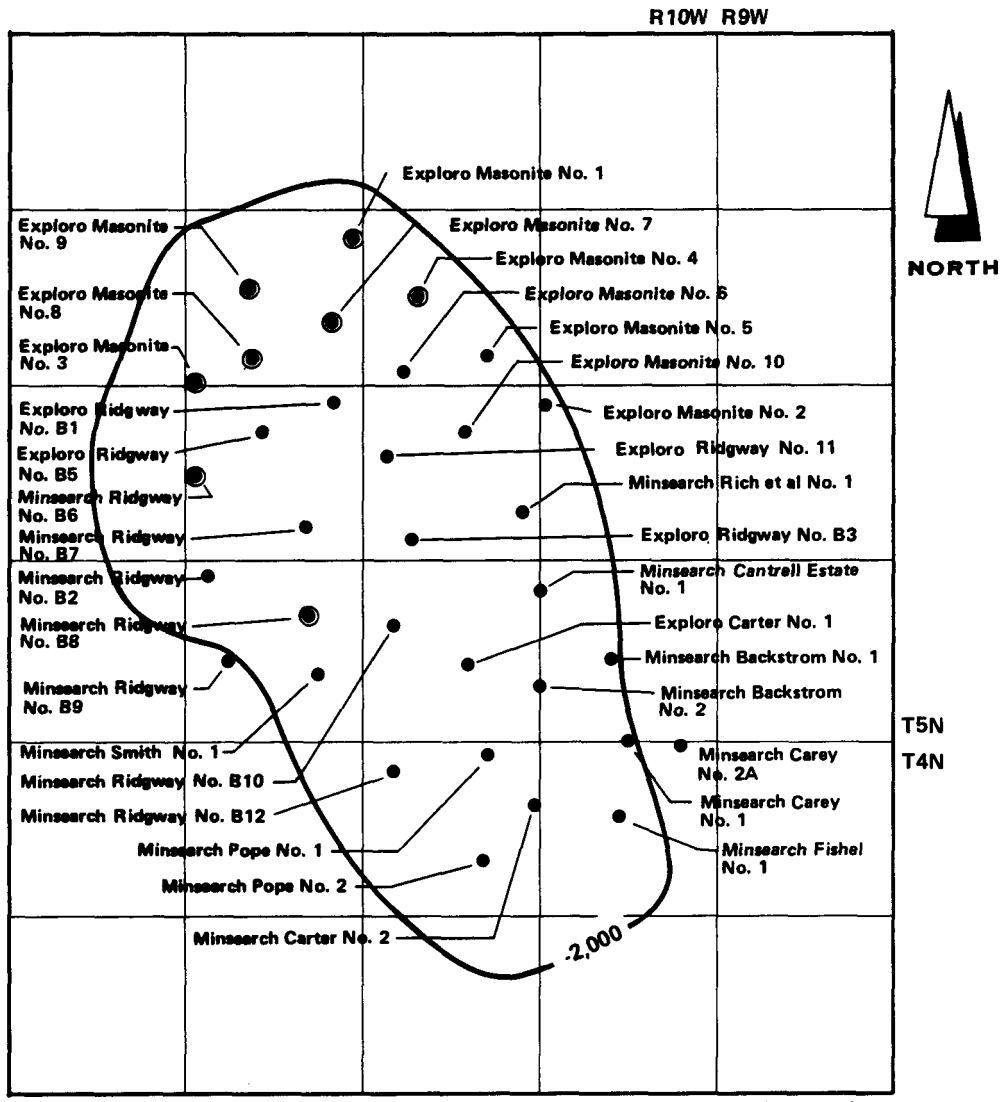
Data from sulfur exploration test wells at Richton Dome (Figure 3-12) indicate that the caprock covers the entire top of the salt stock. The flanks of the salt stock also appear to be at least partially sheathed by caprock. One sulfur exploration well encountered caprock on the eastern flank at a depth of 562 meters (1,842 feet) (Werner, 1985a). Similarly, a petroleum exploration well (Shell 23-7) appears to have encountered caprock on the eastern flank at a depth of 629 meters (2,062 feet) (Murphy, 1985). In other Gulf Coast salt domes, caprock is believed to cover the flanks of the salt stock to depths commonly greater than 910 meters (3,000 feet) (Karably et al., 1983, ONWI-355). The known thickness of the caprock of Richton Dome varies from 6 meters (20 feet) at the northern end of the salt stock to approximately 65 meters (213 feet) at MRIG-9, a DOE borehole cored into the salt stock (LETCo, 1982, ONWI-120, p. 13-117). Detailed lithologic information on the Richton Dome caprock is available only from core obtained from MRIG-9 (Drumheller et al., 1982, ONWI-277, pp. 1-21; and Werner, 1985b), where it consists of 57 meters (190 feet) of anhydrite overlain by 7 meters (23 feet) of limestone caprock (Figure 3-13). Less detailed data from the sulfur exploration wells indicate that the limestone ranges from 0 to 21 meters (68 feet) in thickness, but is generally less than 12 meters (40 feet) thick (Werner, 1985a). The thickness of nonlimestone caprock (principally anhydrite) encountered by these same wells varies from 2 meters (6 feet) to greater than 30 meters (100 feet); the greater thickness is common over about two-thirds of the caprock's extent.

The limestone caprock of Richton Dome is described from the sulfur exploration wells as including both banded and massive limestone, with ubiquitous calcite veins (Werner, 1985a). The unit also locally includes hard or dense, black limestone, and portions are described as porous or vuggy. The limestone section at boring MRIG-9 comprises vuggy, banded limestone (Drumheller et al., 1982, ONWI-277). The bands are generally thin (less than 1.2 centimeters [0.5 inch]) and consist of alternating layers of gray, fine-grained and cream-colored, coarse-grained calcite. The vugs in the calcite are generally less than 1.2 centimeters (0.5 inch) across and are often lined with drusy euhedral calcite (Werner, 1985b).

The anhydrite section of MRIG-9 was described by Drumheller et al. (1982, ONWI-277) as massive, fine-grained anhydrite with gypsum veins. The gross appearance of the anhydrite comprises light- to dark-gray layers and white clasts in microconglomeratic zones. The gypsum veins vary in thickness from several millimeters to over 3 meters (10 feet). Lithologic logs from sulfur exploration test wells indicate that gypsum veins fully penetrate the thickness of the anhydrite, but that they occur only in localized areas of the caprock (Werner, 1985a).

The gypsum veins formed by hydration of the wall rock as water invaded fractures that formed in the anhydrite as a result of postdiapiric structural arching (Werner, 1985b). The fractures appear to belong to three systems. The first system is interpreted to be the direct result of arching of the caprock. As hydration took place along these fractures, volumetric expansion (which occurs when anhydrite is hydrated to gypsum) caused additional stresses in the caprock, with the result that a second system of fractures developed. These were also invaded by water so that the adjacent wall rock was hydrated to form gypsum veins. Further arching of the caprock is interpreted to have caused a third system of cross-joints between the preexisting fractures.

A small percentage of these fractures appear to be open at the present time; however, most have been healed by the gypsum mineralization. One sulfur exploration boring and MRIG-9 encountered granular anhydrite and salt at the contact between the caprock and the salt. Granular anhydrite was not noted in seven other sulfur exploration wells that penetrated into

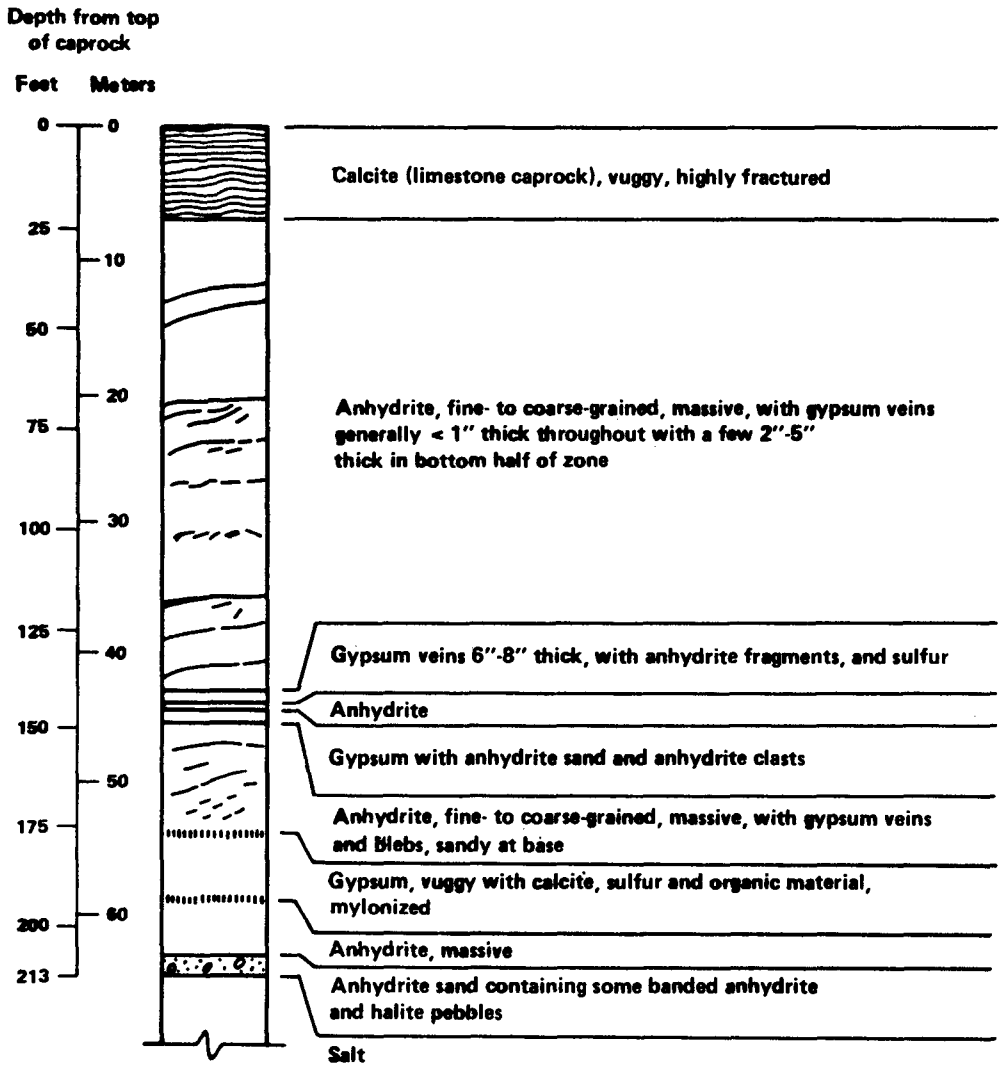


Note: Not shown; one sulfur exploration well abandoned before completed

Sources: LETCo, 1982, ONWI-120, p. 13-103; ETC, 1985b, Figure 2-5.

Sulfur Exploration Well Locations
Richton Dome, Mississippi

Figure 3-12



Note: Top of caprock at MRIG-9 was encountered at -297 feet MSL

Source: Drumheller et al., 1982, ONWI-277, pp. 8-11

Caprock Stratigraphy at Borehole MRIG-9
Richton Dome, Mississippi

Figure 3-13

salt. However, zones of granular anhydrite might be expected at the base of the caprock at other locations on the dome (Murphy, 1985). Loss of drilling fluid circulation zones occurred in several of the sulfur exploration borings and at MRIG-9. The loss of circulation in the sulfur borings occurred principally in the limestone caprock and at the interface of the anhydrite and limestone; none occurred at the caprock/salt interface. The hydrology of the caprock is discussed in Section 3.3.2.1.3.

Borehole data from sulfur exploration wells (LETCo, 1982, ONWI-120, pp. 12-32 through 12-35) indicate that the shallowest salt was encountered at -155 meters (-508 feet) MSL, which corresponds to a depth of 220 meters (722 feet) below the ground surface. In boring MRIG-9, salt was first encountered at -155 meters (-508 feet) MSL. Boring MRIG-9 cored 150 meters (501 feet) of salt (Drumheller et al., 1982, ONWI-277, pp. 12-14). The salt generally consists of fine- (less than 0.6 centimeter [0.25 inch]) to coarse-grained (2.5 to 5.0 centimeters [1.0 to 2.0 inches]) halite crystals (Drumheller et al., 1982, ONWI-277, p. 20) with an anhydrite-rich zone in the upper 2 meters (6 feet) (Drumheller et al., 1982, ONWI-277, p. 12). Numerous zones of very large or megacrystalline (greater than 5.0 centimeters [2.0 inches] thick) halite crystals are present and are usually bordered by anhydritic bands 6 millimeters (0.25 inch) thick. Anhydrite also occurs as scattered grains or as distinct inclusions in the salt (Drumheller et al., 1982, ONWI-277, p. 13). The average composition of the sampled salt core is approximately 91 percent halite and 8 percent anhydrite. Dolomite, pyrite, quartz, plagioclase, calcite, and organic material have also been identified as trace constituents in the salt (Drumheller et al., 1982, ONWI-277, p. 32). A precise salt purity analysis applicable for the entire salt stock cannot be assigned because only a small portion of the salt stock was sampled (Drumheller et al., 1982, ONWI-277, p. 21); salt mining experience in the Gulf Coast area, however, indicates that the salt in other parts of the Richton Dome salt stock is not likely to differ greatly from that found at MRIG-9.

3.2.3.2.4 Anomalous Zones. Gulf Coast salt stocks typically consist of 90 to 99 percent pure halite (NaCl), with a medium-grained texture and subvertical layering or banding (LETCo, 1982, ONWI-117, p. 2-51). However, the occurrence of anomalous features has been reported from mining operations in salt stocks in the Gulf Coast region. These anomalous features may be compositional (inclusions of clastic material, gas, or brine); textural (megacrystalline salt); or structural (sheared salt and discontinuous layering). Where these features occur together in restricted portions of a salt dome, they are often referred to as "anomalous zones." The origin of these anomalous features has been hypothesized by several authors (Kupfer, 1976; Wilson, 1975; Jackson and Talbot, 1985), but the theories are inconclusive to date.

Studies of the uppermost portion of the Richton Dome salt stock, the caprock, and overlying sedimentary strata give no indication of the presence of major anomalous features within the dome (Werner, 1985a). Core from borehole MRIG-9 shows some very coarsely crystalline salt and traces of nonsalt minerals, but no major anomalous conditions (Drumheller et al., 1982, ONWI-277). However, because the salt stock at Richton Dome has been explored in only a few locations, it is appropriate to describe and evaluate the types of anomalous features that exist at other Gulf Coast salt domes and examine the likelihood of their presence at the Richton Dome.

The salt domes in the Gulf Coast region have been divided into two categories based on different geographical settings: coastal (near-coast) and interior (inland) (Figure 3-5). The two settings are characterized by different depositional environments and structural differences are seen in the salt domes of the two settings. Shale sheaths (diapiric shale) are found around the Five Island coastal domes: Avery Island, Belle Isle, Cote Blanche, Jefferson Island, and Weeks Island (Figure 3-5). The shale sheaths may be related to the development of thick, deep-marine facies. The absence of similar facies in the interior salt basins of Mississippi, Louisiana, and Texas has apparently precluded the development of diapiric shales in those areas (Atwater and Forman, 1959, p. 2594). In general, the internal structure and pattern of folding in the interior salt domes appear to be simpler or more consistent than in the coastal domes (Kupfer, 1976, p. 86; 1962, pp. 97, 106; Hofrichter, 1968, p. 378). Based on the simpler folds, the more consistent fold pattern, and the thick

caprock in the interior domes, Muehlberger and Clabaugh (1968, p. 87) suggested that the interior domes appear to be at a deeper structural level (i.e., nearer to the salt source bed) than the Five Island coastal domes.

This geologically and geographically defined distinction provides a basis for comparison between coastal and interior Gulf Coast salt domes with regard to anomalous features and their respective mode of occurrence, frequency, size, location, and construction constraints. The Richton Dome is an interior dome, and data and characteristics of other interior domes such as Grand Saline, Palangana, Winnfield, and Hockley may be used to indicate the potential occurrence and significance of anomalous features in a typical interior salt dome environment. Similarly, data and characteristics from the coastal Five Island salt domes may be used to indicate typical conditions in a coastal salt dome and the possible differences between anomalous features of the interior and coastal salt domes of the Gulf Coast.

Anomalous Features. Anomalous features have been reported from mining operations in salt domes in the Gulf Coast Region (Kupfer, 1980, pp. 20, 25, Figure 9; 1974, pp. 201-202, Figure 5; Howard, 1971, pp. 512-513; Ver and Anderson, 1977; Atwater and Forman, 1959, Figures 9 and 12). These include such features as inclusions of solids (principally clastic, nonsalt materials like sand, silt, clay, and carbonate), anhydritic or potash-bearing salt, liquids (brine and petroleum products), extensively sheared salt, coarse-crystalline salt, and voids, fractures, and faults. Anomalous features typically affect only a small percentage of the total volume of the salt stock. For example, inclusions of clastic material are generally of limited extent and occupy less than 1 percent of the volume, although some hand specimens may contain up to 90 percent (Kupfer, 1980, p. 122). During the mining of Gulf Coast salt domes, vertically oriented planar discontinuities of limited width (anomalous zones) have been reported to contain a variety of the anomalous features mentioned above. A summary and comparison of the reported anomalous zones and their associated features in the extensively mined Five Island coastal salt domes and three interior salt domes (Grand Saline, Palangana, and Winnfield), of which two have been mined (Grand Saline and Winnfield), are presented in Table 3-3. The information for Palangana Dome was taken from drilling records of vertical and deviated coreholes. The limited information available for the mine in the Hockley Dome is presented in the text only.

Edge Anomalous Zones. Anomalous zones found at the boundary between the salt stock and the surrounding sediments include ledges (horizontal projections bounded above and beneath by recesses) and drag zones, gas and brine pockets, inclusions of sediments, and coarse-crystalline salt. This boundary has been described as a fault zone consisting of an internal salt sheath (outermost margin of the salt stock) and an external shale sheath (Kupfer, 1974, p. 210). The external shale sheath is found adjacent to the internal sheath in some coastal domes but has not been reported from interior domes. The most significant water leaks and gas outbursts have occurred in association with the anomalous features of the internal salt sheath at both interior and coastal domes during mining near the edge of the dome (see also Section 3.2.6.1.2).

Central Anomalous Zones. Anomalous features in the central portion of salt domes consist of generally localized zones of highly deformed salt (commonly referred to as shear zones), often containing inclusions of clastic material (Michalski, 1985, p. 7).

The central anomalous zone has been interpreted as a sediment-marked shear boundary between two spines (large masses of salt with differential movement) within a salt dome (Kupfer, 1980, p. 120) or as an internal salt-to-salt shear zone, without sediments, between spines. However, because of the lack of evidence for internal salt-to-salt shear zones and because structural changes indicative of such a shear zone commonly occur under normal conditions in domal salt (Kupfer, 1974, p. 202), the origin of anomalous zones in the central portions of domes is speculative.

Table 3-3. Summary of Anomalous Features in Gulf Coast Region Salt Domes (Caprock not included)

Dome	Concentration of Features of Anomalous Conditions at the Center Portion of the Dome				Concentration of Features of Anomalous Conditions Near the Margin of the Dome				Anomalous Features Outside the Anomalous Zones					
	Sed. Incl.	Gas or Brine	Sheared Salt	Coarse Cryst. Salt	Sed. Incl.	Gas or Brine	Sheared Salt	Coarse Cryst. Salt	Sed. Zones	Anhydritic Salt and/ or Potash	Coarse-Grained and Recrystallized Salt	Porous or Fractured Salt	Faults	Nearest Mining Distance to Salt Stock Edge
Exterior (Five Isl.)														
Avery Isl.	P	B	P	N.R.	No Data				N.R.	A	P	N.R.	P	100m
Belle Isle	P	G + B	P	N.R.	P	G	N.R.	N.R.	N.R.	A	P	N.R.	P	150m
Cote Blanche	N.R.	N.R.	N.R.	N.R.	No Data				P	K (trace)	P	P	N.R.	300m
Jefferson Isl.	P	B	P	N.R.	P	(H_2O)	N.R.	N.R.	N.R.	A	P	N.R.	P	30m
Weeks Isl.	P	G + B	P	N.R.	P	G(+H_2O)	P	N.R.	N.R.	A	P	N.R.	P	100m
Interior (Gulf Coast)														
Grand Saline	N.R.	N.R.	N.R.[a]	N.R.	No Data				N.R.	A + K[c]	P	N.R.	N.R.	100m
Palangana	N.R.[b]	N.R.	N.R.	N.R.	No Data				P	A + K[c]	P	N.R.	N.R.	N/A
Richton	No Data	No Data	No Data	No Data	No Data				N.R.	A	P	N.R.	N.R.	N/A
Winnfield	N.R.	N.R.	N.R.	N.R.	N.R.	G + B	N.R.	P	N.R.	A[c]	P	N.R.	N.R.	30m

(a) Change in strike of layering and attenuation of folds in one portion of the mine indicates differential motion of the salt.
(b) Zone of sediment of possible primary origin seen in San Diego Group.
(c) Generally higher percentage and more prevalent than in the exterior salt domes (Five Island).

Key

B = Brine
G = Gas
N.R. = Not reported (Michalski, 1985)
P = Feature is present
A = Anhydritic salt
K = Potash
N.A. = Not applicable.

Source: Michalski, 1985.

Central anomalous zones in salt domes might originate by several mechanisms. No substantive evidence exists for any specific mechanism; however, the most likely hypotheses for the origin of anomalous features in the center of salt domes are the following:

- Shear zones or faults along which external sediments have been incorporated (Kupfer, 1976)
- Zones of indigenous sedimentary material within the evaporite sequence carried with the salt during dome growth (Wilson, 1975)
- Zones of material incorporated into the dome by plucking and entrainment of substrata and overburden (Wilson, 1975).

Kupfer (1974) inferred shear zones in salt stocks because of the rapid attenuation of strata or the sudden disappearance of a particular salt lithology. The shear zones were considered to be fault-like surfaces between two hypothesized spines of movement.

The spine model postulates that sediments surrounding the salt stock at depth were caught between two masses of salt, carried upward, and incorporated within the salt stock to form a zone with anomalous characteristics in the center of the dome (Kupfer, 1974, pp. 201-202). Heat and buoyancy were suggested as the causes of the differential motion of the spines (Kupfer, 1974, p. 201); however, geomechanical considerations (density, viscosity, etc.) (Michalski, 1985) rule this out as a likely cause of differential motion. Rapid thermal diffusive characteristics of salt tend to eliminate heat-driven buoyancy differences. The highly deformed salt identified as shear zones could be caused by folding and refolding during dome growth (Michalski, 1985).

Wilson (1975) hypothesized that indigenous sedimentary material within the source bed may be carried up with the growing dome. Thus, the indigenous materials should show a generally conformable structure with the salt layering. However, the original physical characteristics of an anomalous feature may be highly deformed by subsequent salt movement (Michalski, 1985). The amount and character of the deformation will depend on the physical characteristics of the original feature, the orientation of the feature in the salt, and the magnitude and direction(s) of strain that the feature has been subjected to while in the salt dome. A mass of sediment near the axis in a growing dome will become highly elongated vertically. Thus, all structures of the initial anomalous feature will have a greater or lesser overprint from the subsequent deformation that may obscure the original appearance. Features may also take on new characteristics because of rheological properties.

Wilson (1975) also hypothesized that material could be incorporated into a growing dome by glacier-like plucking of the substrata and overburden of the source bed. Incorporation of discrete masses of rock material by plucking seems to be an unlikely cause of the extensive planar or sheet-like masses found in anomalous zones.

Modeling studies by Jackson and Talbot (1985) proposed that anomalous zones originate by infolding of rock that originally surrounded the dome within mushroom-shaped overhangs on salt domes. However, because of limitations of the model, it is not possible to confirm the results by analogy to known dome structures.

The majority of features in anomalous zones appear to indicate that the zones originate as an interbed or a major structural feature such as a fault or shear zone. However, no definitive driving mechanism, such as differential spine movement, can be identified as responsible for major faults or shear zones within a salt dome. Zones of indigenous material weaker than the surrounding salt may localize shear and also cause structural discordances. The deformation of the original characteristics of the anomalous feature makes hypotheses about the origin of a central anomalous feature highly speculative. Nevertheless, their existence is verified by mining operations in several coastal Gulf Coast domes, and their potential impact on salt stock characteristics and geomechanical properties is discussed in Sections 3.2.6 and 3.3.2.1.

Other Anomalous Features. Other anomalous features common to the salt dome environment between the edge and center portion of the dome are sediment zones, anhydritic salt and potash, coarse-grained and recrystallized salt, porous and fractured salt, and faults (Table 3-3).

Anhydritic salt and, in some instances, potash are found in all mined salt domes as well as in cores from Palangana and Richton domes (Table 3-3). In general, anhydritic salt and potash have higher strength and slower creep characteristics than normal salt, but are more brittle. They occur less frequently in the coastal Five Island salt domes than in the interior salt domes (Table 3-3).

Summary. Gulf Coast salt domes of the coastal and interior settings display a variety of anomalous features (Table 3-3). Based on reported occurrences of anomalous features, these are more frequent and larger in the coastal Five Island salt domes than in the interior domes. Central anomalous zones containing sedimentary inclusions in highly deformed salt are found in four of five mined coastal domes, but have not been observed in interior domes. Hence, Richton Dome (an interior dome) should, in accordance with the characteristics suggested by Muehlberger and Clabaugh (1968, p. 97), exhibit less frequent and smaller anomalous features than the coastal domes. No major anomalous features have been identified in the salt stock at the Richton Dome; however, if they are present, it is expected that these features would occupy a small volume of the dome only and be of little consequence to mining operations (see Section 3.2.6.1.2). Additionally, it is expected that such features would be predictable on the basis of stratigraphy and salt characteristics.

3.2.4 Paleontology

Strata exposed at the surface (the Hattiesburg and Citronelle formations, stream terraces, and alluvium) are sparsely fossiliferous. Fossiliferous beds in the subsurface, such as the Tatum Limestone member of the Catahoula Formation (LETCo, 1982, ONWI-120, p. 12-23), are typical of those throughout the Gulf Coast region and do not represent either a unique or readily accessible paleontologic resource. The Tatum Limestone is typically several hundred meters below the ground surface in the Richton Dome vicinity.

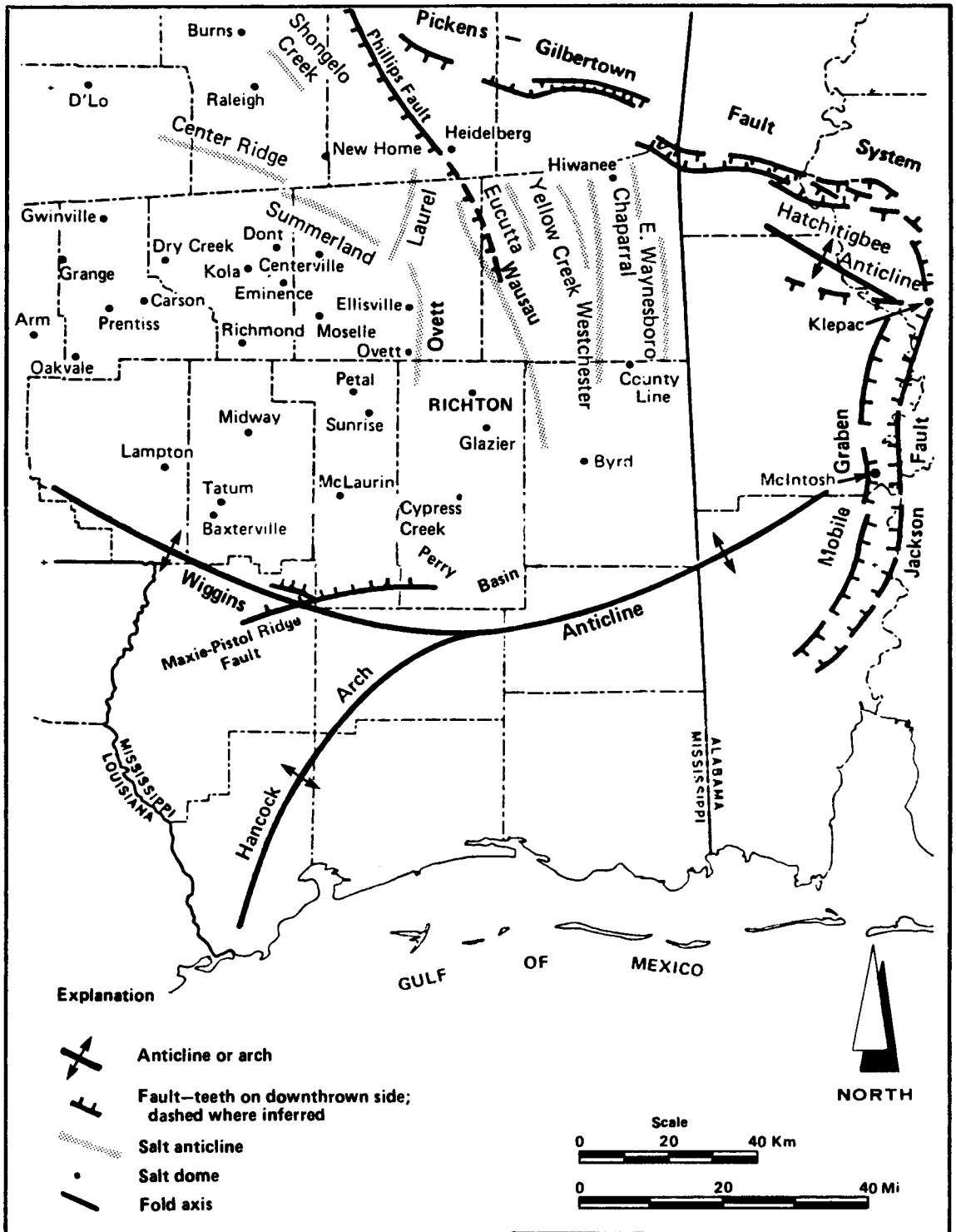
3.2.5 Structure and Tectonics

The region surrounding Richton Dome, at one time or another, has been affected by tectonic activity such as faulting, seismic activity, folding, igneous activity, uplift, subsidence, and salt migration with associated perturbation of the overlying sediments.

3.2.5.1 Faulting

Faults in the vicinity of Richton Dome have been induced by a variety of mechanisms. Some faults are related to crustal tectonics (principally Triassic rifting and extensional faulting) which created basement faults that predate the deposition of the Louann Salt. Other faults that are related to the migration of salt have disrupted sediments above the salt.

3.2.5.1.1 Faults in the Region Caused by Crustal Tectonics. As a result of the continental rifting that occurred in this region during the Triassic Period (see Section 3.2.1), numerous faults are likely to exist in basement rocks beneath the sediments of the Mississippi Salt Basin. One such basement fault is known to exist beneath the Pickens-Gilbertown Fault System (Figure 3-14) along the northern edge of the basin (Williams, 1969) and another basement fault is hypothesized along the northern flank of the Wiggins Anticline (Figure 3-14) (LETCo, 1982, ONWI-120, pp. 12-107 to 12-108). However, the Phillips Fault is the only postulated basement fault in the Richton Dome vicinity (Figure 3-14).



Sources: Oxley et al., 1968, p. 40; Williams, 1969; Gulf Coast Association of Geological Societies, 1972; Peppard-Souders and Associates, 1982; LETCo, 1982, ONWI-120, p. 12-55.

Structural Elements of the Southeastern Mississippi Salt Basin

Figure 3-14

The Phillips Fault Zone is a prominent north-south-trending series of normal en echelon faults recognized in the subsurface in Jasper County extending southward through central Mississippi for 117 kilometers (75 miles) (Oxley et al., 1968, p. 43). Within the Mississippi Salt Basin, the fault occurs beneath the Louann Salt. Movement along the fault synchronous with deposition of the Louann Salt may have resulted in thicker accumulations of salt adjacent to the fault scarp; the thicker salt, in turn, may have served to initiate the formation of the Heidelburg-Sand Hill Salt Ridge that is believed to be the core of the Wausau Anticline that is located approximately 8 kilometers (5 miles) east of Richton Dome (Figure 3-14) (Oxley et al., 1968, p. 45; LETCo, 1982, ONWI-120, p. 12-111). Paulson and Pescatore (1979, unpublished manuscript) state that variations in thicknesses of Jurassic sediments as evidenced by their isopach maps suggest movement throughout the Jurassic Period. Oxley et al. (1968, p. 43) state that movement along the Phillips Fault occurred intermittently during Jurassic time. The presence of the Phillips Fault in the immediate vicinity of Richton Dome has not been confirmed. The potential for seismic activity is currently unknown (BGI and LETCo, 1983, ONWI-293, p. 263); however, the Phillips Fault is thought to have ceased movement prior to the end of the Jurassic (Oxley et al., 1968, p. 43). In this context, the faulting above the Wausau salt anticline, such as the F-9 faults discussed below, must be due to growth of the salt ridge, not to post-Jurassic movement of the Phillips Fault.

3.2.5.1.2 Faults in the Region Caused by Salt Tectonics. A large number of faults are recognized within the thick sequence of sediments that overlie the Louann Salt. Most faults are present only below the Eocene Wilcox Formation, with few faults exposed at the surface. Movement along faults within the sediments appears to be related to the vertical and horizontal migration of salt: upward (diapiric) movement of salt often induces arching and concomitant normal faulting in the overlying strata, whereas horizontal withdrawal of salt from large areas (to feed the diapirs) may result in normal-fault collapse along the perimeter of the area of withdrawal. This section discusses faulting due to the movement of salt; the salt diapirs that result are described in Section 3.2.5.6.

Three major faults or fault systems are present along the basin's margins: the Pickens-Gilbertown Fault System, the Jackson Fault and Mobile Graben, and the Maxie-Pistol Ridge Fault. The Pickens-Gilbertown Fault System is part of a regional Gulfward concave system of faulting (Murray, 1961, p. 180). This fault system is a complex graben, with the throw on individual faults diminishing upward (Murray, 1961, p. 182). These faults typically have the smallest displacements at the surface, where the observed offsets rarely exceed 60 meters (200 feet) (Murray, 1961, p. 186). Movement along these faults was nearly continuous throughout the Mesozoic and at least through the late Tertiary (Murray, 1961, p. 182). In western and central Mississippi these faults are mostly subsurface; however, in eastern Mississippi and western Alabama they are recognized at the surface where they displace strata of the Claiborne, Jackson, and Vicksburg Groups. Movement on some of these faults has occurred sufficiently late for some of the grabens to be distinct topographic lows (Murray, 1961, p. 186).

The Mobile Graben, a structurally complex, north-south trending zone of normal faults, is located near the eastern edge of the Mississippi Salt Basin (Figure 3-14). It is at least 40 kilometers (25 miles) east of Richton Dome. The eastern limit of the Mobile Graben is the Jackson Fault (Moore, 1971, p. 24) (Figure 3-14). The western limit of the Mobile Graben has been inferred from petroleum well data, but it has not been identified in drill holes (Moore, 1971, pp. 24, 26). Displacement on the northern portion of the Jackson Fault is 1,640 meters (5,000 feet) on the Upper Cretaceous Selma Formation and 410 meters (1,350 feet) at the surface (Moore, 1971, p. 24).

The east-west trending Maxie-Pistol Ridge Fault is predominantly on the northern side of the Wiggins Anticline. The fault has been identified on the basis of data from petroleum

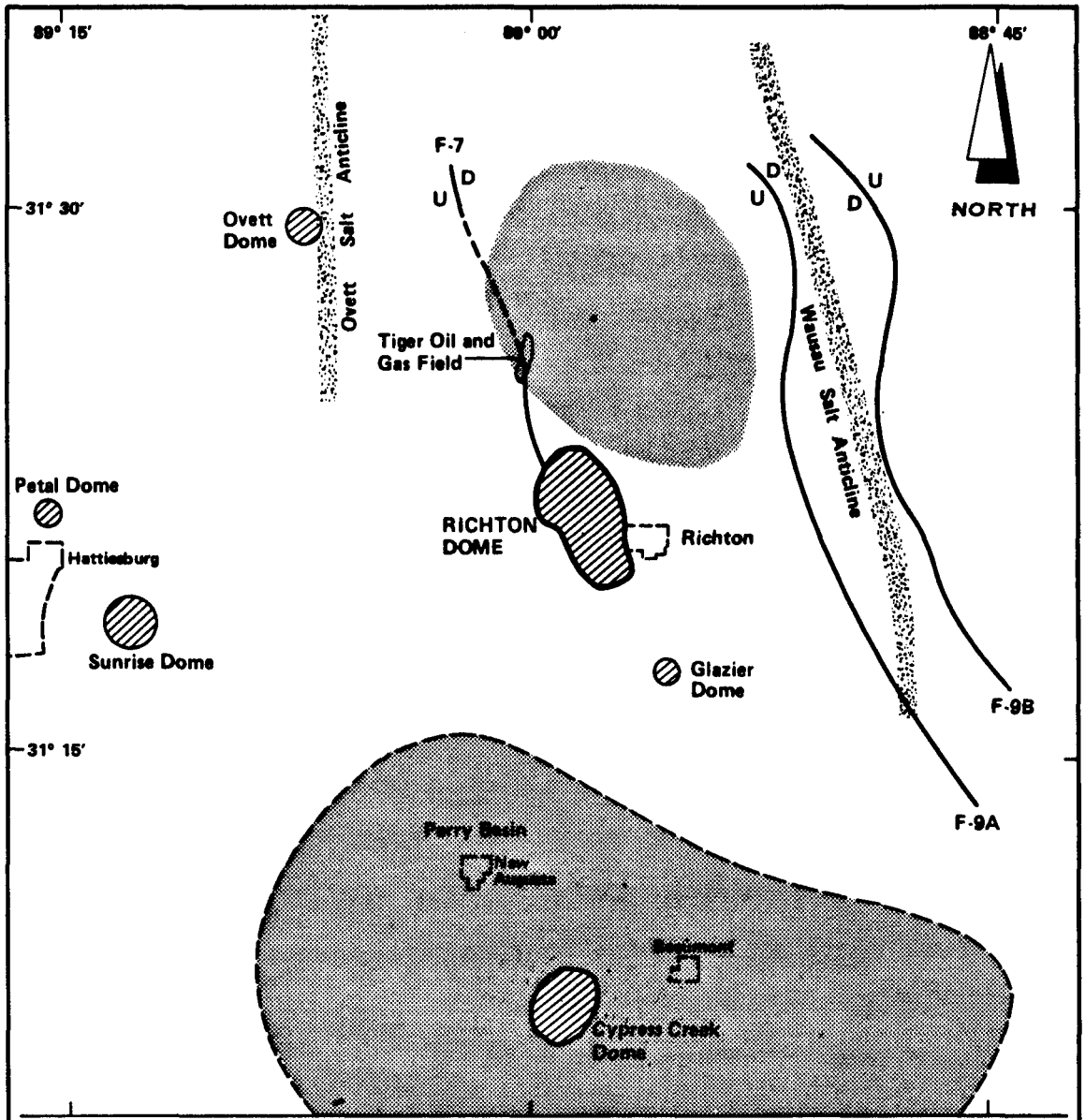
wells and has been mapped for a distance of approximately 48 kilometers (30 miles) (Peppard-Souders and Associates, 1982). Its closest approach to Richton Dome is 43 kilometers (27 miles) (LETCo, 1982, ONWI-120, p. 12-110). The fault has displacement of 76 meters (250 feet) on top of the Lower Cretaceous units. Displacement on the fault decreases stratigraphically upward such that there is an observed offset of 30 meters (100 feet) or less in the Miocene Catahoula Formation (Tatum Limestone) (Eargle, 1968, pp. 391-401). The Maxie-Pistol Ridge Fault has not been recognized in younger strata or at the surface (LETCo, 1982, ONWI-120, p. 12-110). Within the basin, many faults are present around the salt domes and over the crests of salt ridges. Only faults in the immediate vicinity of Richton Dome are described below.

The F-9 faults (Figure 3-15) are a north-south trending fault system subparallel to the Wausau Salt Anticline. These faults are identifiable in seismic reflection profiles and on structural contour maps produced from well data (ETC, 1984a, Figure 4). The system is composed of two parallel faults that form a graben and is the result of salt anticline development. The westernmost fault (F-9A) is approximately 8 kilometers (5 miles) east of Richton Dome (LETCo, 1982, ONWI-120, p. 12-123). The maximum length of this system is 35 kilometers (22 miles), with a maximum displacement of 240 meters (800 feet) in the Upper Cretaceous Tuscaloosa Formation (LETCo, 1982, ONWI-120, p. 12-123). The lengths and displacements of the faults decrease stratigraphically upward, and become minor in sediments younger than the Wilcox Formation (early Eocene) (ETC, 1984a, Figure 4).

3.2.5.1.3 Faults at Richton Dome. The F-7 fault was originally identified by LETCo (1982, ONWI-120, p. 12-120). The fault is parallel to the north-northwest trend of Richton Dome, intersects its northwestern edge, and extends obliquely away from the dome. ETC (1985a) has reinterpreted the F-7 fault based on additional seismic data and has indicated that the pattern of faulting most likely abuts and terminates against the northern edge of the dome. The maximum length of the fault is 4 kilometers (2.5 miles) on the structural top of the Upper Cretaceous Selma Group. The fault is not present above the Paleocene Midway Group (ETC, 1985a). Development of the fault is apparently related to salt migration and concomitant withdrawal during formation of Richton Dome. Movement along the fault is most likely a readjustment created by the migration of salt. As such, the faults and salt withdrawal basins/rim syclines are probably structurally related features.

Based on data from area characterization borings, two possible faults were identified in the Hattiesburg Formation atop Richton Dome (LETCo, 1982, ONWI-120, p. 13-151). The evidence for the faults consisted of either observations of a sandy lens at different elevations in two borings or an offset interpreted from geophysical logs. A recent reevaluation (Werner, 1985c) indicates that although several laterally traceable units (identified from geophysical logs) occur at different elevations in different borings, the elevation differences are consistent with gentle arching over the salt stock; that is, the same unit appears at a higher elevation in borings at the crest of the dome than in borings closer to the edge of the salt stock. Werner (1985a) postulated arching during deposition of the Hattiesburg Formation based on lithologic data from both shallow area characterization borings and sulfur exploration borings. Werner also concluded that the arching ceased prior to deposition of the Citronelle Formation, and that the faults, if they exist, do not appear to offset the base of the Citronelle.

A number of lineaments have been identified in the vicinity of Richton Dome based on an evaluation of satellite and high-altitude imagery (LETCo, 1982, ONWI-120, Figure 12-8). Under certain geologic conditions, lineaments may indicate fault traces. Consequently, an analysis was done to compare the locations of the lineaments with geologic structures depicted on intersecting seismic profiles of the underlying strata (Werner, 1985c). The results of this analysis indicate that the spatial correlation between lineaments and faults is exceedingly poor and that the faults noted on the seismic profiles are overlain by at least 300 meters (1,000 feet) of unfaulted strata. The available data do not indicate a relationship between faults and lineaments.



Sources: USGS, 1970; LETCo, 1982, ONWI-120, pp. 12-45, 12-53, 12-55, 12-59, 12-61, 12-65 to 12-71; ETC, 1985b, Figure 2-5.

Major Mesozoic and Cenozoic Structures in the Vicinity of Richton Dome, Mississippi

Figure 3-15

3.2.5.1.4 Potential for Active Faulting. Within the Gulf Coast Region, there are four fault zones where surface rupture has been recognized. Surface faulting occurs along the Big Creek Fault Zone in Arkansas, the Catahoula Lake and Red River Fault Zones in Louisiana; contemporaneous faulting (growth faulting) occurs along the coast in Alabama, Mississippi, Louisiana, and Texas (Fisk, 1944, pp. 23, 29, 33; Hardin and Hardin, 1961, p. 241). No faults with surface rupture have been reported within the Mississippi Salt Basin, which is the geologic setting of the Richton Dome site. Growth faults, as shown on Figure 3-4, are driven by active sediment accumulation such as is occurring in the Texas-Louisiana Coastal Basin; the Mississippi Basin ceased accumulating sediments in the Pliocene.

Knowledge concerning the contemporary state of stress in the Gulf Coast region is restricted to measurements made at shallow depths in sedimentary strata. The state of stress in the region is most likely the result of sediment loading and is apparently uniform; the greatest principal stress is vertical and the orientation of least principal stress is perpendicular to the continental margin (Zoback and Zoback, 1980, p. 6137). Although stress data for Mississippi are sparse, measurements in the northwestern part of the state indicate a strike-slip stress regime with least principal horizontal stress oriented N 25 W (Zoback and Zoback, 1980, p. 6120). The Mississippi Salt Basin apparently marks a transition from the north-northwest-oriented least horizontal stress of the Mississippi Embayment region to the northeast-oriented direction of the eastern Gulf Coast. In addition, the state of stress changes from a principally strike-slip to a normal fault regime (Zoback and Zoback, 1980, Plate 1). Figure 3-14 indicates that this latter stress configuration coincides with regional structures in the Mississippi Salt Basin. For example, the north-northwest-trending anticlines/arches and Phillips Fault system correlate with a north-northwest-trending least principal horizontal stress.

3.2.5.2 Seismicity

A seismicity evaluation by LETCo (1982, ONWI-120, pp. 12-132 through 12-140) indicates that the Mississippi Salt Basin is located in a region of low seismicity. No local shocks have been felt in the vicinity of Richton Dome. Historically, Richton Dome has experienced earthquake shaking up to Modified Mercalli Intensity (MMI) VI from distant earthquakes. The Modified Mercalli Intensity scale is shown on Table 3-4.

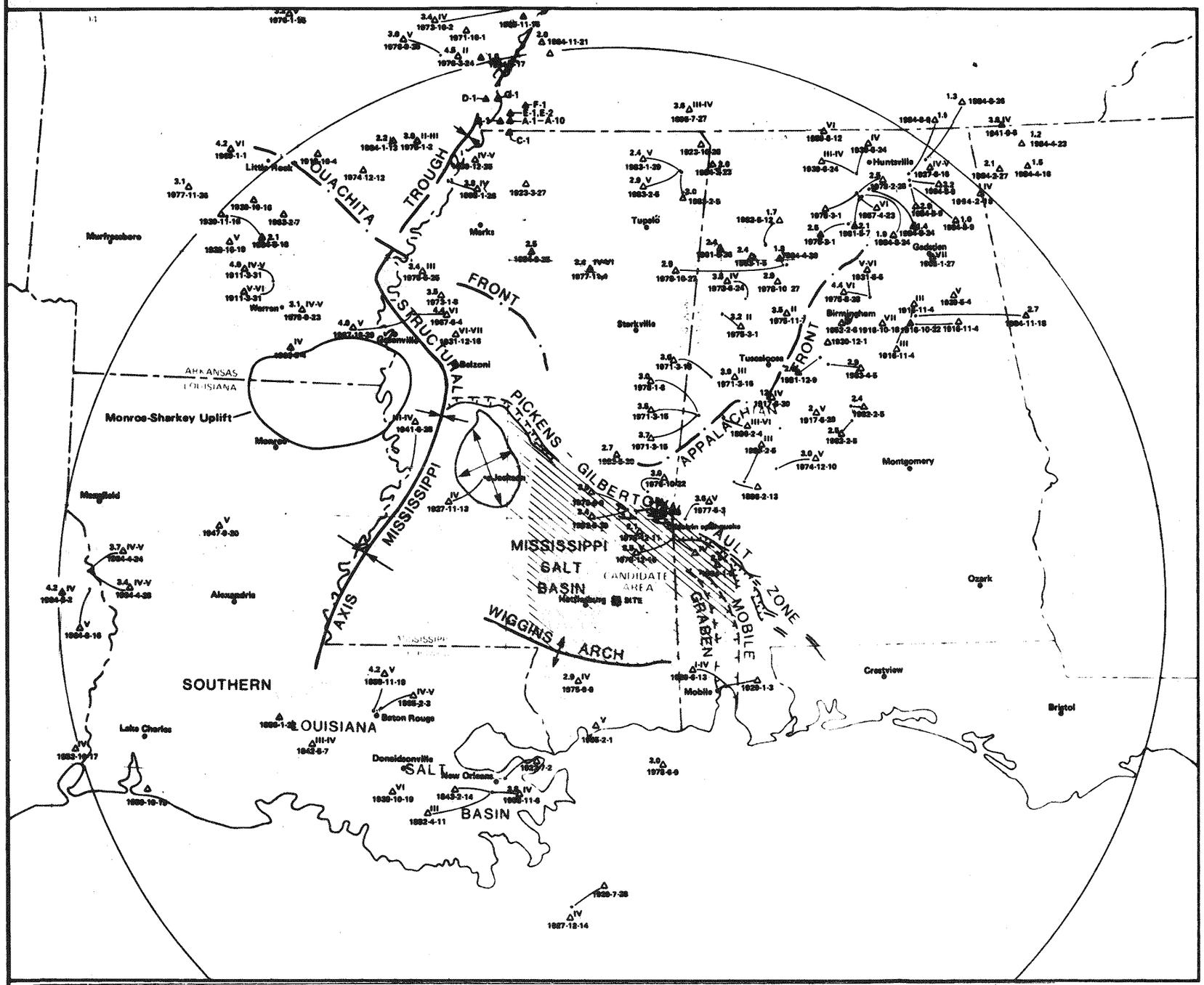
Figure 3-16 shows the approximate epicenters of historic earthquakes within 500 kilometers (300 miles) of Richton Dome. Most of the locations are based on felt reports, but some are instrumentally determined using data from regional seismograph stations. These regional stations do not provide sensitive detection of microearthquakes (magnitudes less than about 2) that might occur in south-central Mississippi. The nearest earthquakes have been a 1975 shock, MMI IV, approximately 75 kilometers (45 miles) south-southwest of the site, and a 1978 shock, MMI V, approximately 75 kilometers (45 miles) north-northeast of the site. These nearest earthquakes occurred on the margins of the Mississippi Salt Basin, and were not within the geologic setting in which Richton Dome is located. The maximum historical shaking experienced at the site is estimated to have been MMI V to VI, and resulted from the 1811-1812 earthquakes near New Madrid, Missouri (Nuttli, 1973, p. 230).

Several faults are present in the region around the site (see Section 3.2.5.1). The data available indicate these faults have not been active during the Quaternary Period (approximately the past two million years), although conclusive evidence to prove lack of movement has not been developed for some faults such as the Phillips, F-7, and F-9 (Ertec, 1983, ONWI-484, p. 44). No seismically active tectonic structures within the geologic setting are indicated by the historical earthquake data (LETCo, 1982, ONWI-120, p. 12-132). The nearest location with a possible correlation between seismicity and tectonic structures is in Clarke County, Mississippi, and neighboring Melvin, Alabama, where a few earthquakes have occurred near the Pickens-Gilbertown Fault System. However, the accuracy of this correlation is uncertain because of inexact epicenter determinations.

Table 3-4. Abridged Modified Mercalli Intensity Scale, Intensity Value, and Description

I	Not felt except by a few under especially favorable circumstances. (I Rossi-Forel Scale.)
II	Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing. (I to II Rossi-Forel Scale.)
III	Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motorcars may rock slightly. Vibration like passing of truck. (III Rossi-Forel Scale.)
IV	During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing motorcars rocked noticeably. (IV to V Rossi-Forel Scale.)
V	Felt by nearly everyone, many awakened. Some dishes, windows, and so on, broken; cracked plaster in a few places; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop. (V to VI Rossi-Forel Scale.)
VI	Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster and damaged chimneys. Damage slight. (VI to VII Rossi-Forel Scale).
VII	Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving cars. (VIII Rossi-Forel Scale.)
VIII	Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water levels. Persons driving cars disturbed. (VII+ to IX Rossi-Forel Scale.)
IX	Damage considerable in specially designed structures; well designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken. (IX+ Rossi-Forel Scale).
X	Some well built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed, slopped over banks. (X Rossi-Forel Scale.)
XI	Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.
XII	Damage total. Waves seen on ground surface. Lines of sight and level distorted. Objects thrown into the air.

Source: Wood and Neumann, 1931, pp. 979-987.



Explanation

- Fault (teeth on downthrown side)
- Anticline or arch
- Syncline
- Igneous dome
- Subsurface projection of contact between Pre-Cambrian basement rocks and Paleozoic rocks of Ouachita and Appalachian Fold Belts

Richter Magnitude — 6.9 VI — Modified Mercalli Intensity (MMI)

Epicenter Location — 1927-6-16 — Date (based on Central Standard Time)

OR, for more than one shock:

6.9, VI, 1927-6-16
V, 1931-3-2

Data for earthquakes clustered in Southwestern Tennessee

Location	Richter Magnitude	MMI Intensity	Date
A-1	3.4	III	1872-4-20
A-2	3.2	II-III	1872-8-20
A-3	3.2	II-III	1873-8-22
A-4	3.8	IV	1875-10-27
A-5	3.8	IV	1881-10-7
A-6	4.7	VI	1883-6-11
A-7	3.4	III	1889-6-5
A-8	3.6	III-IV	1891-1-14
A-9	3.8	IV	1941-11-14
A-10	4.4	V	1954-4-26
B-1	3.8	IV	1930-3-27
C-1	3.4	III	1894-7-18
D-1	4.1	IV	1880-7-13
E-1	3.8	VI	1889-7-19
E-2	3.4	III	1895-10-3
F-1	3.8	IV	1970-1-7
G-1	2.8	–	1981-4-29

Scale
0 75 150 km
0 50 100 mi

Sources: Heck and Bodle, 1931, pp. 6-8; Neumann and Bodle, 1932, pp. 5, 6, 16; Neumann, 1932, pp. 6-9; Bodle, 1941, p. 39; Brazee and Cloud, 1960, pp. 9-12; Eppley and Cloud, 1961, p. 11; Talley and Cloud, 1962, p. 9; von Hake and Cloud, 1969, p. 12; Docekal, 1970, pp. 2-93; Gulf Coast Association of Geologic Societies, 1972; Gulf States Utilities, 1973, pp. 2E-1 to 2E-4; Nuttli, 1974, p. 1192; Necioglu and Nuttli, 1974, p. 115; Coffman and von Hake, 1975, pp. 11-25; Bollinger, 1975, p. 2; Coffman and Stover, 1977, pp. 12-14; Stover et al., 1979a, p. 2; Stover et al., 1979b; Nuttli, 1979, p. 71; Coffman and Stover, 1979, pp. 9, 14, 38; Stover and von Hake, 1980, p. 15; Buschbach, 1980, p. 112; Bograd, 1981, pp. 4, 6; NGSDC, 1982, pp. 1-17; Coffman et al., 1982, pp. 24-43; Metzger, 1983, p. 8; Minch, J., 1984, personal communication; Nava and Everett, 1984a, p. 11; Nava and Everett, 1984b., p. 22; Nava and Everett, 1984c, pp. 13-44; Nava and Everett, 1984d, pp. 12, 37; Sibol and Bollinger, 1985, pp. 1, 17, 19, 22.

Tectonic Features and Earthquake Epicenters Within 300 Miles of Richton Dome, Mississippi

Figure 3-16

In a study estimating maximum earthquakes at locations in the central United States, Nuttli and Herrmann (1978, pp. 14 and 78) included the Mississippi Salt Basin in a "Residual Events" zone. For this zone, the maximum earthquake is estimated to be magnitude M_{bLg} 5.3, and it is presumed to occur at random locations (i.e., from undetected subsurface faults). Near the epicenter, such a shock could produce intensities up to MMI VI or perhaps VII. A mean-value estimate for peak ground acceleration near the epicenter of the shock is 0.14 gravity, using an equation by Nuttli and Herrmann (1981). The same equation indicates that accelerations from the 1811-1812 New Madrid earthquakes were on the order of 0.05 gravity at Richton Dome. Other potential earthquake sources in the region have distances and magnitudes that yield peak ground accelerations less than 0.14 gravity. Therefore, the local shock with magnitude M_{bLg} 5.3 is taken as the maximum earthquake for the site.

3.2.5.3 Igneous Activity

The nearest known igneous body, Jackson Dome, is located 160 kilometers (100 miles) northwest of Richton Dome, and appears to be of Cretaceous age (Bornhauser, 1958, p. 345). No evidence of recent (less than 10,000 years) volcanic activity exists within 800 kilometers (500 miles) of Richton Dome (USGS, 1962).

3.2.5.4 Uplift and Subsidence

Uplift and subsidence on both regional and local scales have occurred within the Mississippi Salt Basin throughout its development. Local uplift in response to salt migration is described under Folding (Section 3.2.5.5) and Salt Dome Development and Geometry (Section 3.2.5.6). Regional subsidence that prevailed throughout most of the basin's earlier history is described under Regional Geology (Section 3.2.1). Regional uplift that has been active since the early Pleistocene is described in this section.

Both geologic and geomorphic evidence clearly indicate that the Mississippi Salt Basin has experienced uplift since the early Pleistocene. The Plio-Pleistocene Citronelle Formation, deposited at or near sea level (Doering, 1956, p. 1821), is presently situated well above sea level and has been eroded, exposing the underlying sediments of Miocene age (Figures 3-9 and 3-10). Multiple-stream terraces flanking many modern streams in the region are remnants of Quaternary floodplains that have been elevated by regional uplift (Fisk, 1940, p. 59). Recent studies of alluvial streams in the Gulf Coastal Plain by Burnett and Schumm (1983) suggest uplift is continuing. Despite this evidence of uplift, some uncertainty remains about the rate of uplift.

Estimates of uplift for the Gulf Coast Region that are based on geologic and geomorphic observations consistently suggest that Quaternary uplift has occurred at a rate of 0.3 meters per 1,000 years (1 foot per 1,000 years) or less. Kolb et al. (1983, ONWI-467, p. 85) calculated a rate of 0.08 to 0.3 meter per 1,000 years (0.27 to 1 foot per 1,000 years) based on elevation differences between Quaternary terraces that were located in northern Louisiana. Maxwell (1971) constructed profiles of the top of the Citronelle Formation in southwestern Alabama and estimated an uplift rate of 0.01 meter per 1,000 years (0.03 foot per 1,000 years) during the late Pliocene and Pleistocene. Ertec (1983, ONWI-484, pp. 26-28) estimated the elevation of the pre-erosional surface of the Citronelle Formation in the vicinity of Richton Dome. Assuming that the Citronelle surface was at sea level at the beginning of the Quaternary, a regional uplift rate of about 0.1 meter per 1,000 years (0.4 foot per 1,000 years) was calculated.

The Earth Technology Corporation (1985a) also examined stream aggradation/degradation, fluvial terraces, and fluvial morphology of selected streams in southern Mississippi for evidence of stream response to regional uplift. Estimates of stream channel aggradation and degradation at gaging stations in the region were made using specific-gage-height analyses that identified five stations where, historically (since the mid-1930s), streams have incised into their channels. The locations of these stations suggest an arcuate zone of incision that strikes east-west across southern Mississippi. Convexities in fluvial terraces along the Pearl River suggest that uplift has influenced the region during the Quaternary, and patterns of stream activity (as illustrated by active point bars, recent meander cutoffs, mid-channel

bars, and sinuosity) suggest that downstream portions of the streams studied may be responding to increased valley gradient. However, there are only minor systematic variations in channel morphology and sinuosity, and consistent evidence of back tilting associated with arching is not observed. Thus, streams in the region may be responding to coastward tilting rather than arching.

Much greater modern rates of uplift are suggested by analysis of geodetic releveling surveys reported by Holdahl and Morrison (1974, p. 381). They reported that the eastern portion of the Mississippi Salt Basin has experienced uplift at 2 to 4 millimeters per year (0.08 to 0.16 inch per year). The releveling surveys were made over a series of north-south and east-west transects between 1906 and 1973.

Geodetic releveling data for the Gulf Coast were recently reevaluated by ETC (1985a). This evaluation differed from that of Holdahl and Morrison (1974) in that (1) data were adjusted for known systematic errors (i.e., normal orthometric, rod, refraction, temperature, and astronomical effects); (2) data were portrayed and analyzed as profiles rather than contour maps to avoid introducing uncertainties associated with circuit closure and data contouring; (3) the influence of subsidence related to ground-water withdrawal was recognized; and (4) more recent releveling surveys were included. The releveling profile between Jackson, Mississippi, and New Orleans, Louisiana, for the period from 1934 to 1969 is the only geodetic evidence of arching and associated back tilting that was suggested by initial geodetic studies of the region. Relative uplift along this profile has been estimated to be 1 to 1.8 millimeters per year plus or minus 0.3 millimeter per year (0.04 to 0.07 inch per year plus or minus 0.01 inch per year) as measured between a point located 30 kilometers (19 miles) south of Jackson (to avoid the influence of subsidence induced by ground-water withdrawal) and the maximum point of uplift near Magnolia, Mississippi. However, possible systematic errors, for which the cause is presently unknown, appear to be present in the releveling data and may account for much of the apparent uplift (ETC, 1985a). If corrected for these systematic errors, the Jackson to New Orleans profile would illustrate coastward tilting similar to the tilting observed in other regional north-south profiles rather than arching.

Jurkowski and Reilinger (1981, NUREG/CR-2290) demonstrated that the apparent uplift in the Jackson to New Orleans profile could result from crustal flexure caused by loading of sediments in the vicinity of the Mississippi Delta during the Quaternary Period. Given the reduced rate of sedimentation in the Gulf since the end of the Pleistocene, the rate of associated uplift should be expected to decline.

3.2.5.5 Folding

Folds in the sediments of the Mississippi Salt Basin are largely the result of differential subsidence between crustal blocks and the migration of salt. Thus, these folds are actually the warping or draping of sediments, rather than folds caused by compressional tectonic forces. Near Richton Dome, the major folded features that have developed in the post-Louann sediments as a result of salt movement are the salt anticlines, salt withdrawal basins or rim synclines, and local upwarping of sediments on the flanks of the dome (Figure 3-15).

Two salt anticlines (Wausau and Ovett) are located within 16 kilometers (10 miles) of Richton Dome (see Figure 3-15). A third salt anticline may exist along the trend defined by Glazier Dome, Richton Dome, and Tiger Field (Figure 3-15). If present, this third structure would be at least 19 kilometers (12 miles) long and would trend north-northwest. The Glazier Dome salt stock rises above the Louann Salt to an elevation of -2,348 meters (-7,770 feet) MSL (Anderson et al., 1973, p. 12); salt is believed to form the core of the structure at Tiger Field (LETCo, 1982, ONWI-120, p. 12-149).

As the salt migrated into Richton Dome, a large area on the north-northeast side of the dome was evacuated of salt, and the overlying sediments were depressed to form a salt withdrawal basin, or rim syncline (LETCo, 1982, ONWI-120, p. 13-146). The Richton Dome salt withdrawal basin, or rim syncline, reportedly has 90 meters (300 feet) of closure (structural relief) on top of the Upper Cretaceous Lower Tuscaloosa Formation, centered 6 kilometers

(4 miles) north of Richton Dome, where the depression abuts the F-7 fault (LETCo, 1982, ONWI-120, p. 12-53). In stratigraphically higher units such as the Paleocene-Eocene Wilcox and the Oligocene Vicksburg Group, the syncline is located northeast of the dome with a closure of 30 to 60 meters (100 to 200 feet) (LETCo, 1982, ONWI-120, pp. 12-55 through 12-71).

Most domes in the Mississippi Salt Basin probably have rim synclines or salt withdrawal basins near them, but these features are generally not large enough to have names. Perry Basin, a subbasin within the Mississippi Salt Basin, is located south of Richton Dome and north of Wiggins Anticline, and surrounds Cypress Creek Dome (Figure 3-14). This structural depression, considered to be partly a salt withdrawal basin, has a diameter of approximately 39 kilometers (24 miles) (LETCo, 1982, ONWI-120, p. 12-87). Seismic reflection surveys and well data indicate that the sedimentary strata in the basin are warped downward with decreasing structural relief on progressively younger sediments. This gradual upward shallowing trend is apparent on the Upper Cretaceous Lower Tuscaloosa Formation, with 914 meters (3,000 feet) of closure, through the Oligocene Vicksburg Group, with 152 meters (500 feet) of closure (LETCo, 1982, ONWI-120, pp. 12-88).

Jurassic, Cretaceous, and Tertiary sediments are tilted and locally warped on the flanks of Richton Dome as a result of salt diapirism. Seismic data indicate that Lower Cretaceous strata are upturned as much as 213 meters (700 feet) on the western side of the dome (LETCo, 1982, ONWI-120, p. 13-146). Structural relief decreases to approximately 60 meters (200 feet) on Upper Tertiary strata. LETCo (1982, ONWI-120, pp. 13-151 through 13-155) has indicated little or no upwarping of post-Miocene strata. On the eastern side of the dome, seismic data indicate that pre-Miocene strata dip gently toward the dome to within approximately 1.6 kilometers (1 mile) of the domal flank. Closer to the dome the seismic data are difficult to interpret, and the degree of sediment upwarping is uncertain.

3.2.5.6 Salt Dome Development and Geometry

Salt domes in the Gulf Coast Region are vertically oriented features within an otherwise flat-lying and slightly deformed sedimentary sequence. The low density of salt and its inherent tendency to deform plastically at slightly elevated temperatures and pressures (which are caused by sediment loading) are the underlying mechanisms for salt dome development. It is generally recognized that salt domes in the Mississippi Salt Basin are derived from the originally flat-lying Louann Salt, which now lies beneath 4,900 to 9,100 meters (16,000 to 30,000 feet) of sediment (LETCo, 1982, ONWI-120, p. 12-23). Since deposition of the Louann Salt, the domes have moved upward relative to their source bed as sediments accumulated in the basin.

Salt domes develop through a characteristic sequence of stages as the original salt bed deforms by horizontal and vertical flow of salt (Trusheim, 1960, pp. 1519-1540). Initial salt movement is a slow, horizontal flow toward locally thickened zones within the bedded salt. With time, the thickened zones bulge upward, forming salt pillows which are commonly elongate (salt anticlines). Plastic flow of salt continues to feed these pillows, leaving behind areas depleted in salt. Subsidence occurs at an increased rate over the evacuated area (rim syncline), causing thickening of the contemporaneously deposited sediments. The record of domal growth is preserved in the differential thicknesses of contemporaneous sediments: thin or absent over the dome (but this record is commonly removed by later erosion) and thick in the rim syncline. Continued lateral flow under an increasing temperature and pressure regime induced by sedimentation and contemporaneous basin subsidence further enlarges the salt pillow until the buoyant force is sufficient to cause vertical domal growth and piercement through overlying sediments (diapirism). Diapirism continues with further deposition until the forces causing vertical flow (sedimentation and subsidence) cease. Salt flow may continue (post-diapiric growth) at lower rates until equilibrium is reached. The relationship between sedimentation and salt flow is best illustrated in the East Texas Basin by Seni and Jackson (1984, p. 80) and is consistent with observations made during area characterization (LETCo, 1982, ONWI-117, pp. 2-26 to 2-36).

Sediments deposited in rim synclines adjacent to Richton Dome indicate diapirism occurred from the Late Cretaceous to the early Oligocene. The greatest amount of salt movement occurred during the early Tertiary (Ertec, 1983, ONWI-484, p. 50). Because the processes that cause vertical flow of salt (sedimentation and subsidence) have ceased in the Mississippi Salt Basin, Richton Dome is inferred to be in a postdiapiric stage of dome evolution. Growth of Richton Dome appears to have ended prior to the early Pliocene, as evidenced by the lack of deformation of the Citronelle Formation and several Quaternary-aged terraces. Between late Oligocene and early Pliocene times, dome growth appears to have occurred at an average rate of only 5 to 28 millimeters per 1,000 years (0.2 to 1.1 inches per 1,000 years) (Werner, 1985a). This rate is consistent with that developed for postdiapiric growth of salt domes in the East Texas Salt Basin. There, Seni and Jackson (1984, p. 75) suggested growth rates of 10 to 60 millimeters per 1,000 years (0.4 to 2.4 inches per 1,000 years).

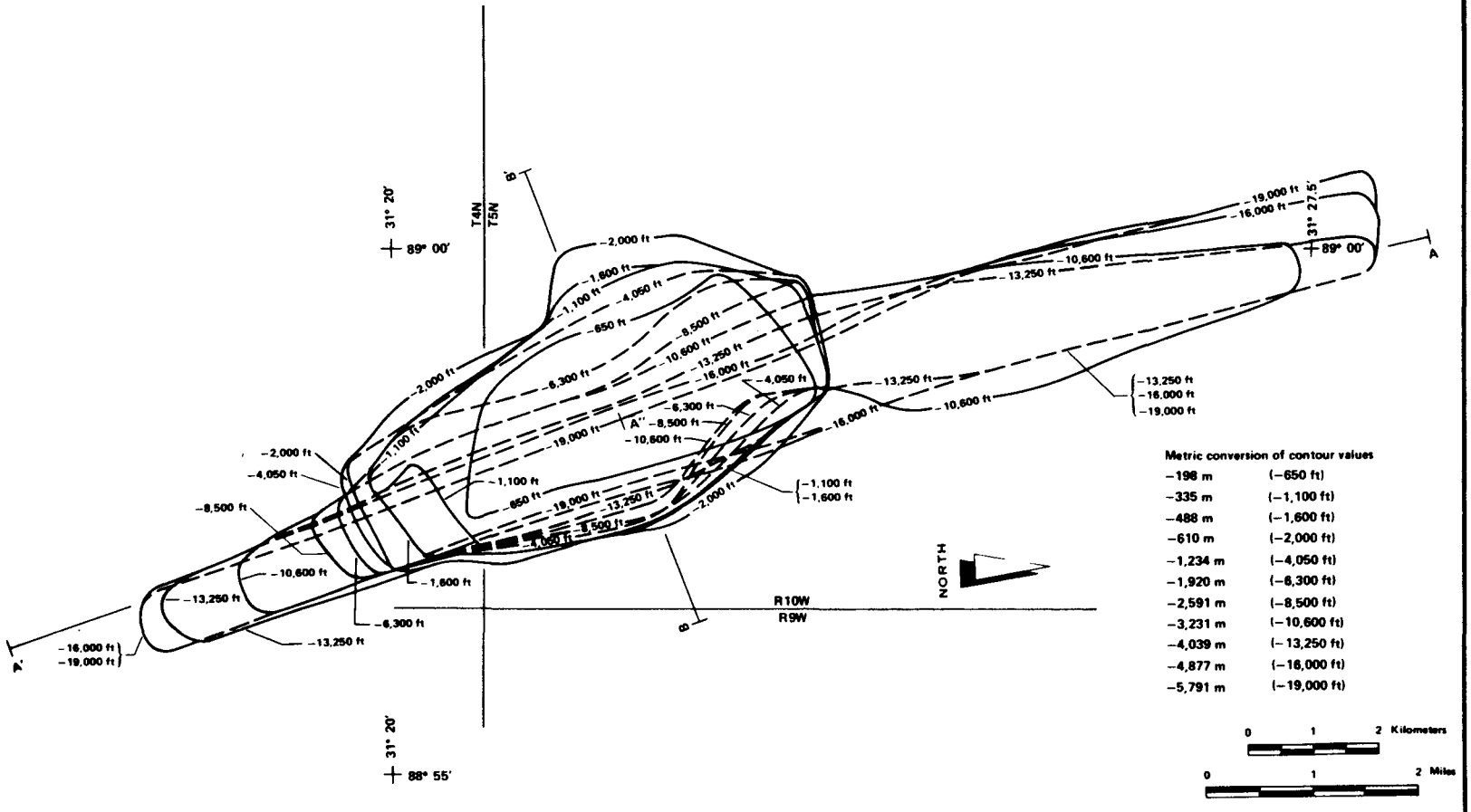
Area Characterization studies cite a number of geomorphic and surficial geologic features as possible evidence of recent uplift and, therefore, dome growth at Richton Dome (LETCo, 1982, ONWI-120, pp. 13-124 - 13-135, and 13-160). The evidence includes a topographic high, apparent radial drainage, an exposure of the Hattiesburg Formation surrounded by exposures of the younger Citronelle Formation over the northern half of the dome, and an abrupt change in the course of Beaver Dam Creek off the northeast flank of the dome.

Reexamination of these features in the context of the region around the dome has resulted in the conclusion that similar coincidences are observed beyond the supradomal area (Murphy, 1985, pp. 6,7). Richton Dome is located beneath an interfluve (Section 3.2.2.1) that is at approximately the same elevation as surrounding interfluves (Figure 3-7). The apparent radial drainage reported by LETCo (1982, ONWI-120, p. 13-125) may not be radial and is not unique to the supradomal area (Section 3.2.2.1). Werner (1985a, p. 17) notes that the Citronelle Formation was deposited on an erosional surface on top of the Hattiesburg Formation that is similar to modern topography and drainage. The highest hilltops preserved on the Hattiesburg Formation are accordant on and off the dome at similar elevations. Furthermore, Werner (1985a, p. 17) suggests that Beaver Dam Creek is in a paleodrainage and the abrupt change in course may be the result of processes occurring prior to the deposition of the Citronelle Formation. Thus, the occurrence of these features appears to reflect the influence of Miocene-age geology and Pliocene-age topography rather than an association with recent domal uplift (Murphy, 1985, p. 6,7).

Richton Dome is the largest known piercement salt structure in the Mississippi Salt Basin (Karges, 1975, p. 175). Interpretation of gravity data indicates that Richton Dome is situated on top of a long, northwesterly-trending salt ridge (LETCo, 1982, ONWI-120, p. 13-97). A thorough review of data from oil exploration wells, sulfur exploration wells, area characterization borings, seismic reflection profiles, and gravity data has led to an integrated interpretation of the geometry of the dome. A gravity model (ETC, 1985b) has been constructed using 4,500 gravity stations within the 25 townships surrounding Richton Dome. It is constrained by geologic data from 50 borings, density data from 8 borings and several publications, and structure interpretations from 13 seismic reflection lines. The model shows that the dome is oval in shape, about 7 kilometers (4.5 miles) long on a northwest axis and about 3 kilometers (2 miles) wide at its widest point. The areal extent of salt at the proposed repository level of about -610 meters (-2,000 feet) below mean sea level (MSL) is estimated to be 2,221 hectares (5,489 acres), based on the -2000 MSL contour (Figure 3-17; ETC, 1985b, Figure 2-3). This area is based on additional seismic reflection data and differs from that of previous estimates. The previous estimates were based on less constraining gravity data.

3.2.5.7 Dissolution

Evidence for past dissolution and thus the potential for future dissolution of Richton Dome must be evaluated in the context of geologic conditions at the site. Data pertinent to assessing the influence of dissolution were collected during area characterization; the results are summarized in LETCo, 1982 (ONWI-120, pp. 13-96 to 13-166). Some of these data and the interpretations of these data have been extensively reexamined and reinterpreted. Of particular interest are studies of overdome sediments (Werner, 1985a) and fractures in the



Source: ETC, 1985b, Figure 3-7.

Structure Contours
Top of Salt Model
Richton Dome

Figure 3-17

anhydrite caprock (Werner, 1985b). Data pertinent to dissolution at Richton Dome are examined in Murphy (1985).

The available data suggest that dissolution has not significantly altered the site over the past 25 million years and that the potential for future dissolution is low. The small number of boreholes that penetrate into caprock and salt and the potential changes that could be induced by a repository do not appear to significantly increase the potential for future dissolution.

3.2.5.7.1 Evidence for Dissolution. Dissolution of domed salt is the process by which crystalline salt is lost from the salt stock to undersaturated ground water and transported away from the site via the ground-water flow system. Possible evidence of dissolution includes: indications of subsidence or collapse of the overdome sediments as illustrated by geomorphology (e.g., topography, terraces, drainage patterns); structure of the overdome sediments (e.g., faults, folds, overthickened sediments); and residuals of the dissolution process (e.g., caprock and ground-water salinity anomalies).

Geomorphic Evidence of Dissolution. Geomorphic conditions at Richton Dome suggest that neither subsidence (a possible result of dissolution) nor uplift (an indicator of net salt dome growth) have affected the site during the past 3 to 4 million years. A supradomal topographic depression, similar to those commonly observed over the interior domes of Texas (Seni and Jackson, 1984, pp. 25-99) and Louisiana (Newchurch, 1976) and suggestive of dome-related subsidence, is not present at Richton Dome (Murphy, 1985). Rather, regional Quaternary-age terraces identified over the dome and on adjacent drainage divides are not warped by either uplift or subsidence (Werner, 1985a, p. 23). A small, closed topographic low, about 244 meters (800 feet) in maximum dimensions with less than 3 meters (10 feet) relief, was observed just east of Richton Dome (LETCO, 1982, ONWI-120, p. 13-125). This feature is similar to other surficial depressions observed in Perry County from topographic maps and reported in George County by Williams et al. (1966). The origin of these widely distributed depressions is uncertain. Williams suggests that depressions may be the result of near-surface selective leaching of iron and aluminum minerals by acidic ground water. Dissolution of salt at depth is an alternative mechanisms for their formation; however, no subsurface disruption of sediments is seen on seismic sections or from well logs (sulfur well P-78) near the depression east of the dome. Further work by Isphording and Flowers (1985) suggests that the depressions are the result of a phase change from kaolinite to gibbsite resulting in a volume reduction and surficial subsidence.

Evidence of uplift might suggest instability of the dome which would induce caprock fracturing that could affect assessment of future dissolution potential. However, as described in Section 3.2.5.6, geologic conditions cited by LETCo (1982, ONWI-120) as possible evidence of Quaternary domal uplift appear to be the result of regional processes that are independent of domal movement.

The arching of overdome sediments and caprock without apparent structural collapse due to faulting provides evidence that subsidence has not occurred to a significant degree. Structural contour maps illustrate broad arching over the dome with the focus on two centers of arching (Werner, 1985a, p. 12), and do not indicate areas of subsidence.

The importance of these observations and interpretations to the assessment of dissolution at Richton Dome is that dissolution has not been rapid or severe enough to cause collapse of overdome sediments or caprock since the time the oldest continuous units were deposited (in the late Oligocene). Further supporting evidence for this conclusion is found in the gypsum veining (late Oligocene) of the anhydrite caprock, reported by Werner (1985a) as the last significant dissolution to take place at the site. On the other hand, if dissolution has occurred since the late Oligocene (about 25 million years ago), the rate of dissolution must have been approximately equal to the rate of upward salt movement; this dissolution would have been very slow.

Thickness and Lithology of Caprock. The record of dissolution at the site is present in the caprock. Although some caprock may be precipitated from ground water in sediments adjacent to the dome, anhydrite caprock at Richton Dome is considered to be a residual of salt stock dissolution (Section 3.2.7.2). Assuming the caprock at Richton Dome (Section 3.2.3.2.3) was derived by dissolution of the salt stock and that the salt stock contains 8 percent disseminated anhydrite, the caprock penetrated by MRIG-9 (65 meters [213 feet]) represents a total loss of up to 850 meters (2,775 feet) of salt. Granular anhydrite (1.5 meters [5 feet]) at the caprock base represents loss of about 15 meters (50 feet) of salt (assuming a porosity of 20 percent). Approximately 725 meters (2,375 feet) of salt were dissolved to form the crystalline anhydrite section (57 meters [190 feet]). The limestone section (7 meters [23 feet]), if it formed from alteration of anhydrite, represents about 110 meters (350 feet) of salt stock dissolution, assuming a 20 percent loss in volume in the transition from anhydrite to calcite. Most of this dissolution occurred from the middle Eocene through late Oligocene (Section 3.2.5.7.2). Loss of anhydrite from the caprock by dissolution is possible; this process could have slightly reduced the original caprock thickness, thus slightly reducing the estimated salt loss as compared to the actual salt loss. However, Werner (1985b, p. 27) cited observed anhydrite textures as an indication that dissolution of anhydrite has not been significant.

Salinity Anomaly. Concentrations of sodium and chloride ions in groundwater (i.e., salinity) commonly increase with increasing depth in Gulf Coast sediments (LETCo, 1982, ONWI-120, p. 14-40). However, anomalously high salinity can be expected in ground water that is downflow from domes experiencing active dissolution. A large number of salinity anomalies have been reported in the vicinity of Gulf Coast salt domes (Smith, 1976) based on salinities calculated from downhole geophysical logs, but few anomalies have been confirmed with water-chemistry data (see Table 3-5).

A reported salinity anomaly (LETCo, 1982, ONWI-120, p. 14-18) was identified on the basis of ground-water salinities estimated from dual-induction logs run in 11 deep Gulf Coast Salt Dome project borings (Ertec, 1983, ONWI-484 p. 54) shown in Figure 3-18. LETCo (1982 ONWI-120, pp. 14-21 and 14-25) depicted the anomaly as increases in the elevations of (1) the regional base-of-fresh-water (TDS concentrations less than 1,000 milligrams per liter) surface, and (2) the regional top-of-very-saline-water (TDS concentrations less than 10,000 milligrams per liter) surface. The regional surface (base-of-fresh-water) is defined by six widely-spaced wells. The extent of the reported salinity anomaly at Richton Dome is defined by five project borings (MRIG-9, MRIG-10, MRIH-11, MH-4, and MCCG-2). Murphy (1985) examined data pertinent to the reported saline anomaly at Richton Dome.

MRIG-10, located about 3 kilometers (2 miles) northeast of the dome (Figure 3-18) illustrates the tendency for increasing dissolved solids with depth. Dissolved-solids estimates for the Upper Aquifer are generally 1,000 milligrams per liter equivalent sodium chloride, increase abrubtly to 3,600 milligrams per liter equivalent sodium chloride in the Vicksburg/Jackson, and continue to increase with depth in each hydrogeologic unit to a maximum of over 10,000 milligrams per liter equivalent sodium chloride in the uppermost Wilcox Formation.

MRIG-9, located over Richton Dome, did not have elevated salinities in overdome Upper Aquifer sediments, but rather at the caprock/salt stock interface where elevated concentrations of salinity would be expected.

MRIH-11 and MH-4 are located 2 kilometers (1.2 miles) and 9.5 kilometers (6 miles) south of the dome (Figure 3-18), respectively, and are the primary evidence of increases in dissolved solids south of the dome. The regional trend toward increasing salinity with depth is observed in both holes, but is complicated by marked increased in estimated dissolved solids for the lower member of the Catahoula Formation and the limestones of the Vicksburg Group and the Cockfield Formation. A similar distribution of dissolved solids is observed in MCCG-2, located 18 kilometers (11 miles) south of Richton Dome (Figure 3-18) south of the Leaf

Table 3-5. Chemical Analyses of Ground Water from Selected Wells in the Vicinity of Richton Dome

Well Number[a]	Aquifer	Concentration, parts per million[b] Sodium	Chloride	TDS
MH-4D	Catahoula	3,200	4,400	8,150
MRIH-11D	Catahoula	3,800	4,700	9,410
Mean background[c] concentration	Catahoula	383	449	1,008
MH-4C	Cook Mountain	8,900	14,000	23,400
Mean background[c] concentration	Cook Mountain	5,517	8,250	14,400
MH-4B	Sparta	11,000	17,000	28,700
Mean background[c] concentration	Sparta	8,000	12,075	20,800
MH-4A	Upper Wilcox	8,500	13,000	22,200
MRIH-11B	Upper Wilcox	6,400	9,100	16,300
Mean background[c] concentration	Upper Wilcox	12,863	19,825	33,463
MRIH-11A[d]	Lower Wilcox	39,000	63,000	104,000

Note: The well numbers MH-4(A-B-C-D) and MRIH-11(A-B-C) define two well sites where water was sampled from four different wells, each completed in different aquifers.

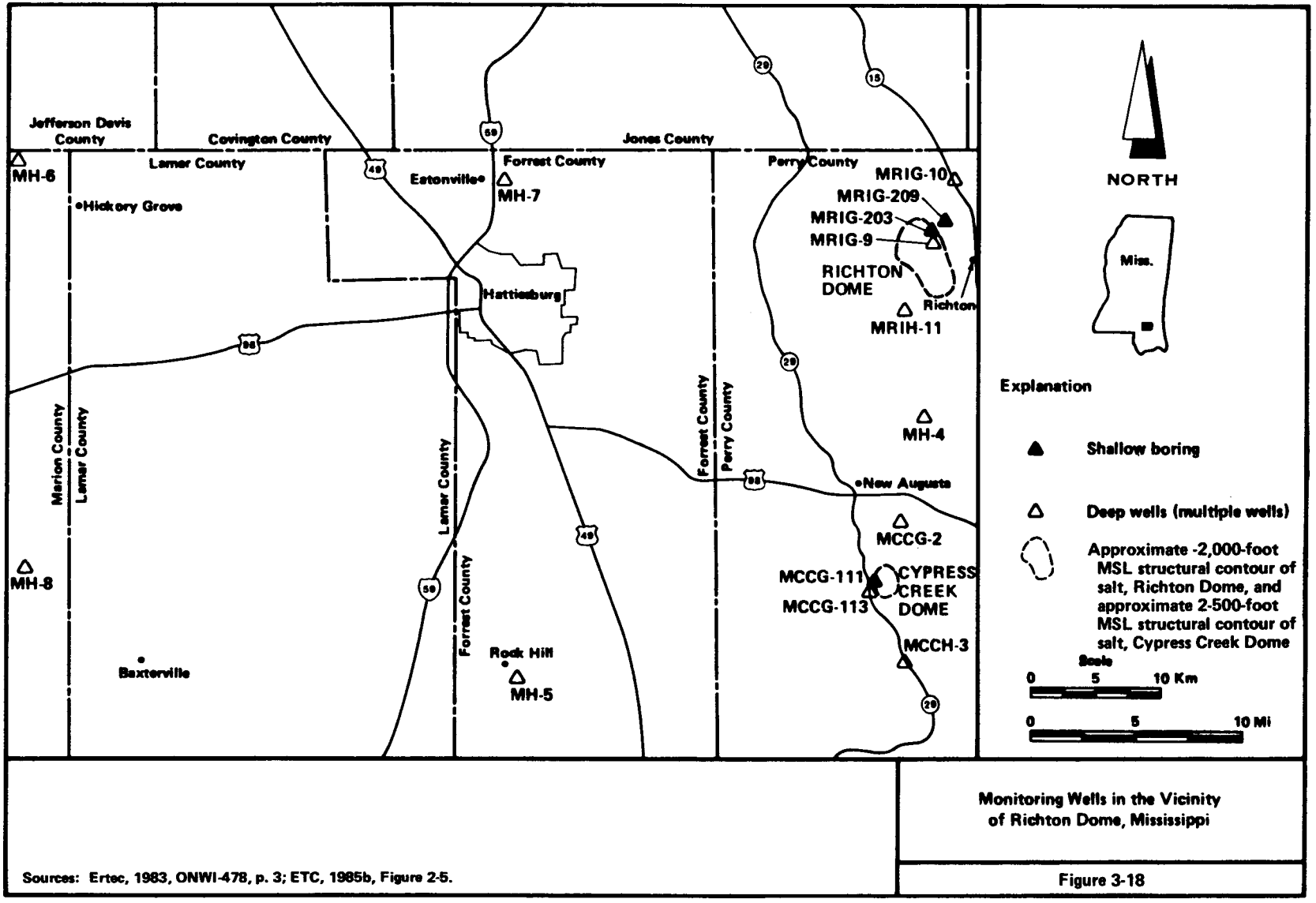
(a) Well locations are found on Figure 3-18.

(b) Total dissolved solids (TDS) is calculated by summing the dissolved constituents.

(c) Mean background concentrations were calculated using data from Marion, Lamar, Forrest, and Perry Counties. Data from wells MCCG-1, MCCG-2, and MCCH-3 (near Cypress Creek) were not included in the calculation where anomalous salinities have been reported.

(d) No other data are available on wells screened in the lower portion of this unit. Therefore, a mean background concentration cannot be obtained.

Source: Bentley, 1983, pp. 28-31.



Sources: Ertec, 1983, ONWI-478, p. 3; ETC, 1985b, Figure 2-5.

Monitoring Wells in the Vicinity of Richton Dome, Mississippi

Figure 3-18

River and within 2.5 kilometers (1.5 miles) of Cypress Creek Dome. A greater depth to and the thickness of geologic formations in MCCG-2 as compared to the other boring is caused by the influenced of the Perry Basin.

The relatively elevated concentration of dissolved solids in the lower portion of the aquifer is observed in all of the boreholes but is most pronounced in MRIH-11 and MH-4. In these holes dissolved solids are estimated to be as much as 27,000 milligrams per liter equivalent sodium chloride, and salinity estimates vary greatly over short vertical and horizontal distances. In both holes, salinities are greatest in a section of limestone, shale and sand at the base of the lower member of the Catahoula. A thick (6 to 7 meter [20 to 25 foot]) shale separates these units from overlying sands that contain water with only 2,000 to 5,000 milligrams per liter eNaCl. The shallow well at each of these sites (MRIH-11D and MH-4D) was completed just beneath this shale and produced water between 8,000 and 9,500 milligrams per liter TDS. In contrast, estimates of dissolved solids vary from 500 to 5,000 milligrams per liter eNaCl in upper portions of the aquifer at MRIH-11 and MH-4.

Both boreholes are located near discharge areas for the Upper Aquifer. MRIH-11 is located less than 1 mile (0.6 kilometer) from Bogue Homo Creek. MH-4 also is located near Bogue Homo Creek, just north of its confluence with the Leaf River. Water samples from Thompson Creek near Hintonville (close to the MH-4 well location) show anomalous salinities suggestive of seasonal saline discharge from the Upper Aquifer (Table 3-18 in Section 3.3.1.2). Seasonal salinity increases also have been reported from sampling stations on other drainages both upstream and downstream of Richton Dome (Table 18 in Section 3.3.1.2 and Figure 3-24 in Section 3.3.1.1).

Dissolved solids are less at the base of the Upper Aquifer at both MRIG-10 (6,000 milligrams per liter) and MCCG-2 (13,000 milligrams per liter) as compared to concentrations at MRIH-11 and MH-4. This difference appears to be associated with changes in lithology and position within the basin (Murphy, 1985). However, the quality and distribution of geochemical data are insufficient to definitively determine the origin and nature of elevated concentrations of dissolved solids. Several hypotheses have been developed (Bentley, 1983) to explain the anomalous salinities.

There appears to be a correlation between the degree of shaleyness of the lower member of the Catahoula Formation and high estimates of dissolved solids. This portion of the aquifer clearly contains more interbedded shale at MRIH-11 than observed at MH-4, and MRIG-10 and MCCG-2 are less shaley than either MRIH-11 or MH-4. The lower and upper portions of the Upper Aquifer exhibit very different flow characteristics. The primary difference is at least a tenfold decrease (locally this decrease may be even larger) in permeability of the lower portion, which results in slower ground-water velocities. Flow in both portions of the aquifer is driven by head (i.e., elevation) differences between drainage divides and adjacent drainages. Thus, the direction of flow is similar in both zones.

Dissolved solids in the lower zones are isolated from the more rapidly circulating ground water in the upper zone. However, in the vicinity of a major discharge zone such as the Leaf River, the component of upward flow increases and water from both zones mixes; this mixing results in an observable increase in dissolved solids near discharge zones in the Upper Aquifer.

Despite the constraints of the ground-water flow system, increased dissolved solids in the lower Catahoula are not restricted to the flow system influenced by Richton Dome. The Leaf River is a major discharge zone for the Upper Aquifer. Borehole MCCG-2 is located on a drainage divide south of the Leaf River, and should not receive flow from the direction of Richton Dome. However, deeper flow from Cypress Creek Dome may be influencing this borehole. Yet, concentrations of dissolved solids are, as expected, relatively low in the upper portion of the aquifer but elevated in the lower Catahoula. Because the lithology of the lower Catahoula at this site is very similar to that observed north of the Leaf River, it is inferred that lithology is the major factor in influencing water quality in this unit.

Dissolution of the Richton Dome, or movement of more highly saline waters upward along the dome flanks, cannot be completely discounted as a contributor to the observed patterns of salinity. However, Werner (1985a and 1985b) has revealed little that would indicate active dissolution of the upper portions of Richton Dome. Also, regional modeling of deep basinal ground-water flow suggests little potential for upward migration of saline waters along the dome flank (Sections 3.3.2 and 6.4.2.3.5), although upward leakage of deeper waters does occur in the vicinity of Perry Basin, south of the dome. Salt dome dissolution represents a point-source of salinity and, therefore, does not explain the regional distribution of salinities reported for the Upper Aquifer.

Leakage of saline water from lower saline units (e.g., the Vicksburg Limestone) was also considered as a possible origin of salinity. However, the Chickashaway and Bucatunna Formations that separate the Vicksburg Formation from the Upper Aquifer generally contain less dissolved solids than either the lower Catahoula or the limestones. Similarly, human-induced contamination was considered (Murphy, 1985). However, like salinity from dome dissolution, this source is a point source and does not explain the observed regional distribution of dissolved solids.

Summary. Undisturbed terraces and simple arching of overdome sediments are evidence that dissolution has not been rapid or severe enough to cause collapse of these features. The only direct evidence of dissolution at Richton Dome is the presence of caprock. Caprock, which seems to have been formed prior to the late Oligocene, is also the only evidence from which meaningful estimates of dissolution rates can be obtained. Salinity observed in the Upper Aquifer south of Richton Dome does not appear to be derived from a point source such as dome dissolution or man-induced contamination, but rather represents current aquifer conditions.

3.2.5.7.2 Dissolution History. A history of dissolution at Richton Dome was developed by Werner (1985a, pp. 59-68) on the basis of overdome stratigraphic and structural relationships based on descriptions of sediments and caprock encountered in sulfur exploration and Gulf Coast Salt Dome project borings (Section 3.2.3.2). This history of dome-top dissolution is summarized and possible alternative histories are examined below.

The history of dissolution at Richton Dome described by Werner (1985a) provides an explanation of caprock development that is consistent with the history of dome development (Section 3.2.5.6). Major elements of this history are based on the following:

1. The presence of Oligocene and younger sediments over the dome and the unconformity between these overlying sediments and the caprock indicate that the top of the caprock existed during the late Oligocene.

2. Warping and thinning of overdome sediments suggest decreasing net salt dome growth with time through the Oligocene and Pliocene. The evidence suggests limited or negligible net salt dome growth since the late Pliocene. Quaternary-age stream terraces confirm that no net salt dome growth has occurred since the early Quaternary.

3. Thickness and lithology of caprock establishes the magnitude of dissolution at the site.

4. Gypsum-filled fractures penetrating the entire thickness of the caprock, from boring MRIG-9 and several sulfur borings, establish the age of the caprock as pre-late Oligocene.

5. Upward salt dome growth is the primary mechanism for fracturing caprock.

6. Granular anhydrite at the caprock/salt stock interface represents post-Oligocene dissolution.

Geologic alternatives to Werner's interpretation are examined by Murphy (1985) to assess what impact reasonable variations might have on the assessment of dissolution potential at Richton Dome. These alternatives include alternate stratigraphy interpretations, alternate timing of gypsum veining, and granular anhydrite as an indication of Quaternary dissolution.

Preferred Dissolution History. The geologic history of Richton Dome that was studied by Werner (1985a) begins in middle to late Eocene (38 to 45 million years ago), when Richton Dome was experiencing postdiapiric growth. During middle Eocene through Oligocene time, the top of the dome was actively dissolved by undersaturated ground water and was essentially flat. Caprock developed by accumulation of anhydrite residuum and, by the end of the late Oligocene, a thick anhydrite caprock had formed, overlain by a thinner layer of limestone.

Continued dome growth brought the caprock to the surface and, during the late Oligocene, erosion removed both a thin layer of overdome sediments and the top of the caprock over two centers of arching. As a result of this differential uparching, fracturing occurred over these centers, permitting circulation of water through the caprock. Subsequently, the hydration of anhydrite along the fracture walls occurred to form gypsum veins throughout the entire thickness of anhydrite in these centers of arching. The gypsum-filled fractures slowed the movement of water through the caprock and prevented significant dissolution of the underlying salt stock.

Beginning in the latest Oligocene or earliest Miocene (22 to 25 million years ago) and continuing until the early Pliocene (about 5 million years ago), sedimentation continued over the dome, interrupted by occasional periods of erosion. During this period, differential dome growth continued and the caprock and overlying sediments were arched above the two distinct centers of arching in the salt, resulting in a total net growth of approximately 180 meters (590 feet) of uplift (Werner, 1985a, pp. 40, 41). Fracturing of the caprock was primarily along existing fractures now filled with gypsum. This new fracturing did not result in additional significant dissolution.

From late Pliocene (about 3 million years ago) to the present, there appears to have been no additional net growth of the salt stock and no arching of the caprock to cause additional fracturing. Thus, the caprock continued to impede the movement of fluid and additional dissolution.

This interpretation of the dissolution history of Richton Dome suggests that significant dissolution related to caprock formation occurred from the middle Eocene (abut 40 to 50 million years ago) to the late Oligocene (about 25 million years ago) at an estimated rate of 3 to 5 centimeters per 1,000 years (1 to 2 inches per 1,000 years). Any subsequent dissolution (i.e., within the last 25 million years) was minor and is most likely to have occurred when the caprock was fractured by arching of the underlying salt. This post-Oligocene dissolution may be represented by the accumulation of granular anhydrite at the base of the caprock. The rate of this dissolution is uncertain, but the long-term average rate may have been much less than 1 centimeter per 1,000 years (0.4 inch per 1,000 years) (Murphy, 1985).

Alternate Stratigraphy. Werner's (1985a, p. 11) correlation of the overdome sediments to the regional stratigraphic sequence is based on lithologic similarity and stratigraphic position and is not constrained by fossil evidence. Some uncertainty remains about these correlations because lithologic variations can be expected to occur in the immediate vicinity of the domes (Seni and Jackson, 1983, p. 1223).

A reasonable alternative is obtained if overdome sediments are assumed to be younger than predicted by Werner (1985a). In this alternative the oldest overdome sediments are assumed to correlate with strata in the upper Catahoula Formation (i.e., Oligocene-age units are not present). Such an assumption suggests that the unconformity over the caprock is early Miocene

in age, or about 20 million years old, rather than the previously mentioned 25 million years. The estimated dissolution rate under this scenario would be about 3 to 4 centimeters per 1,000 years (1.2 to 1.5 inches per 1,000 years). Other characteristics of Werner's interpretation remain unchanged, including the assessment of Quaternary dissolution.

Alternate Timing of Gypsum Veinina. Werner's (1985a) interpretation of dissolution history fixes the age of the entire caprock by (1) establishing the age of the unconformity of the caprock, (2) noting the presence of gypsum-filled fractures through the entire thickness of the caprock, and (3) associating gypsum-filling of fractures with water circulation through the caprock at the time of unconformity. This alternative examines the possible rates of dome dissolution under the assumption that fracturing of the caprock and subsequent gypsum infilling of fractures occurred significantly later than suggested by Werner.

This alternative suggests a significantly different dissolution history. The unconformity fixes the beginning of caprock formation (i.e., at least some nominal thickness of anhydrite caprock must have been present at the time the unconformity developed), and the gypsum veining marks the end of the period of significant dissolution which resulted in caprock formation. Thus, dissolution could have begun 25 million years ago during the late Oligocene and ceased very recently. Assuming a 25-million-year period of dissolution, the rate of dissolution would be approximately 3 centimeters per 1,000 years (1.5 inches per 1,000 years).

Granular Anhydrite as an Indicator of Quaternary Dissolution. A final alternative was examined by assuming that the accumulation of granular anhydrite at the base of the caprock is the result of localized dissolution during the Quaternary. Making a second assumption that this dissolution occurred over no less than one-quarter of the Quaternary (400 to 500 thousand years), rates of less than 4 centimeters per 1,000 years (1 inch per 1,000 years) are obtained.

Using available data, it is not possible to date the granular anhydrite at the base of the caprock. Stratigraphic relationships suggested by the residual accumulation origin of caprock formation suggest only that the granular anhydrite accumulated after the overlying crystalline anhydrite caprock. Therefore, it is possible to assume that the anhydrite accumulated entirely during the Quaternary, although this ignores the time period between caprock lithification (20 to 25 million years ago) and the beginning of the Quaternary. Given that only two of the nine boreholes penetrating the caprock/salt interface were reported to have encountered granular anhydrite (Section 3.2.3.2), such dissolution appears to have been localized. Hence, given the distribution of sulfur exploration wells that penetrate salt over the northern portion of the dome, it is likely that granular anhydrite occurs in a similar localized distribution over the southern portion of the dome. Furthermore, this dissolution occurred slowly enough that it would not result in collapse of the caprock or overlying sediment. The uncorroded nature of the anhydrite grains and the highly saline nature of the brines (e.g., 312,000 milligrams per liter from MRIG-9) (Bentley, 1983, p. 26) within the anhydrite sand indicate that significant interconnections do not appear to exist with the fresh water aquifer. Therefore, current dissolution at the caprock/salt interface is believed to be very slow, if occurring at all.

Conclusions. The consistently slow dissolution-rate estimates obtained using reasonable geologic alternatives are evidence that dissolution has been and should continue to be a slow process at Richton Dome. Rates of this magnitude appear consistent with postdiapic growth rates of 1 to 6 centimeters per 1,000 years (0.4 to 2.3 inches per 1,000 years) derived by Seni and Jackson (1983, p. 1245) for salt domes in eastern Texas. The dissolution history proposed by Werner (1985a) appears to be the most reasonable description of dissolution events at Richton Dome. None of these alternatives suggests that significant dissolution has occurred during the Quaternary Period (Murphy, 1985).

3.2.5.7.3 Geohydrology as It Relates to Dissolution. The potential for dissolution and the expression of dissolution effects (i.e., dissolution-related saline ground water) are strongly influenced by the geohydrologic setting. Detailed descriptions of the regional geohydrology are presented in Section 3.3.2. Flow directions and associated velocities for geohydrologic units over and adjacent to Richton Dome have been evaluated by Severini (1985). Preliminary findings of these evaluations indicate that the following information is important in the assessment of dissolution at Richton Dome.

Five geohydrologic units are recognized in the sediments over and adjacent to Richton Dome, including (from oldest to youngest) the Wilcox aquifer unit, Lower Claiborne confining unit, the Upper Claiborne aquifer unit, the Vicksburg-Jackson confining unit, and the Upper Aquifer unit. South of Richton Dome, the principal directions of ground-water flow through these geohydrologic units are (1) down dip to the southeast in the Wilcox unit; (2) vertically upward in the Lower Claiborne, Upper Claiborne, and Vicksburg-Jackson units; and (3) from recharge areas near topographic highs to discharge areas near streams in the Upper Aquifer unit.

Caprock over the crest and flanks of Richton Dome (Section 3.2.3.2) reduces the contact of undersaturated water in the adjacent sediments with the salt stock (Section 3.3.2). Ground-water movement within the caprock is restricted to open fractures in the limestone and upper anhydrite portions of the caprock. Ground water, if present and circulating in the caprock, will move in response to conditions similar to the Upper Aquifer unit. Ground-water flow in the localized permeable anhydrite sand at the base of the caprock is believed to be restricted based on the reported occurrence of highly saline brines (Werner, 1985b, p. 27) and the lack of dissolution features on anhydrite grains (Murphy, 1985). Locally, open fractures may exist in the caprock that permit some flow through the caprock.

Based on ground-water directions and velocities in the near-dome area, ground water containing dissolved salt from Richton Dome would travel in predictable paths. Ground water flowing through the base of the Wilcox unit would not reach the top of the Wilcox unit until it reached the vicinity of the Gulf of Mexico. Ground water in the confining units (Vicksburg-Jackson and Lower Claiborne units) would travel no more than several hundred to a few thousand meters in the downdip direction away from Richton Dome before entering the base of the Upper Aquifer unit. Ground water in the Upper Aquifer unit would travel in the direction governed by the local discharge systems, which are the Bogue Homo and Thompson Creeks and the Leaf River and its tributaries.

3.2.5.7.4 Potential For Induced Dissolution. The potential for induced dissolution at Richton Dome may be associated with improperly abandoned boreholes that penetrate the caprock and salt stock or with an elevation of temperature at the edge of the salt stock in response to interred radioactive materials. From 1944 to 1945, 34 sulfur exploration borings were drilled to various depths over Richton Dome; 8 of the borings penetrate into the salt stock. Borehole locations are shown in Figure 3-12. Well completion records for these boreholes leave questions about abandonment practices, which could indicate that boreholes may represent possible pathways for dissolution.

In 1972, Shell Oil Company drilled an exploratory oil and gas borehole (Shell 23-7) off the northeast flank of the dome. Evaluations of geophysical logs indicate that the borehole entered the outermost portion of the salt stock at -540 meters (-1,767 feet) MSL and exited at -800 meters (-2,637 feet) MSL. Direct evaluations have not been performed of the potential of induced dissolution from Shell 23-7. Analyses have been performed (Monti and Gupta, 1984, p. 42) to quantify the maximum increase in borehole diameter due to salt dissolution and the opposing effect of salt creep on borehole closure for boreholes penetrating the flank of a salt dome. In these analyses, the condition assessed as having the maximum potential for salt dissolution was an uncased borehole entering the salt stock by way of the Upper Aquifer unit and exiting into the Wilcox unit. Salt dissolution was assumed to be directly proportional to the flow rate through the borehole. Results of these analyses indicate that, initially, salt dissolution causes the diameter of the borehole to increase to approximately 2 meters

(6.6 feet); however, salt creep and siltation subsequently cause the borehole to decrease in size, eventually leading to borehole closure (Monti and Gupta, 1984, p. 11).

Walters (1975, p. 77) evaluated salt dissolution in oil and gas boreholes in central Kansas and concluded that (1) from an estimated 72,000 boreholes drilled through the Hutchinson Salt Member of the Wellington Formation within the state of Kansas, only 7 known instances of dissolution leading to collapse and surface subsidence occurred; and (2) that no salt dissolution occurs after drilling ceases in oil and gas test holes that have properly cemented surface casing protecting aquifers above the salt. According to the well completion report submitted to Mississippi Oil and Gas Board, both conductor and surface casings were installed and cemented into place at Shell 23-7 to a depth of -1,115 meters (-3,661 feet) MSL (Murphy, 1985). Therefore, based on data presented in Monti and Gupta (1984, p. 42) and evaluations of the potential for dissolution discussed by Walters (1975), there is limited potential for significant dissolution associated with this borehole.

The potential for increased dissolution rates caused by elevated temperatures from waste emplacement is evaluated in Gupta et al. (1985, BMI/ONWI-567, p. 52). Based on this evaluation, it can be anticipated that temperature increase could result in a maximum of a 13 C (55 F) increase in the Wilcox unit and a 1.1 percent increase in salt solubility.

3.2.6 Rock Characteristics

This section summarizes geomechanical, thermal, and natural radioactive properties of the rock units in the Richton Dome area, specifically at borehole MRIG-9, and the impact of potential anomalous features. A description of anomalous features in domal salt is presented in Section 3.2.3.2.4; hydrogeologic properties are discussed in Section 3.3.2.1.3.

3.2.6.1 Geomechanical Properties

The geomechanical properties important to the design, construction, operation, closure, and postclosure phases of a nuclear waste repository are the elastic parameters, yield or failure strength, and time-dependent deformation.

3.2.6.1.1 Geomechanical Properties of Overburden. The overburden at Richton Dome as encountered in borehole MRIG-9 consists of alluvium, and the Citronelle and Hattiesburg Formations. These units are described in Section 3.2.3.2.1 under Surface Geology.

Estimated values for geotechnical engineering parameters of the overburden materials at Richton Dome provide a fair indication of the geomechanical conditions at the site. These estimates have been obtained from published empirical correlations, experience at other sites, and engineering judgments (Table 3-6).

The estimated values are presented to provide a preliminary indication of soil conditions at Richton Dome. Site-specific laboratory and in situ test data will be required for final designs.

For the purposes of geomechanical analysis, the overburden has been divided into four major layers (1 through 4) based on dominant lithology inferred from both geophysical logs and drill cuttings from borehole MRIG-9. In addition, from these data four sublayers in layer 1 have been identified (Ertec, 1983, ONWI-481, p. 13). The description of the major layers and sublayers and their characteristics is presented in Table 3-6.

In general, overburden at MRIG-9 is 169 meters (554 feet) thick and consists predominantly of unconsolidated material, except for possible thin layers of cemented sand or rock between depths of 145 and 150 meters (475 and 492 feet). The water level has been recorded at a depth of 32 meters (105 feet). The stratigraphic column shows a transition from clays in the top 20 meters (65 feet) to sands below a depth of 125 meters (410 feet), with interbeds of clay and sand. Clay layers predominate at the shallower depths; sand is more common at deeper intervals. The clays at MRIG-9 are stiff to very hard and are of medium to high plasticity. In the shallower intervals, the sands are very dense, fine, and very silty.

Table 3-6. Estimated Geomechanical Characteristics of the Overburden, Richton Dome

Hattiesburg Layer and Depth Interval	Description	Density (D)[b] Porosity (N) and Water Content (W) (4)	Fine-Grained Soil (Silt and Clay)				Coarse-Grained Soil (Gravel and Sand), Angle of Internal Friction (2, 5, 12, 8)	Maximum Low Strain Shear Modulus[b] (1, 5, 8, 13)	Soil[e] Corrosiveness (9)	Thermal Conductivity (6)
			Plasticity (7)	Undrained[c] Shear Strength (3, 7, 8)	Compressibility[c] (7)	Swelling Potential[c] (10)				
1A 0 to 12 m	Clay with some silty or clayey sand interbeds; ranges from a clay with 50% clay fraction to a very silty fine sand with 35% silt content[a]	No data	Medium[b] to high	60-140[g]	High beyond maximum past overburden stress, moderate otherwise. Maximum past overburden is about 620 kN/m^2 higher than current overburden	High	35-40 [c]	48,000 to 144,000kN/m^2	No data	No data
1B 12 to 20 m	See Layer 1A[a]	D = 2.0 to 2.2 g/cm^3 N = 30 to 45% W = 16 to 30%	Medium[b] to high	160-310[g]	See Layer 1A	High	35-40 [c]	120,000 to 240,000kN/m^2	Very corrosive	Sand 0.7[d][h] to 1.0 Clays: 1.4 to 1.9
1C 20 to 44 m	See Layer 1A[a]	See Layer 1B	Medium[b] to high	160-360[g]	See Layer 1A	High	35-40 [c]	383,000 to 719,000kN/m^2	Very corrosive	See Layer 1B[b]
1D 44 to 53 m	Clayey sand, sand content increasing with depth[a]	See Layer 1B	Medium[b] to high	---	---	---	35-40 [c]	359,000 to 671,000kN/m^2	Mildly corrosive	See Layer 1B[b]
2 53 to 94 m	See Layer 1A[a]	See Layer 1B	Medium[c] to high	240[g]	See Layer 1A	High	35-40 [c]	407,000 to 766,000kN/m^2	Very corrosive to moderately corrosive	See Layer 1B[b]
3 94 to 126 m	Sand and clay layers, coarser than Layers 1	See Layer 1B	Medium[d] to high	240[g]	See Layer 1A	High	35-40 [d]	498,000 to 944,000kN/m^2	Corrosive to mildly corrosive	See Layer 1B[b]
4 126 to 169 m	Sand, fairly clean, very little clay[b]	See Layer 1B	---	---	---	---	35-40 [d]	450,000 to 853,000kN/m^2	Corrosive to mildly corrosive	See Layer 1B[b]

NOTE: These estimates were based on limited data and should not be used for design purposes. The letters in parentheses indicate the basis upon which each estimate was made.
(a) Direct information from MRIG-9 or from the same horizon in nearby borings.
(b) Based on empirical correlations.
(c) Based on more than one level of empirical correlation or extrapolated correlation charts.
(d) Based on extrapolated data.
(e) Corrosion potential of buried metallic structures, based on soil resistivity measurements.
(f) All values given in kN/m^2.
(g) All values given in watt/m-C.

SOURCES:

(1) Anderson and Stokoe, 1978, pp. 66-90
(2) de Beer, 1965, pp. 165-169
(3) U.S. Department of the Navy, 1982, pp. 7.1-85-91
(4) Ertec, 1983, ONWI-481; pp. 21-23
(5) Imai and Tonouchi, 1982, pp. 67-72
(6) Lade and Lee, 1976, pp. 107, 108
(7) Lambe and Whitman, 1969, pp. 318, 451
(8) LETCo, 1982, ONWI-167
(9) Peabody, 1969, pp. 5-17
(10) Portland Cement Association, 1971, Vol. II, p. 15
(11) Terzaghi and Peck, 1967, p. 347
(12) Vesic and Clough, 1968, pp. 661-688
(13) Ohsaki and Iwasaki, 1973, pp. 61-73.

Fairly clean but dense sand is found below a depth of 135 meters (443 feet) (Ertec, 1983, ONWI-481, p. 11-23). The existing overburden property data show variations with depth and location. Additional site-specific laboratory and in situ measurements are required to assess the variability of soil properties.

3.2.6.1.2 Geomechanical Properties of Caprock and Salt. The caprock and salt stock stratigraphy are presented in Section 3.2.3.2.3. In terms of rock mass discontinuities and heterogeneities, the caprock and salt stock are relatively distinct, reflecting the divergent nature of the two materials.

At the MRIG-9 location the caprock consists of 7 meters (23 feet) of limestone underlain by 57 meters (190 feet) of anhydrite (Section 3.2.3.2.3). In places the caprock is highly fractured; however, most if not all fractures are filled with gypsum. Locally the gypsum veins penetrate the entire caprock thickness (Werner, 1985a and 1985b). A zone of unconsolidated anhydrite sand several feet thick (Figure 3-13) was also encountered between the caprock and the salt stock in the MRIG-9 borehole and one sulfur exploration well.

The salt stock at the MRIG-9 location consists primarily of fine- to coarse-grained halite. Anhydrite is frequently present (approximately 8 percent) and generally occurs as thin banding. Anhydrite and other minor impurities also occur as scattered grains or as distinct inclusions in the salt (Drumheller et al., 1982, ONWI-227, p. 13).

The mechanical properties of the caprock and salt units at Richton Dome were assessed using site-specific and generic test data. The Richton Dome test specimens were obtained from borehole MRIG-9 at depths between 180 and 387 meters (590 and 1,269 feet) from the surface. Typical test procedures were used for unconfined compression and indirect tension (Brazilian disc) tests. The listed generic data were similarly generated. The information is presented as a preliminary data base to be used for feasibility studies.

Site-specific data for the mechanical properties of anhydrite are summarized in Table 3-7. These properties are comparable to anhydrite properties from other sources. Variations are observed in the mechanical properties of the Richton anhydrite between samples from the same depth and in the average values between depths. Due to lack of relevant data, it is not possible to determine the causes of these variations. One possible cause could be the heterogeneity of anhydrite. No distinct trends are noted except decreasing unconfined strength with depth. More data will be required to quantify this variability and possible spatial variability across the caprock.

Site-specific laboratory data for the rock mass mechanical properties of the Richton Dome salt and generic data are presented in Table 3-8 and 3-9. Generally, the tests were conducted on specimens 9 to 10 centimeters (3.5 to 4.0 inches) in diameter (Pfeifle et al., 1983, ONWI-450, pp. 8-11) and, based on the average grain size (Pfeifle et al., 1983, ONWI-450, pp. 14-17), are believed to be representative of the rock mass. The possible influence of discontinuities will be addressed subsequently.

Data on the elastic properties and strength of salt at the Richton Dome site are presented in Table 3-8. Young's modulus appears to depend on temperature and pressure as shown by the stress-strain curves (Pfeifle et al., 1983, ONWI-450, pp. 67-72). The values decrease with increasing temperature and increase with increasing confining pressure. Poisson's ratio has no apparent variation with confining pressure or temperature. The variation of strength with confining pressure and temperature is similar to other domes, with strength increasing with confining pressure and decreasing with temperature increases. The generic data (Table 3-9) indicate that the tensile strength of halite under room conditions is very low, less than about 1.5 megapascal (218 pounds per square inch).

A material model for the thermomechanical behavior of the repository horizon salt is required for design and performance assessment calculations. The material model gives the relationship between load quantities such as stress and stress rate and deformation quantities

Table 3-7. Elastic Parameters and Strengths of Anhydrite from Richton Dome Caprock

Rock Unit/ Horizon	Elastic Parameters						Strength			
	Young's Modulus, GPa			Poisson's Ratio			Unconfined Compressive Strength, MPa			Tensile Strength, MPa[a]
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	
Anhydrite/ 180 meters	67.8	70.1	73.6	0.34	0.39	0.47	71.2	95.2	102.9	6.9
Anhydrite/ 199 meters	77.6	78.5	80.3	0.33	0.35	0.43	82.0	87.3	90.9	6.1
Anhydrite/ 219 meters	68.3	73.1	76.2	0.36	0.38	0.42	78.1	82.4	86.5	5.9

(a) Indirect (Brazilian) tension test data; mean value reported.

Source: Pfeifle et al., 1983, ONWI-450, p. 53-58.

Table 3-8. Geomechanical Properties of Salt Triaxial Compression Tests

Site	Young's Modulus (GPa)	Poisson's Ratio	Specimen Dimensions, Diameter x Length (mm x mm)	Temperature (C)	Loading Rate (MPa/sec)	Confining Pressure (MPa)	Differential Stress at Failure (MPa)	Condition At Failure
Richton Dome(1)	31.5 ± 3.0	0.36 ± 0.09	90 x 180	24	0.025	0	13	Failed
				24	0.025	5	48	15% Strain
				24	0.025	10	55	15% Strain
				24	0.025	15	57	15% Strain
				100	0.025	10	34	15% Strain
				200	0.025	10	10	7.5% Strain
Avery Island Dome(2)	32.7 ± 6.5	0.42 ± 0.06	100 x 200	24	0.002	0	25	Failed
				24	0.002	0.7	32	Failed
				24	0.002	1.7	40	Failed
				24	0.002	3.4	47	Failed
				24	0.002	20.7	61	Failed
Jefferson Island Dome(3)			50 x 100	24	0.057	0	24	Failed
				24	0.002	0	22	2.9% Strain
				24	0.057	3.4	52	Failed
				24	0.002	3.4	43	13% Strain
				24	0.002	6.9	47	13% Strain
				24	0.057	10.3	66	Failed
				24	0.002	13.8	48	13.5%

Sources: (1) Pfeifle et al., 1983, ONWI-450, pp. 29, 67-72, 87-92, 107-121, 147-152
(2) Mellegard et al., 1983, ONWI-250, p. 25
(3) Hansen, 1978, pp. 18-21.

Table 3-9. Tensile Strengths - Generic Data

Site	Strength (MPa)	No. of Samples
Bryan Mound, LA (1)	1.58 ± 0.39	3
Bayou Choctaw, LA (1)	1.39 ± 0.17	3
Jefferson Island, LA (1)	1.42 ± 0.10	5
Jefferson Island, LA (2)	1.54 ± 0.31	17
West Hackberry, LA (1)	1.49 ± 0.34	6
Red Lake, AZ (1)	1.62 ± 0.30	4
Huntorf, Germany (1)	1.51 ± 0.72	3

Sources: Thoms and Gehle, 1982, p. 994; Hansen, 1978, p. 15.

such as strain and strain rate. The thermomechanical behavior of salt deviates markedly from the typical linear elastic, Mohr-Coulomb failure model that is often assumed to represent the material behavior of many brittle rocks. This deviation increases substantially as the temperature increases and therefore is especially important for the elevated temperatures associated with disposal of high-level nuclear waste.

The total deformation of salt can be divided into three components: elastic deformation, thermal expansion, and inelastic deformation. The elastic deformation and thermal expansion are readily modeled by the classical generalized Duhamel-Neumann form of Hooke's Law (Sokolnikoff, 1956). The elastic constants, e.g., Young's modulus, E, and Poisson's ratio, n, are readily evaluated from unload-reload cycles performed on specimens that are deformed in triaxial compression (Pfeifle et al., 1983, ONWI-450). The coefficient of linear thermal expansion, a_L, is determined by measuring the change in specimen dimensions that corresponds to a specified change in specimen temperature (Yang, 1981). Following are the laboratory-determined values and calculated standard deviations for Young's modulus, Poisson's ratio, and the coefficient of thermal expansion of Richton Dome salt:

Young's modulus, Epsilon = 31.5 $\pm$ 3.0 GPa

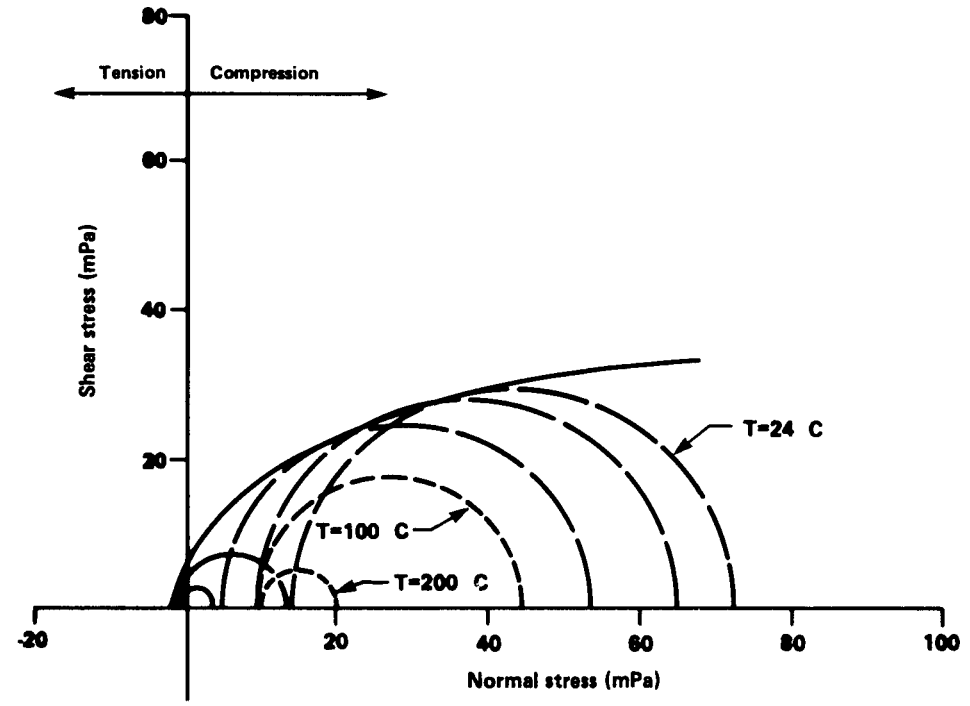
Poisson's ratio, Nu = 0.36 $\pm$ 0.09

Coefficient of linear thermal expansion, $Alpha_L = (42 \pm 3) \times 10^{-6}\ K^{-1}$

The elastic and thermal expansion contributions to salt deformation, although important for calculating thermal stresses produced by waste emplacement, are often insignificant when compared to the large inelastic deformations that are produced by the stresses, temperatures, and times of interest for nuclear waste isolation. The inelastic deformation is primarily viscoplastic (i.e., ductile behavior in which the stress depends not only on the strain, strain history, and temperature, but also on the rate of strain). Over the range of temperature of interest, the viscoplastic behavior is strongly temperature-dependent.

The inelastic deformation has been modeled using an exponential-time model (Senseny, 1985). This is a semi-empirical model based on first-order kinetics and incorporates both transient and steady-state deformation. Stress and temperature dependence of the deformation is incorporated using a functional form that assumes that deformation results from a diffusion-controlled micromechanism, which is expected to be operable at the stresses and temperatures expected for a nuclear waste repository. Values for the inelastic parameters in the exponential-time constitutive model have been determined for the Richton Dome salt (Senseny, 1985). Although this model poorly reproduces the laboratory data from which it was derived, it does predict strain rates approaching steady-state conditions fairly well, and is used for preliminary repository design and performance assessment calculations since long-term behavior can be modeled with some confidence. However, based on comparisons of predicted and measured strains, the transient part of the exponential-time model requires substantial revision. Therefore, short-term behavior cannot be accurately modeled. Additionally, more tests need to be performed so that the uncertainty associated with the parameter values can be reduced. Ongoing studies investigating the development of an improved model are in progress and model predictive capabilities are expected to be enhanced. The uncertainty in the model results from both salt variability and lack of fit of the model.

Failure of salt over the ranges of stress and temperature of interest can be either brittle or ductile. Failure under either mode is defined to occur when peak stress is reached. At low mean stress and low temperature, brittle failure is observed; whereas at higher mean stress and temperature brittle failure is suppressed and the salt undergoes very large deformations without fracturing. For example, triaxial compression tests performed at 24 C and at a constant stress rate of 2.5×10^{-2} megapascals show that brittle failure is suppressed at confining pressures greater than about 5 megapascals and the test is stopped at about twelve percent specimen shortening when the limits of the apparatus are reached (see Figure 3-19) (Pfeifle et al., 1983, ONWI-450). This shortening corresponds to a true strain of about fourteen percent, and there is no evidence of fracture. The hardening modulus, (the rate of change of true stress with regard to true strain in the plastic range) however, is very low so that the stress when the test is stopped is close to the peak stress.



Explanation

- Tests where peak axial stress was reached
- Tests where large axial strain limits were reached
- Tests at elevated temperatures

Notes: Tests performed on salt core taken from MRIG-9 at depths ranging from 359 m to 387 m.

Envelope Curve and Mohr's Circles at Failure for Salt Richton Dome, Mississippi

Source: Pfeifle et al., 1983, ONWI-450, p. 31.

Figure 3-19

The envelope of Mohr's circles at the end of the tests is characterized by a nonlinear Mises-Schleicher law that empirically assumes an exponential decay in the mean stress dependence of the shear strength:

$$J_2' = \text{Kappa} + \text{Alpha} \left[1 - \exp(-\text{Beta}\ J_1) \right]$$

where

J_2' = the second invariant of the deviator stress

J_1 = the first invariant of stress

Kappa, Alpha, Beta = fitting parameters.

This Mises-Schleicher model was chosen instead of a similar Mohr-Coulomb model because the manner in which the Mises-Schleicher model incorporates the influence of the intermediate principal stress is thought to be more appropriate for ductile behavior.

Following are values of the Mises-Schleicher parameters of Richton Dome salt as well as the uncertainty in the parameter values.

Kappa = 0.2 ± 0.9 MPa

Alpha = 40.0 ± 2.8 MPa

Beta = 0.018 ± 0.004 MPa^{-1}

The uncertainty results from both variability of the salt and lack of fit of the model.

Site-specific data for in situ stress conditions are not available; however, it is estimated that the in situ stress at the repository level will be approximately isotropic and equal to the overburden pressure. This estimate is based on the existing regional stress data, augmented by characteristic salt material properties and their rheologic deformation behavior (Michalski, 1985). Previous in situ stress measurements in the salt stocks of the Gulf Coast Salt Dome Basin indicate an average vertical stress gradient of approximately 2.3×10^{-2} megapascal per meter (1 pound per square inch per foot) (Hoek and Brown, 1980, pp. 95-101; Lindner and Halpern, 1977, pp. 1-6). Based on assumptions of overburden pressure, Tammemagi et al. (1985, ONWI-364, p. 20) calculated a stress level of 12.4 megapascals (1,798 pounds per square inch) for a geologic repository at a depth of 580 meters (1,900 feet). Therefore, the stress magnitude at a depth of 648 meters (2,125 feet) at Richton Dome is estimated to be between 13 and 15 megapascals (1,885 and 2,175 pounds per square inch). Maximum horizontal stresses determined by overcoring in Gulf Coast salt domes range from approximately 1.16 to 0.86 times the reported vertical stress values (Michalski, 1985, p. 3). These in situ stress measurements were made in shallow boreholes drilled from underground openings. The results are expected to be influenced by the opening and may represent stress conditions in the zone disturbed by mining rather than the virgin (undisturbed) stress field as illustrated by Obert (1962, p. 55). In addition, the ability of overcoring to accurately determine in situ stresses in salt is complicated by the reliance on elastic solutions to interpret test data. Salt at the test depths is a nonlinear material.

Mining Considerations Related to Anomalous Salt Conditions. As described in Section 3.2.3.2.4, Gulf Coast salt domes of the coastal and interior settings display a variety of anomalous features (Table 3-3). Based on reported occurrences of anomalous features, these are more frequent and larger in the coastal Five Island salt domes (Avery Island, Belle Isle, Cote Blanche, Jefferson Island, and Weeks Island) than in the interior domes. Central anomalous zones containing sedimentary inclusions in highly deformed salt are found in four of five mined coastal domes, but have not been observed in interior domes.

Hence, the Richton Dome (an interior dome) should, in accordance with the characteristics suggested by Muehlberger and Clabaugh (1968, p. 97), exhibit less frequent and smaller anomalous features than the coastal domes. No major anomalous features have been identified in the salt stock at the Richton Dome; however, if they are present, it is anticipated that these features would occupy a small volume of the dome only and be of little consequence to mining operations. Additionally, it is expected that such features would be predictable on the basis of stratigraphy and salt characteristics.

Central Anomalies. Central anomalous features have been identified in four of the five mined coastal salt domes in the Five Island area but not in the mined interior Gulf Coast salt domes (Table 3-3). The width of the sediment-bearing zones is generally 2 to 7 meters (7 to 23 feet), but, locally, the zone can extend up to 30 meters (98 feet). Sediment-bearing salt of 300 meters (984 feet) in width was reported from one level at the Jefferson Island mine; the vertical extent of this salt appears to be limited as it was reported for only one level. This zone was interpreted as being refolded, sheared, and otherwise repeated (Kupfer, 1974, p. 204). Some central anomalous features also show evidence of shearing in areas ranging from 30 to 150 meters (98 to 492 feet) in width (Kupfer, 1980, p. 125). The sediment inclusions in the central zones of the coastal domes are generally parallel with the banding of the salt, and, although they are discontinuous and lenticular, they follow a sinuous pattern of folding for hundreds or thousands of meters (Kumar, 1981, p. 31; Kupfer, 1974, p. 203). Refolding of the central zone during later dome movement was suggested for the Weeks Island and Jefferson Island mines (Kupfer, 1980, p. 132; 1974, pp. 204-205). Gas and brine have been encountered in central anomalous zones. The flows generally tend to decrease with time, indicating that they are contained in isolated pockets. The geohydrologic characteristics of anomalous zones are discussed in Section 3.3.2.1.3.

Edge Anomalies. During mining, the approach of the dome margin in both coastal and interior domes can be predicted based on structural characteristics of the salt. Pervasive shearing of salt as much as 200 meters (656 feet) away from the outer edge of a salt stock is a major characteristic of the salt stock/sediment boundary and commonly gives ample warning of the approach to the edge, as shown in the Weeks Island mine (Kupfer, 1980, p. 125). An increased intensity of layering, which probably occurred by thinning of salt beds on fold limbs in response to vertical straining/shearing, occurred near the edge of the Winnfield Dome (Hoy et al., 1962, p. 1444). The strike of subvertical salt layers is another major diagnostic characteristic of the outer rim of salt stocks; parallelism of the strike of salt layers to the dome margins can be observed in structural maps and in oriented cores from the Palangana Salt Dome in south Texas (Hofrichter, 1968, p. 378). Layering parallel to the dome margin appears to be traceable for a distance of at least 100 to 300 meters (328 to 984 feet) from the edge of salt stocks. The width of the marginal anomalous zones appears to be site-specific and may range from a few tens to a few hundred meters (Michalski, 1985, pp. 4-5). The characteristics of the edge anomalous features in the coastal and interior domes are summarized in Table 3-3.

Gas and fluids are common in sediments adjacent to salt stocks in the Gulf Coast Region. Gas outbursts and water leakages were encountered at both coastal (Belle Isle, Jefferson Island, and Weeks Island) and interior (Grand Saline, Winnfield) salt domes when mining operations were within 30 to 100 meters (98 to 328 feet) of the edge of the salt stock (Michalski, 1985, p. 8). Excavations were about 30 meters (98 feet) from the edge of the stock at the Jefferson Island and Winnfield mines when a serious water leakage (Jefferson Island) and a gas outburst (Winnfield) stopped further advancement (Hoy et al., 1962, Figure 5; Kupfer, 1980, p. 129). In portions of four mines (Belle Isle, Weeks Island, Grand Saline, and Winnfield), the edges of the salt stocks were approached to within about 100 meters (328 feet) before similar problems occurred. Although the distances of the outburst zones from the edge of the salt are different in the mines, outburst zones follow the general trend of layering and are parallel to the dome margin. Sediment inclusions near the salt stock margin were not reported from the interior salt mines, even though mining came closer to the edge of these salt stocks than in most of the Five Island salt mines (Michalski, 1985, p. 4). No gas outburst or leakage problems are reported for the Hockley Dome mine (an interior dome) (Kumar, 1981, p. 17).

Uncategorized Anomalies. Narrow sediment zones are reported in one interior and one coastal salt dome. Zones from 0.1 to 1 meter (0.3 to 3 feet) wide are reported from the coastal Cote Blanche Dome. One of these zones has been associated with 17 gas outbursts (Kupfer, 1980, p. 128; Golder Associates, 1977, p. 45). Several sediment zones up to 4 meters (13 feet) wide are reported from boreholes in the interior of Palangana Dome, but no gas occurrences were reported. These sediment zones have been postulated to be original sedimentary layering (Hofrichter, 1968).

Coarse-grained and recrystallized salt are secondary textures in the predominantly medium-grained salt of the Gulf Coast domes. They are also considered to indicate stability (Kupfer, 1980, p. 124). In addition, brine, gas, or oil are often associated with recrystallized, coarse-grained salt in four of the coastal salt domes (Avery Island, Belle Isle, Cote Blanche, and Weeks Island) (Kupfer, 1980, p. 124; Golder Associates, 1977, pp. 43-44). Coarse-grained salt was found in two interior domes: in core from the MRIG-9 borehole at Richton Dome and during mining operations in the Grand Saline Dome. However, no gas or brine was present in Grand Saline Dome (Muehlberger, 1960, p. 32).

Porous and fractured salt has been encountered in coastal Gulf Coast salt domes. In the coastal Cote Blanche mine, porous and fractured salt was associated with various degrees of gas flow. A borehole connected with the surface experienced a major gas flow, and a subsurface borehole adjacent to a pillar experienced a gas flow of limited duration (Golder Associates, 1977, pp. 24 and 43-44). Vertical boreholes at the Belle Isle Dome encountered gas in zones of limited extent, but the character of the zones was not indicated (Plimpton et al., 1979, p. 10). Potential problems associated with anhydritic salt and potash layers are generally ceiling slabbing (roof falls) and flows of gas and brine along fracture planes parallel to the layering (Michalski, 1985, p. 20).

Fracture healing in salt can occur by precipitation (recrystallization), plastic injection of halite, and creep closure of fracture walls (SWEC, 1983, ONWI-363, p. 2), and probably accounts for the scarcity of natural fractures. The only reported natural openings (fracture and pore spaces) in domal salt are those filled with fluids (brine, gas, oil) (Kupfer, 1980, p. 125).

Small faults have been encountered occasionally in the coastal Five Island salt domes (Table 3-3). The faults are generally recognized by bedding-slip, with accompanying striations that exhibit negligible stratigraphic separation (Kupfer, 1963, p. 115). No brine drips, gas, or oil were reported in association with these faults, which have no engineering significance (Michalski, 1985, p. 23). No faults have been reported from mines in interior domes.

Summary. Anomalous zones, as described in Sections 3.2.3.2.4 and 3.3.2.1.3, were not identified in the core from the MRIG-9 borehole at Richton Dome. The evidence summarized in Section 3.2.3.2.4 suggests that central anomalous zones do not occur in the interior domes such as Richton; if anomalous features are present, they are expected to be discontinuous and of limited extent. Characteristics of anomalous zones are known from their occurrence in the coastal salt domes. The compositional, structural, and textural features of the central anomalous zones in four of the Five Island mines, together with an analysis of data on water leaks and gas outbursts and emissions at the zones, suggest that these zones are locally more permeable than most of the domal salt mass. However, because of their discontinuous nature, these anomalous features do not appear to seriously affect the hydrologic integrity of underground openings, except at shallow depths. Data on gas outburst occurrences in four of the Five Island mines seem to confirm the isolated character of the gas and brine pockets (Michalski, 1985).

Water leaks and gas outbursts are not limited to the central zones; they also occur at the dome margin and in other parts of salt stocks. Only in Weeks Island mine has a distinct relationship between gas outbursts and the central anomalous zone been established. Small- to

medium-sized outburst cavities occurred near and along the trace of this zone and the branch mapped by Kupfer at the 244-meter (800-foot) level (Mine Safety and Health Administration, 1978, p. 23). Gas outbursts with large outburst cavities at the Jefferson Island and Belle Isle mines have no or only a vague relationship to central anomalous zones. At Jefferson Island, the main outburst zones near the center of the mine at two lower mining levels were independent of a central anomalous zone (Kupfer, 1980, p. 130) and the edge anomalous zone. Anomalous conditions anticipated at the dome margin may be predicted on the basis of characteristic structures associated with the margin as discussed in Section 3.2.3.2.4.

Mining experience in anomalous features in domal salt has not revealed major stability problems. The central anomalous zones have been mined in Belle Isle, Jefferson Island, and Weeks Island; the central anomalous zone at Belle Isle has been almost totally extracted. Potential stability problems encountered in anomalous zones have been controllable with structural reinforcement (roof bolts) or by decreasing extraction ratios. The currently proposed extraction ratios for a salt dome repository are much lower than those currently used in domal salt mining operations. Problems that could be encountered in edge anomalous zones can be avoided by attention to structural characteristics or by providing a sufficiently wide perimeter pillar between the edge of the stock and the closest repository opening. Therefore, major stability problems relevant to repository development are not anticipated in anomalous zones.

3.2.6.2 Thermal Properties

Thermal properties were measured on four relatively intact caprock- and salt-core samples from the MRIG-9 borehole. Depths sampled ranged from 192 to 384 meters (629 to 1,260 feet) below the surface. Thermal property results are presented in Table 3-10, and include coefficient of linear thermal expansion, thermal conductivity, and specific heat. Standardized test procedures were used for this effort, as described by Lagedrost and Capps (1983, BMI/ONWI-522, pp. 99-177). Typically, the thermal conductivity of caprock and salt varies nonlinearly with temperature, as shown in Figures 3-20 and 3-21, with caprock units tending to be more sensitive during an initial cycle of heating. An estimate of salt thermal conductivity can be obtained directly from the fitted curve of Figure 3-20.

LETCo (1983, ONWI-289, p. 39) estimates the ambient in situ temperature at the site to be approximately 50 C (122 F) at the proposed repository depth of 648 meters (2,125 feet). The thermal decrepitation (slaking) initiation temperature of salt is above 450 C (842 F), based on the fracturing of thin slabs of salt used in thermal expansion testing (Lagedrost and Capps, 1983, BMI/ONWI-522, p. 1). This is significantly higher than the maximum design salt temperature of 250 C (482 F). Senseny (1982, ONWI-9(82-4), p. 155) reports that no thermal decrepitation of Richton Dome rock salt tested occurred up to a temperature of 450 C (842 F). The maximum waste package surface temperature assumption used in Section 6.4.2.3, Preliminary Subsystem Performance Assessments, is near 300 C (572 F).

3.2.6.3 Natural Radiation

The content of uranium and thorium, their disintegration products, and the radioactive isotope of potassium (potassium-40) determine the natural radioactivity of rock. Generally, the presence of radioactive elements in the Gulf Coastal sediments is a result of deposition of sediments, the origin of which was igneous rocks containing these radioactive elements.

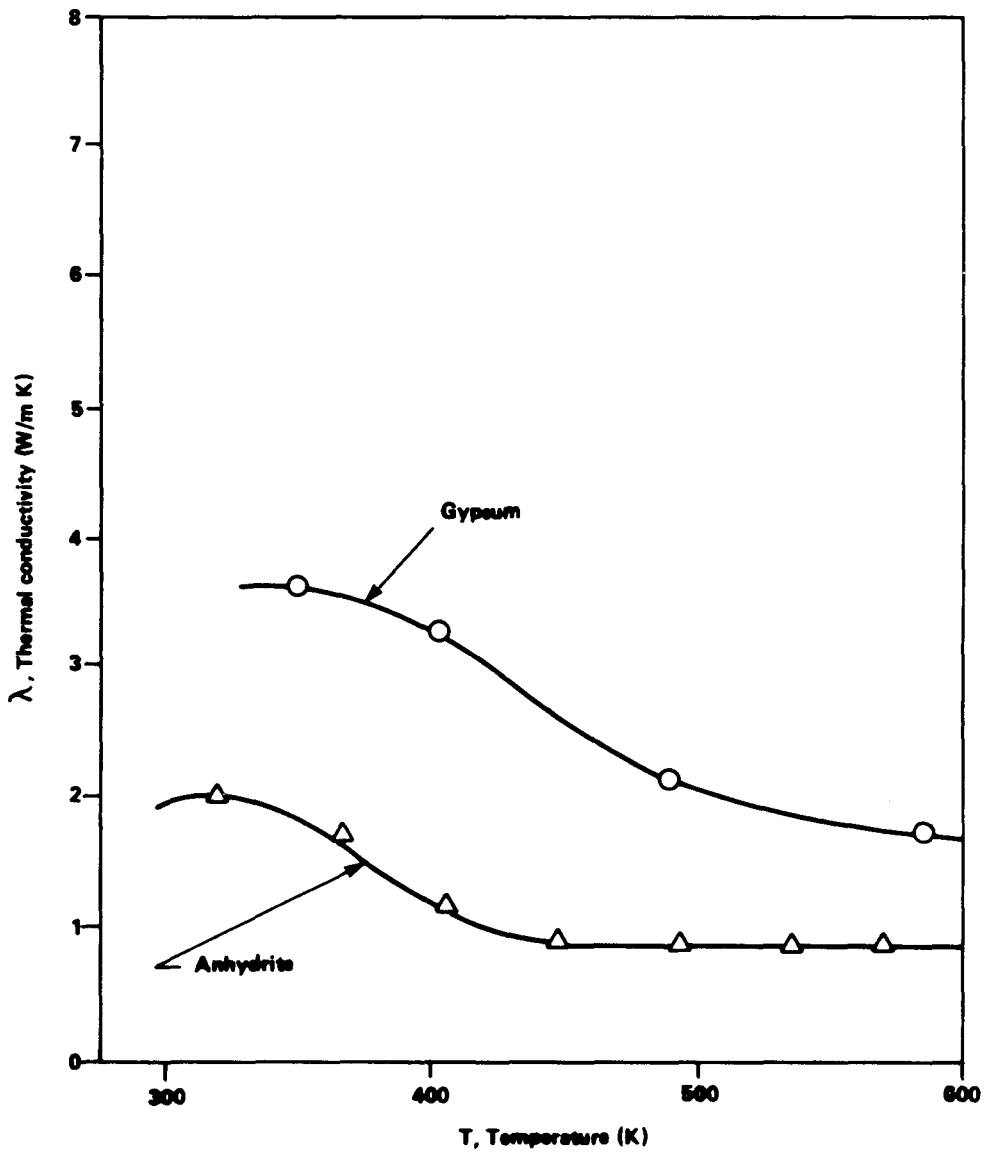
Levels of background radiation in Mississippi have been measured by the Oak Ridge National Laboratory (Myrick et al., ORNL/TM-7343, 1981). Samples were taken near Richton Dome, near the town of Forest, and approximately 19 kilometers (12 miles) west of the Mississippi-Alabama border on Interstate 20. Radionuclide concentrations of radium-226, thorium-232, and uranium-238 in the surface soil average 1.18 $\pm$ 0.06 picocuries per gram, 1.26 $\pm$ 0.22 picocuries per gram, and 1.25 picocuries per gram, respectively (Myrick et al., ORNL/TM-7343, 1981, p. 48). The average external gamma exposure rate at 1 meter (3 feet)

Table 3-10. Summary of Thermal Properties of Richton Dome Core Samples (from MRIG-9)

Rock Type	Depth, m	Density, g/cm^3	Coefficient of Linear Thermal Expansion $10^{-6}/K$ (50 to 250 C)	Thermal Conductivity[a] watt/m-k (at 100 C)	Specific Heat[b] cal/g-C
Caprock					
Anhydrite	192	2.64	N/A[c]	1.62	0.208
Gypsum	213	2.84	22.5	3.45	0.223
Halite	243	2.17	46.5	2.91	0.218
Halite	261	2.20	39.5	3.00	0.218
Halite	294	2.21	41.0	2.88	0.219
Halite	305	2.23	46.5	4.17	0.223
Halite	325	2.22	39.5	3.22	0.218
Halite	378	2.26	45.0	2.66	0.222
Halite	381	2.17	41.0	N/A	0.218
Halite	384	2.22	37.5	2.91	0.221

(a) Based on Pyroceram 9606 calibration standard, and determined using steady-state comparative technique.
(b) Specific heat capacity determined from enthalpy data over a temperature range of 273° to 623° K.
(c) N/A = Not available.

Source: Lagedrost and Capps, 1983, BMI/ONWI-522, pp. 48-51, 54-57.



Explanation

Borehole, Depth, Unit

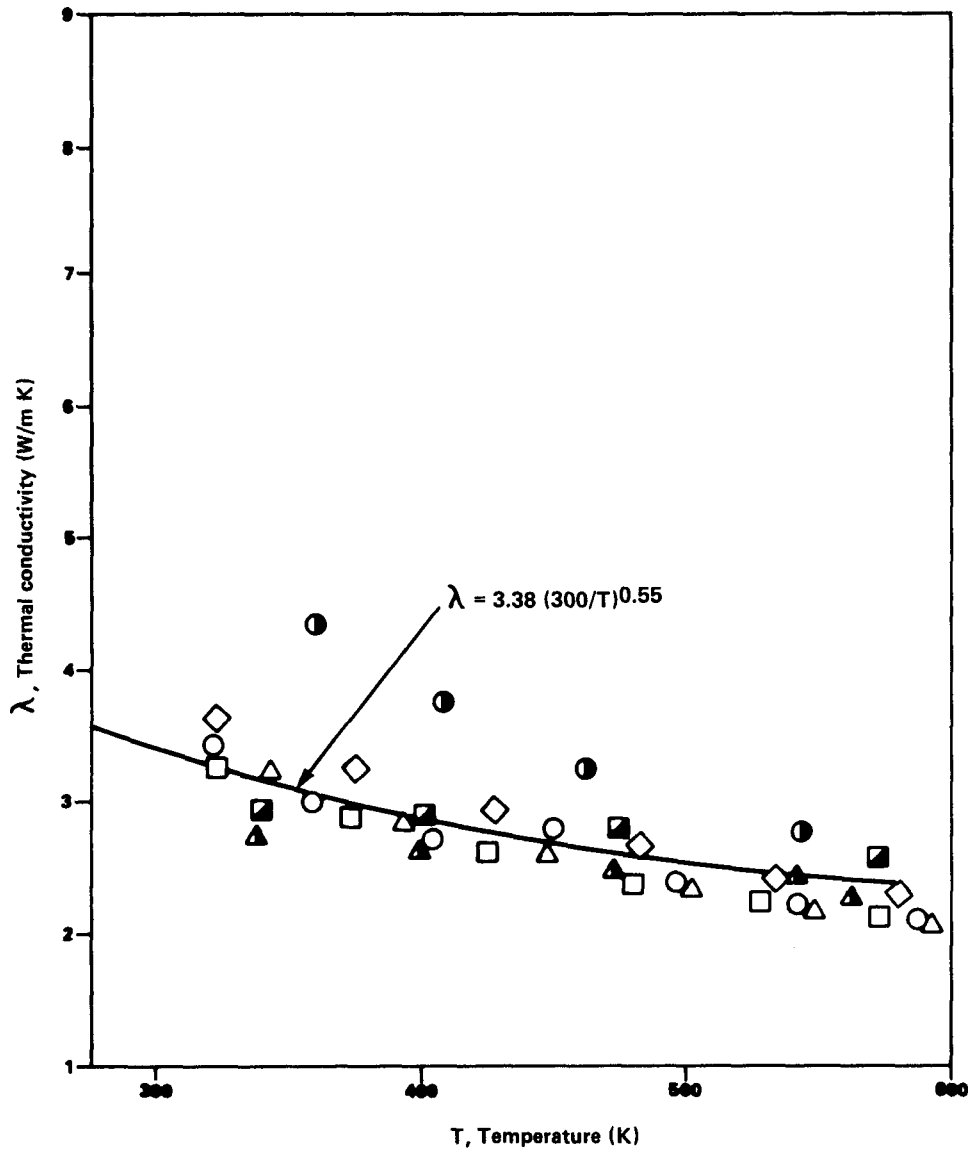
△ **MRIG-9, 192m, Anhydrite**

○ **MRIG-9, 213m, Gypsum**

Thermal Conductivity of Caprock
Richton Dome, Mississippi

Figure 3-20

Sources: Drumheller et al., 1982, ONWI-277, p. 8; Lagedrost and Capps, 1983, BMI/ONWI-522, pp. 49, 52.



Thermal Conductivity of Halite
Richton Dome, Mississippi

Source: Lagedrost and Capps, 1983, BMI/ONWI-522, pp. 49-52.

Figure 3-21

above the ground at the same sampling sites is 6.5 microroentgens/hour (Myrick et al., ORNL/TM-7343, 1981, p. 48). Natural radiation levels in ground water and surface water have not been determined. Table 3-11 provides definitions of all units used to describe radiation, radioactivity, and dose in this document.

3.2.7 Geochemistry

The geochemical setting of Richton Dome is determined by the mineralogy of the caprock and salt stock, the sediments above and adjacent to the dome, and the chemistry of water and fluids within each of these.

The geohydrologic units referred to in this discussion (Table 3-12) consist of adjacent geologic formations (Section 3.2.3) that are apparently hydrologically continuous. The rationale behind these groupings is described in Section 3.3.2. The important geochemical characteristics of these units are described based on mineralogic descriptions and water chemistry data derived from a variety of sources.

3.2.7.1 Geochemistry of Sediments Adjacent to the Dome

The geological units adjacent to Richton Dome are all sedimentary, consisting primarily of limestone, shales, and silty sandstones. The bulk mineralogy of each geohydrologic unit is given in Table 3-12, where the minerals are listed in the approximate order of their abundance. Lignite has been identified in varying abundance throughout the geologic section.

The Hattiesburg and Catahoula formations constitute the lower 260 to 610 meters (350 to 2,000 feet) of the Upper Aquifer unit (Section 3.3.2). These formations are made up of interbedded sand and clay with thin beds of pyritic lignite. This indicates the depositional environment fluctuated between medium- or high-energy marine or fluvial conditions (sand deposition) and low-energy marine or lagoonal conditions where a reducing environment predominated (lignite deposition).

The Tatum Limestone (lower portion of the Catahoula Formation) and the Vicksburg and Jackson groups are predominantly limestone units that were formed in a continental shelf setting. The presence of siderite ($FeCO_3$) and lignite in these units suggests that conditions are reducing. Garrels and Christ (1965, pp. 209-224) have shown that the presence of siderite indicates that a system is in a reducing state with an Eh probably lower than -100 millivolts.

A series of aquitards, composed principally of glauconitic, silty, lignitic limestones, are present below the Catahoula Formation. The extensive volumes of clay minerals in these units (as well as the overlying units) consist primarily of montmorillonite, illite, kaolinite, and chlorite (Table 3-12). Underlying these aquitards are the Claiborne and Wilcox groups, which are composed of interbedded clay, sand, carbonate, and lignite.

In summary, the sediments adjacent to Richton Dome contain lignite, pyrite, siderite, and glauconite, which are indicative of chemically reducing conditions. The presence of large amounts of clay, glauconite, and lignite are expected to provide significant radionuclide sorption capacity should radionuclides ever be released into these units.

3.2.7.2 Geochemistry of Caprock and Salt Stock

The salt dome consists of a salt stock covered by a caprock of clastic sediment. The caprock varies in thickness from 6 meters (20 feet) at the northern end of the dome to approximately 63.4 meters (208 feet) at the MRIG-9 borehole which penetrated the salt stock (LETCo, 1982, ONWI-120, pp. 13-117). In MRIG-9, the caprock consists of 56.4 meters (185 feet) of anhydrite overlain by 7 meters (23 feet) of limestone (calcite) (see Figure 3-13). The anhydrite portion of the caprock is composed predominantly of massive anhydrite permeated by veins filled with gypsum, and to a lesser extent, sulfur and calcite. Traces of calcite, celestite, quartz, sodium feldspar, dolomite (Werner, 1985b), halite pebbles, pyrite, magnetite, barite, strontianite, illite, montmorillonite, and organic material have also been identified (Drumheller et al., 1982, ONWI-277, pp. 8-11).

Table 3-11. Units of Radiation, Radioactivity, and Dose Used in This Environmental Assessment

Curie (Ci)	The basic unit used to describe the intensity of radioactivity in a sample of material. The curie is equal to 37 billion disintegrations per second, which is approximately the rate of decay of 1 gram of radium. $\text{Microcurie (Ci)} = \frac{\text{Ci}}{1{,}000{,}000}$
Dose Commitment	The time integral of the per capita dose equivalent rate from a given practice; usually 50 or 70 years integral.
Man-Rem	The unit of collective dose which is equal to the dose equivalent to the average person in a population times the number of persons in the exposed population.
Maximum Exposed Concentration	That individual who, due to geographical location, diet, habits, and physiology, receives the highest dose per unit release of anyone in the exposed population.
Maximum Permissible Concentration	The amount of radioactive material in air, water, or food which might be expected to result in a maximum permissible dose to a person consuming them for 50 years at a standard rate of intake.
Rad	The basic unit of absorbed dose of any ionizing radiation. A dose of one means the absorption of 100 ergs of radiation energy per gram of absorbing material. $\text{millirem (mrem)} = \frac{\text{rad}}{1000}$
Radiation Background	The radiation in man's natural environment, including cosmic rays and radiation from the naturally radioactive elements, both outside and inside the bodies of men and animals. It is also called natural radiation. The term may also mean radiation that is unrelated to a specific experiment.
Rem	The unit of dose equivalent of any ionizing radiation which produces the same biological effect as one rad absorbed dose of X-rays. $\text{millirem (mrem)} = \frac{\text{rem}}{1000}$
Roentgen (R)	A unit of exposure to ionizing eletromagnetic radiation. It is that amount of gamma or X-rays required to produce ions carrying one electrostatic unit of electrical charge (either positive or negative) in 1 cubic centimeter of dry air under standard conditions. $\text{milliroentgen (mR)} = \frac{\text{R}}{1000}$

Table 3-12. Mineralogy of Sediments Adjacent to Richton Dome, Mississippi

GEOHYDROLOGIC UNITS	GEOLOGIC UNITS	LITHOLOGIC CHARACTER	MINERALOGY	ORGANIC MATTER
Upper Aquifer	Alluvium	Quartz sand, chert and quartz gravel, and silty clay	Quartz, feldspar	Lignite
	Terrace Deposits			
	Citronelle	Silty, clayey sand grading into gravel		
	Pascagoula-Hattiesburg	Interbedded gravelly sand, sand silty clay and lignite	Montmorillonite, illite, kaolinite	
	Catahoula	Silt, clay, fine- to medium-grained sand, gravel, lignite and a marker Heterostegina Zone (Tatum limestone member)	Calcite, dolomite	
Vicksburg-Jackson	Chickasawhay	Argillaceous to sandy limestone, interbedded with clay and marl		
	Vicksburg Group	Limestone, sandstone, and clay	Quartz, feldspar Calcite, dolomite	
	Forest Hill Sand/Red Bluff Clay	Sandy to silty carbonaceous clay and partially indurated fossiliferous marl	Montmorillonite, illite, kaolinite	
	Jackson Group	Variably limy, glauconitic, sandy and silty clay, with basal chalky limestone (Ocala Facies)	Glauconite	
Upper Claiborne	Cockfield	Limestone, sand streaked, lignitic-bearing clay and silt	Calcite, dolomite Montmorillonite, illite, kaolinite Quartz, feldspar Glauconite	
	Cook Mountain	Loosely cemented, porous carbonate sand, glauconitic clay shale, and calcrenitic limestone		
	Kosciusko (Sparta)	Limestone with thin beds of clay, locally sandy		
Lower Claiborne	Zilpha Clay	Interbedded glauconitic clay shale, chalk, and chalky limestone	Montmorillonite, illite, kaolinite Quartz, feldspar Calcite Glauconite, pyrite, chlorite	Lignite
	Winona Sand	Clay shale containing chalk or marl lenses		
	Tallahatta Formation	Glauconitic and limy siltstone and claystone interbedded with clay shale		
Wilcox	Meridian Sand	Sand with sandy shale and lignitic clay	Quartz, feldspar Montmorillonite, illite, kaolinite Chlorite, pyrite	Lignite
	Wilcox Group	Silty, lignitic shale interbedded with silt, sand, lignitic siltstone, and fine- to medium-grained sandstone		
Midway	Porters Creek Clay	Interbedded shales, lignite, silt, siltstone, and sandstone	Montmorillonite, illite, kaolinite Quartz, feldspar Calcite Glauconite	
	Clayton	Sandy, glauconitic marl, marly chalk, or calcareous clay		

Source: LETCo, 1982, ONWI-120, pp. 13-140, Appendices A-1, B-3.

The anhydrite caprock appears to have been formed by the accumulation of anhydrite residuum from the salt stock during diapirism (Werner, 1985b). It is postulated that the anhydrite, dispersed throughout the salt stock, accumulated at the caprock-salt interface as the more soluble salt was dissolved by ground water, as suggested by Halbouty (1979, p. 45). The alternate explanation of caprock origin, in-place precipitation of anhydrite (Walker, 1974, pp. 169 and 190), can explain the geochemical and mineralogic composition of some caprocks but does not seem to apply at Richton Dome (Werner, 1985b). The origin of the limestone caprock is not yet understood. Possible explanations include: (1) precipitation from calcium sulfate-rich solutions (Werner, 1985b), and (2) oxidation of organic matter to carbon dioxide and concomitant bacterially-mediated reduction of anhydrite to free calcium and reduced sulfur species (Kreitler and Dutton, 1983, p. 42). The carbon dioxide and calcium then react in the ground water to form calcite. The oxidation of organic matter does not require highly oxidizing conditions, as sulfate (as opposed to dissolved oxygen) is the oxidant utilized by anaerobic microorganisms in this process.

Three distinct diagenetic events are believed to have affected Richton Dome caprock subsequent to its formation, which appears to have been completed in late Oligocene. The anhydrite underwent fracturing, which was believed to have been caused by the upward arching movement of the underlying salt stock. Water subsequently entered the fractures, causing anhydrite alteration to gypsum along the fracture walls. The transformation of gypsum was accompanied by a volume increase, which in turn induced additional fracturing and allowed further penetration of the ground water in the anhydrite caprock (Section 3.2.3.2.3). The gypsum vein formation event is believed to have been completed by late Oligocene and represents the last significant hydrological communication through the caprock (Werner, 1985b). The second diagenetic event is the mineralization of certain fractures by small amounts of calcite and sulfur. This process is interpreted to have resulted from bacterially-assisted sulfate reduction. The age of calcite/sulfur mineralization is undetermined, but was probably geologically short-lived (Werner, 1985b). The final event was dissolution and pitting, which had relatively little effect on the anhydrite caprock. This process was also short-lived, and its timing not clearly understood (Werner, 1985b).

The Richton Dome salt stock is derived from the underlying Louann Salt, a thick evaporitic sequence formed in a large marine basin (Section 3.2.1). The salt in the stock generally consists of massive to compact interlocking crystals of halite. These are fine- to coarse-grained halite crystals with an anhydrite-rich zone in the upper 2 meters (6 feet) (Drumheller et al., 1982, ONWI-277, p. 12). Numerous zones of very large or mega-crystalline (5 centimeters or 2 inches) halite crystals are present and are usually bordered by anhydrite bands 6 millimeters (0.25 inches) thick. Anhydrite also occurs as scattered grains or inclusions in the salt (Drumheller et al., 1982, ONWI-277, p. 13). The average composition of sampled salt core is 91 percent halite and 8 percent anhydrite. Dolomite, pyrite, quartz, plagioclase, calcite, and organic material make up one percent of the salt composition. The halite likely contains small amounts of water, which is present in hydrated minerals such as clays, intergranular pore fluids, and fluid inclusions (Section 3.2.7.4).

Geochemical conditions in the host salt are expected to be conducive to radionuclide retention. Reduced forms of carbon (organic material), iron (pyrite), and sulfur (pyrite and elemental sulfur) are known to be present in the caprock (Drumheller et al., 1982, ONWI-277). The salt stock also contains minor amounts of pyrite and organic matter (Drumheller et al., 1982, ONWI-277). Fluid inclusions in the host salt contain hydrocarbons, with mean occluded methane contents of 0.64 microliters per gram (Mullin, 1982, p. 37; Drumheller et al., 1982, ONWI-277). The presence of reduced species such as methane and sulfides at least qualitatively suggests the presence of reducing conditions (Lindberg and Runnells, 1984), which will promote the precipitation of many redox-sensitive radionuclides such as technicium, neptunium, uranium, and plutonium. In addition, certain radionuclides (strontium and radium) form relatively insoluble sulfates or carbonates (Langmuir and Riese, 1985; Stumm and Morgan, 1970).

The primary minerals of Richton Dome salt are expected to be stable in the repository environment, which will be characterized by higher than ambient temperatures and significant near-field radiation dose rates. Both halite and anhydrite are stable at temperatures far

exceeding the maximum repository temperature of 250 C (482 F). Any anticipated adverse effects from radiation on mineral stability are expected to be strongly mitigated by the fact that dose rates at the overpack surface will be on the order of 20 rads per hour where there is no experimental evidence of mineral degradation. The thermal and radiolytic stability of the host rock minerals is discussed further in Sections 6.3.1.2.2 and 6.3.1.2.3.

3.2.7.3 Ground-Water Geochemistry Adjacent to the Dome

The Upper Aquifer unit (Table 3-12) in the vicinity of Richton Dome contains fresh water (less than 1,000 milligrams per liter total dissolved solids). The predominant ions in the shallow portions of the Upper Aquifer unit are sodium and bicarbonate. Calcium content in this unit increases with depth. To the south of the dome, several borings have been reported to contain anomalous salinites. Possible sources of these specific saline anomalies are discussed in Section 3.2.5.7.3. Ground waters in the Upper Aquifer unit are moderately high in iron. The predominance of bicarbonate with respect to other dissolved ions indicates continual flushing of the aquifer by meteoric water (LETCo, 1982, ONWI-120, pp. 14-39 to 14-40).

The total dissolved solids content of the ground water of hydrologic units in the Richton Dome area generally increases with depth and distance from the recharge area. Increases in sodium, chloride, and bicarbonate account for most of the increased salinity. Analyses of water from the upper strata of the Wilcox Group at sites MRIG-10 and MRIH-11 indicate a range for total dissolved solids of 14,000 to 18,000 milligrams per liter. Water from the lower strata of the Wilcox Group at site MRIH-11 had a total dissolved solids content of 110,000 milligrams per liter. Details of ground-water chemistry are presented in Section 3.3.2.3.

Ground water near the dome contains methane, ethane (Drumheller et al., 1982, ONWI-277), and sulfide and is considered to be chemically reducing (LETCo, 1982, ONWI-120, Vol. VII, p. C-3-13). Gas analyses in selected DOE wells close to Richton Dome detected methane in concentrations ranging from 13.4 to 27.8 percent by volume, ethane in concentrations of 0 to 4.09 percent by volume, and hydrogen, ranging in concentration from 0.32 to 12.8 percent by volume (LETCo, 1982, ONWI-120, Vol. VII). Sedimentary units adjacent to the dome contain reduced forms of carbon, iron, and sulfur in lignite, pyrite, siderite, and glauconite. Russell (1984, pp. 19-20) reports Eh values averaging less than -17 millivolts in formation fluids from the Upper Aquifer unit. If several suspect values are discarded, the average Eh is more on the order of -50 to -100 millivolts (Russell, 1984). Lindberg and Runnells (1984) point out that obtaining reliable Eh measurements in ground water is problematic, however, the presence of redox-sensitive species such as sulfide, oxygen, and methane can provide at least a qualitative guide to the redox status of water. At these lower redox potentials, redox-sensitive radionuclides such as uranium, neptunium, plutonium, and technicium, are expected to be stable in their lower oxidation states where retention is expected to be great because of low radionuclide solubility (Cleveland et al., 1983; Cleveland, 1979a,b; Bondietti and Francis, 1979; Langmuir, 1978).

3.2.7.4 Aqueous Geochemistry of the Caprock and Salt Stock

Dome salt generally has a very low moisture content and is essentially impermeable (Tien et al., NUREG/CR-3129, SAND82-2223, 1983, pp. 207-211; and ETC, 1984, BMI/ONWI-511, p. 26). Knauth and Kumar (1981) found water contents of 0.0001 to 0.007 weight percent in salt from Rayburn's and Vacherie Domes (Louisiana). Gevantman (1981, Table 1.4) reports brine contents between 0.01 and 0.02 weight percent for Avery Island dome salt and 0.004 and 0.040 weight percent for Weeks Island dome salt. Site-specific water content data are not available for Richton Dome salt; however, Roedder and Chou (1982, pp. 2-8) suggest that a water content of 0.1 weight percent (approximately 0.26 volume percent at 90 C) is a conservatively high value for domal salts.

There is little direct evidence of the oxidation-reduction potential of water in the dome salt per se; however, the presence of elemental sulfur, pyrite, and organic material in the

caprock and dome salt and of methane and other hydrocarbons in fluid inclusions in the halite are consistent with chemically reducing conditions (Drumheller et al., 1982, ONWI-277; Mullin, 1982, p. 37).

Water samples were collected from the caprock at well MRIG-9 (Bentley, 1983, p. 29) and classified as sodium-chloride type brines. Site-specific data on Richton domal salt brine compositions are not available. Expected ranges in brine composition, particularly as it relates to waste package performance, are discussed in Sections 6.3.1.2.2, 6.3.1.2.3, and 6.4.2.3.3.

3.2.8 Mineral Resources

Potential resources at Richton Dome include hydrocarbons, salt, underground storage, sulfur, lignite, uranium, and sand and gravel (Milliken, 1985; Murray, 1983, ONWI-169, p. 49; LETCo, 1982, ONWI-120, p. 13-160). Only salt and the potential for underground storage in the dome, exist near Richton Dome; all other resources are considered speculative to hypothetical (based on the classification system of the U.S. Geological Survey and U.S. Bureau of Mines, 1980).

3.2.8.1 Hydrocarbons

Major quantities of oil and gas are produced from the Mississippi Salt Basin. Most of the region's production comes from numerous oil and gas fields located in Jasper, Clarke, Jones, and Wayne Counties (Figure 3-22). In 1982, Perry County ranked 30th in oil production and 36th in gas production (Figure 3-22) out of the 43 Mississippi counties that produced oil and gas (Mississippi State Oil and Gas Board, 1983, p. 6).

Essentially all the known oil and gas fields are found on salt swells and deep (below 1,524 meters [5,000 feet]) piercement domes. No significant oil or gas reserves have been found on the flanks of any of the 48 known shallow domes.

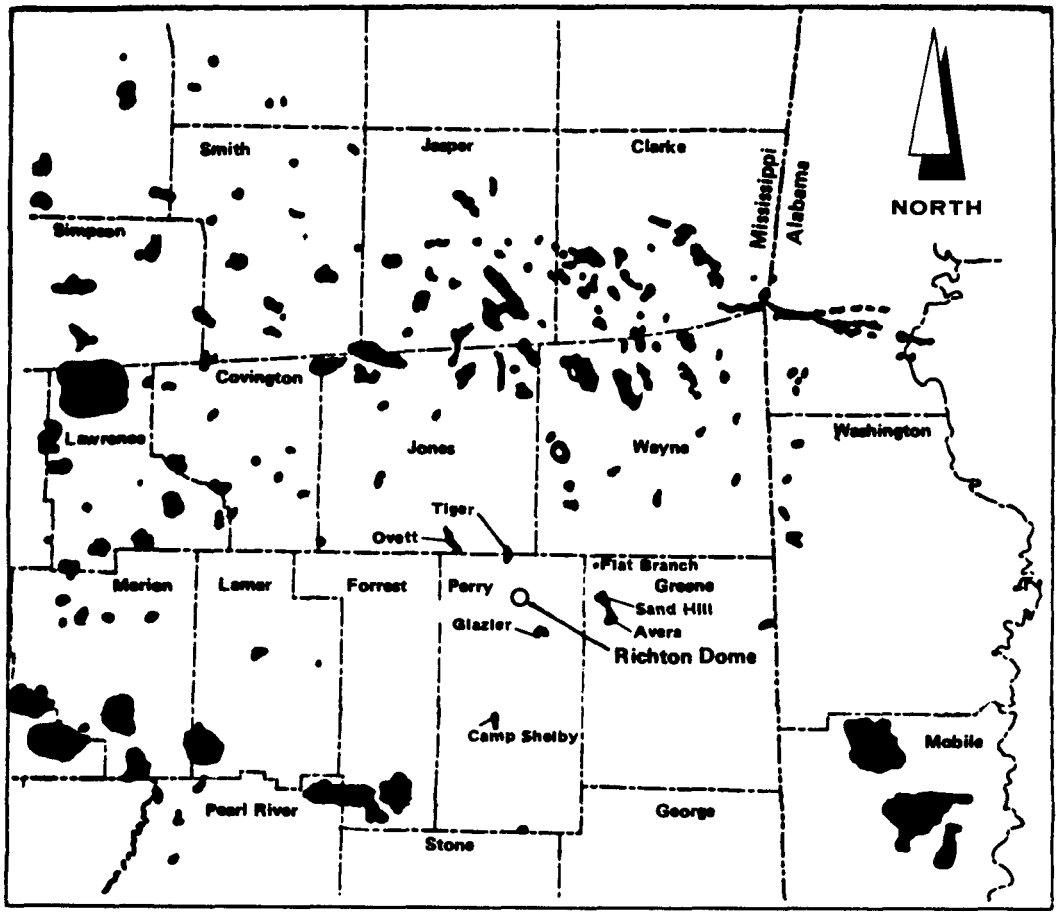
Richton Dome is the largest of the shallow piercement domes in the basin. The average salt dome ranges from 5 to 8 square kilometers (2 to 3 square miles) in areal extent at its surface, whereas the Richton Dome covers approximately 20 square kilometers (8 square miles).

In addition to Richton Dome, there are two other structures nearby. To the north is the Tiger gas-condensate field, which is an elongate, faulted, anticlinal structure resulting from deep-seated salt movement. To the south of Richton is the Glazier oil field, which sits atop an intermediate-type piercement salt dome wherein the shallowest salt has penetrated the Eutaw Formation at a depth of 2,166 meters (7,105 feet).

Because there was a massive volume of salt withdrawn to create Richton Dome, there exists a pronounced rim syncline north and northeast of the dome (Section 3.2.5.6). A much smaller, partial rim syncline flanks Glazier Dome.

Although subsurface control is rather sparse beyond the immediate vicinity of these three salt structures, no other significant local structural anomalies are believed to exist. This is based on the fact that many different oil companies have conducted seismic surveys within 10 kilometers (6 miles) during the past forty years, and only seven wildcat prospects were found that were considered worthy of drilling. None of these wildcat wells showed any evidence of hydrocarbons (Milliken, 1985).

The presence of Richton Dome in the subsurface has been known since 1944 (Hawkins and Jirik, 1966, p. 67), and significant exploration has been conducted along the dome flanks without identifying petroleum reserves. Shell No. 1 Masonite (Figure 3-12) penetrated over 30 meters (100 feet) of sand containing heavy asphaltic oil in Lower Cretaceous deposits beneath the overhang on the eastern flank of the dome. Although Karges (1975, p. 175) reported this occurrence of asphaltic sand, he did not specify that it was a cumulative thickness from three separate horizons over a 185-meter (606-foot) interval. All units were tested for hydrocarbons and all produced saltwater, and no oil. In addition, four relatively deep



Explanation

Oil and gas fields

Scale

0 30 60 Km

0 20 40 Mi

Location of Oil and Gas Fields in the Southeastern Mississippi Salt Basin

Source: Peppard-Souders and Associates, 1982.

Figure 3-22

wildcat wells drilled on the northern and western flanks have tested the most likely areas of the dome margin, indicating that the presence of hydrocarbon resources is very unlikely (Milliken, 1985). There are no known untested structures in the area, based on numerous seismic surveys. Outside of known producing fields, tested structures have proven dry. Geologically, there is no reason to suspect the existence of a trap and an accumulation of hydrocarbons in these untested areas. This assessment is supported by the observation that only 15 of 100 shallow (less than 1,524 meters [5,000 feet] deep) salt domes in the interior salt basins have associated hydrocarbons (Murray, 1983, ONWI-169, pp. 58 and 59).

While older Jurassic rocks (Lower Cotton Valley, Haynesville, Smackover, and Norphet) have not been penetrated, there is no geological reason to regard them as favorable reservoir targets (Milliken, 1985). They are deep - 5,335 to 6,616 meters (17,500 to 21,700 feet) - and there is no nearby production from these formations. Also, the reservoir quality (porosity and permeability) of these deep Jurassic formations will most probably be poor because of the extreme depth of burial in the deeper part of the sedimentary basin.

Murray (1983, ONWI-169, p. 61) and Milliken (1985) have indicated that if hydrocarbon reservoirs are present in the Mississippi Basin, the volume is small: at most less than 1 million barrels, and probably less than 500,000 barrels. The nearby Tiger field has produced 2.2 billion cubic feet of gas and 581,578 barrels of condensate from lenticular Hosston sands during the past 14 years and is now more than 75 percent depleted. The Glazier field has produced 734,977 barrels of very low gravity (9 API) oil during its 33-year life and is now nearly depleted (Milliken, 1985). Currently, there are only two wells, each pumping an average of ten barrels of oil per day from the Eutaw and Tuscaloosa sands that overlie the domal salt.

Perry County has three producing fields: Glazier Field, 5 kilometers (3 miles) southeast of Richton Dome; Tiger Field, 3 kilometers (2 miles) north of the dome; and Camp Shelby Field, 22 kilometers (13.2 miles) south of the dome (Figure 3-22). There is additional production within 16 kilometers (10 miles) of the Richton Dome in the Ovett and Avera Fields north and east of the dome (Figure 3-22). A new discovery was recently drilled 12.8 kilometers (8 miles) east of Richton Dome. The Texaco, Inc. No. 1 Goodnight (Sec. 13-5N-9W, Perry County) was drilled to a total depth of 3,810 meters (12,500 feet) in the Paluxy Formation and completed on June 4, 1985, in a Paluxy sand from 3,367 to 3,375 meters (11,044 to 11,071 feet), flowing 132 barrels of 42.6 API gravity oil per day. This well is located on the west flank of the Larger Thompsons Creek-Avera structure complex east of Richton Dome.

Table 3-13 summarizes the nearest commercial oil or gas reservoirs to Richton Dome in each of the known productive formations of southeastern Mississippi. The only oil fields that have (or will produce) more than 4,000,000 barrels of oil are located 40 kilometers (25 miles) or more from Richton in the more favorable shelf portion of the sedimentary basin (Milliken, 1985). There is no positive geological and geophysical evidence that suggests that the area within 10 kilometers (6 miles) of Richton Dome has any significant potential for profitable oil and gas productivity beyond already known, producing structures (Milliken, 1985). Within 8 kilometers (5 miles) of the flanks of Richton Dome, 32 petroleum exploration wells have been drilled and abandoned with no production reported.

3.2.8.2 Other Resources

The potential for salt production at Richton Dome is very good because the dome is at a shallow depth, and because the salt purity is high (91 percent) (Drumheller et al., 1982, ONWI-277, p. 32). The dome is the largest reported shallow salt dome in the interior basins, one of seven with more than 809 hectares (2,000 acres) of area at shallow depth (Table 3-15). However, 38 other salt domes in the Mississippi, North Louisiana, and East Texas salt basins have depths of -610 meters (-2,000 feet) MSL or less (Table 3-15). Richton Dome does not provide a unique resource for salt. The short term potential in the immediate future for salt production is poor because current production capacity in the region is more than adequate to meet market demand.

Table 3-13. Nearest Commercial Oil or Gas Reservoirs to Richton Dome in Each of the Known Productive Formations of Southeastern Mississippi

Reservoir Formation	Field	Discovery Date	Reservoir Cumulative Production, 12-31-84[b]	Field Cumulative Production, 12-31-84[b]	Approximate Distance From Richton Dome	County
Selma Chalk	Camp Shelby	1-05-73	210,911 bbls	362,255 bbls	13.2 miles South	Perry
Eutaw	Avera	11-12-65	141,790 bbls	1,700,759 bbls	10 miles East	Greene
Tuscaloosa	Glazier	12-19-51	685,814 bbls	734,977 bbls	3 miles South	Perry
Washita-Fredricksburg	So. Thompsons Creek	11-21-64	1,602,452 bbls	3,367,855 bbls	13 miles North	Wayne
Paluxy[a]	So. Thompsons Ck.	2-10-59	923,052 bbls	3,367,855 bbls	13 miles North	Wayne
Rodessa	Avera	2-06-63	428,804 bbls	1,700,759 bbls	10 miles East	Greene
Sligo	West Clara	11-04-69	153,600 bbls	2,575,033 bbls	20 miles NE	Wayne
Hosston	Tiger	2-23-71	581,578 bbls 2,227,136 MCF	581,578 bbls 2,227,136 MCF	2 miles North	Perry
Cotton Valley	Pool Creek	4-23-64	1,251,015 bbls	10,218,951 bbls	25 miles North	Jones
Haynesville	So. Summerland	1-12-74	1,669,825 bbls	2,152,595 bbls	36 miles NW	Jones
Smackover	West Clara	11-15-66	563,119 bbls	2,575,033 bbls	20 miles NE	Wayne
Norphlet	Prairie Branch	12-23-70	4,213,825 bbls	7,625,654 bbls	40 miles North	Clarke

(a) New Discovery (6-4-85), Texaco - No. 1 Goodnight producing 132 BOPD from Paluxy sand, located 8 miles east of Richton dome.

(b) Bbl = barrels, 1 barrel = 0.16 cubic meter.
MCF = 1,000 cubic feet = 28.3 cubic meters.

Source: Mississippi State Oil and Gas Board, 1985.

Table 3-14. Summary of Depth to Top of Salt at Domes in Mississippi, Louisiana, and Texas Interior Salt Basins

Depth to Top of Salt	Number of Salt Domes			
	Mississippi Salt Basin	North Louisiana Salt Basin	Northeast and South Texas Salt Basins	Total
<2,000 ft	12	11	16	39
2,000 ft to <3,000 ft	23	3	1	27
3,000 ft to <4,000 ft	12	0	3	15
4,000 ft to <5,000 ft	10	3	1	14
5,000 ft to <10,000 ft	9	1	3	13
>10,000 ft	12	0	2	14
No Data/ Undetermined	2	1	0	3
Total	80	19	26	125

Source: LETCo, 1981, ONWI-106, pp. 60-63.

Table 3-15. Size Categories of Salt Domes in Mississippi, Louisiana, and Texas Interior Salt Basins

Acreage[a]	Number of Salt Domes			
	Mississippi Salt Basin	North Louisiana Salt Basin	Northeast and South Texas Salt Basins	Total
<1,000 acres	29	12	8	49
1,000 to 2,000 acres	24	5	8	37
>2,000 acres	1	2	4	7
Domes of Unknown Area	26	0	6	32
Total	80	19	26	125

(a) Depth below top of salt at which acreage is determined is variable; see source.

Source: LETCo, 1981, ONWI-106, pp. 60-63.

Table 3-16. Summary of Sulfur Exploration Wells Drilled at Richton Dome

Total number of wells	34
Number completed in:	
Overburden	4
Caprock	22
Salt	8
Range of Depths	177 to 792 meters (583 to 2,601 feet)
Maximum Penetration of Salt	6.4 meters (21 feet)

Note: Total number of wells (34) includes 1 well abandoned before completion.

Source: Rainey, 1981.

Richton Dome is suitable for potential underground cavern storage of liquid or gas (including compressed air) due to the shallow depth and large size of the dome, and the purity of the salt.

Commercial amounts of sulfur have been recovered from 24 coastal domes in Texas and Louisiana (Hawkins and Jirik, 1966, pp. 32 and 35). Extensive testing of the caprock for sulfur at Richton Dome found only traces of sulfur (Alexander et al., 1945, p. 829). Murray (1983, ONWI-169, p. 64) noted that similar trace amounts have been identified in the caprocks of many domes in the interior basins and that no sulfur has been produced from those domes. Given the number and distribution of sulfur exploration borings (Figure 3-12), the potential for economic deposits of sulfur at Richton Dome is negligible.

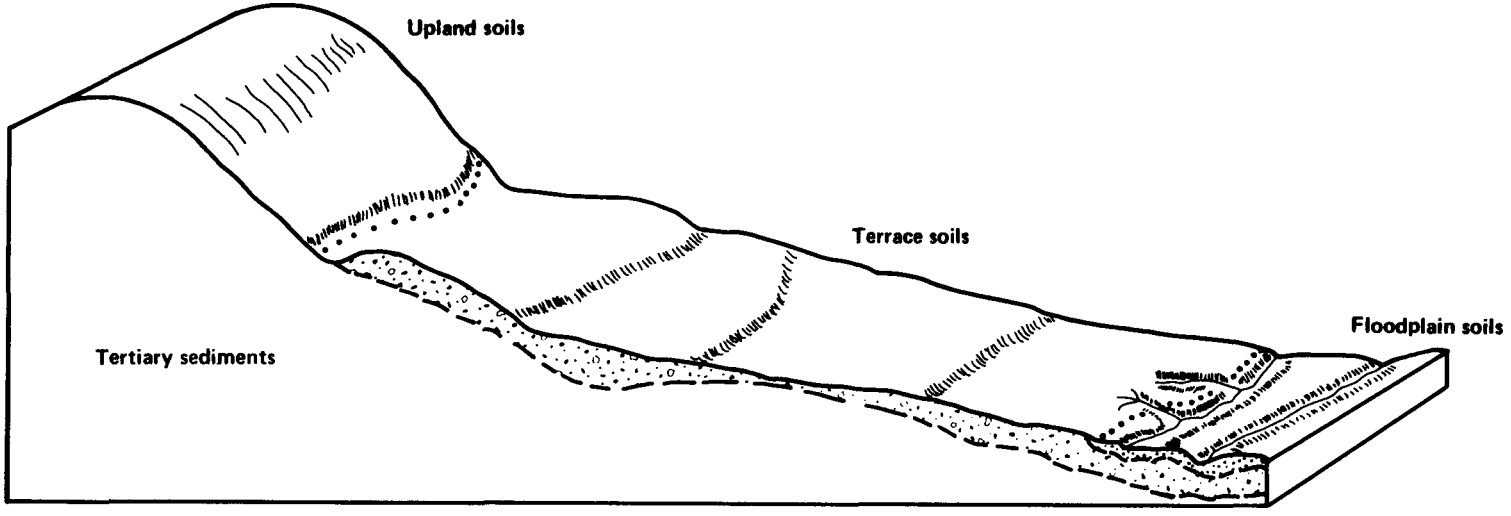
Lignitic material in upper Tertiary units occurs throughout the vicinity of Richton Dome. A review of the descriptions of formations encountered in boreholes drilled during area characterization (LETCo, 1982, ONWI-120, p. 12-150) indicates that traces of lignite are present in the Hattiesburg, Catahoula, and Cockfield Formations; the Wilcox Group; and the Porters Creek Formation. Geologist's logs (LETCo, 1982, ONWI-120, Appendix B) and interpretations of geophysical logs from borehole MRIG-9 (Ertec, 1983, ONWI-481, p. 11) identify lignite within the Hattiesburg Formation at depths between 99 and 102 meters (324 and 335 feet). The descriptions (generally trace or minor), and sporadic occurrence of the lignites indicate they are mostly thin, or disseminated, and restricted to areas of small extent. Because those deposits are thin, deep, and disseminated, development of lignite as a potential resource is considered speculative (Milliken, 1985).

Russell (1984) suggested that an environment favorable for uranium deposition exists in southern Mississippi based on the presence of an oxidation/reduction front in the Miocene-aged sediments. However, uranium concentration values reported by Russell for 40 ground-water samples were extremely low. E.G. and G. Geometrics (1980) conducted an aerial radiometric survey of the Hattiesburg 1 x 2 Quadrangle. This survey documents a uniformly low uranium abundance over the region, with only low-grade anomalies associated with cultural features (i.e., towns, roads, pipelines, etc.). The very low values for uranium in sediments and ground water across the region indicate insufficient source material for uranium deposits. Therefore, it is concluded that the potential for uranium resources in the vicinity of Richton Dome is highly speculative.

The presence of gravel or borrow pit symbols on topographic maps of the area is indicative of past production of sand and gravel. Several gravel pits, including one that covers approximately 0.38 square kilometer (0.15 square mile), are located in the Citronelle Formation as well as in Quaternary terrace and alluvial deposits. Sand and gravel have good potential for development except for local use and there is an abundance of these materials in the region (LETCo, 1982, ONWI-120, p. 13-160; Milliken, 1985). Only one periodically active sand and gravel plant is in Perry County (Bicker, 1970, pp. 42-43). Sand and gravel production is based primarily on local construction and road maintenance needs, and the many pits are small, temporary sources of aggregate.

3.2.9 Soils

Soils in the Richton Dome area may be classified by geographic position as upland soil, terrace soil, and floodplain soil (Figure 3-23). The upland soils are located on topographic highs; and the terrace and floodplain soils are in the drainages (Soil Conservation Service, 1971). In general, soils that form on the upland areas are underlain by sediments of Tertiary age. They form on gentle to moderate slopes and are well drained (Edwards et al., 1980, pp. 136-137). In the Richton Dome area, the clayey upland soils are derived mostly from the Hattiesburg Formation. The loamy and sandy upland soils are derived mostly from the Citronelle Formation (Davis and Byers, 1979, p. 44). Soils that form on terraces are underlain by Pleistocene and Holocene alluvium that were derived principally from the uplands. These soils form on very gentle to nearly level slopes and are moderately to poorly drained. Soils that form on floodplain deposits are underlain by Holocene alluvium that is considerably younger than 10,000 years old. The topographic configuration of the floodplain is caused by frequent overflows which form nearly level slopes that extend from natural levees near the



Explanation

- Tertiary sediments
- Pleistocene and Holocene terrace deposits (alluvium)
- Holocene floodplain deposits (alluvium)

Not to scale

Source: Martinez et al., 1977, p. 394.

Geographic Soil Classification Showing Landscape Position and Surface Stratigraphy

Figure 3-23

stream to clayey back-swamp deposits. These soils range from well to poorly drained (Edwards et al., 1980, p. 136-137).

Two soil associations, the Prentiss-Susquehanna-Benndale and the Prentiss-Bruno-Myatt, made up of six soil series, have been recognized and mapped in the Richton Dome area on the General Soil Map, Perry County, Mississippi (Soil Conservation Service, 1971). The Prentiss-Susquehanna-Benndale association is developed on areas dominated by upland soils. The Prentiss soil series include loamy soils, with a fragipan, that occur on moderately well-drained gentle slopes. The Susquehanna soil series occur on gentle to steep slopes and are poorly drained because of the presence of a clayey subsoil. The Benndale soil series are loamy soils that occur on well-drained, gentle to steep slopes.

The Prentiss-Bruno-Myatt association is developed in areas dominated by terraces and floodplains. The Prentiss soil series is described above. The Bruno soil series includes sandy soils that are excessively drained and occur on gentle slopes. The Myatt soil series include loamy soils that occur on nearly level, poorly drained land (Soil Conservation Service, 1971).

3.3 HYDROLOGIC CONDITIONS

This section discusses the present hydrologic conditions at Richton Dome and includes an examination of the surface-water conditions around the dome, the geohydrologic conditions and the resulting ground-water flow system, the hydrochemistry of the ground waters, and the present and projected water uses in the vicinity of the dome.

3.3.1 Surface Water

This section describes the surface-water conditions in the vicinity of Richton Dome. It includes a description of the surface-water hydrology, surface-water quality, and flooding.

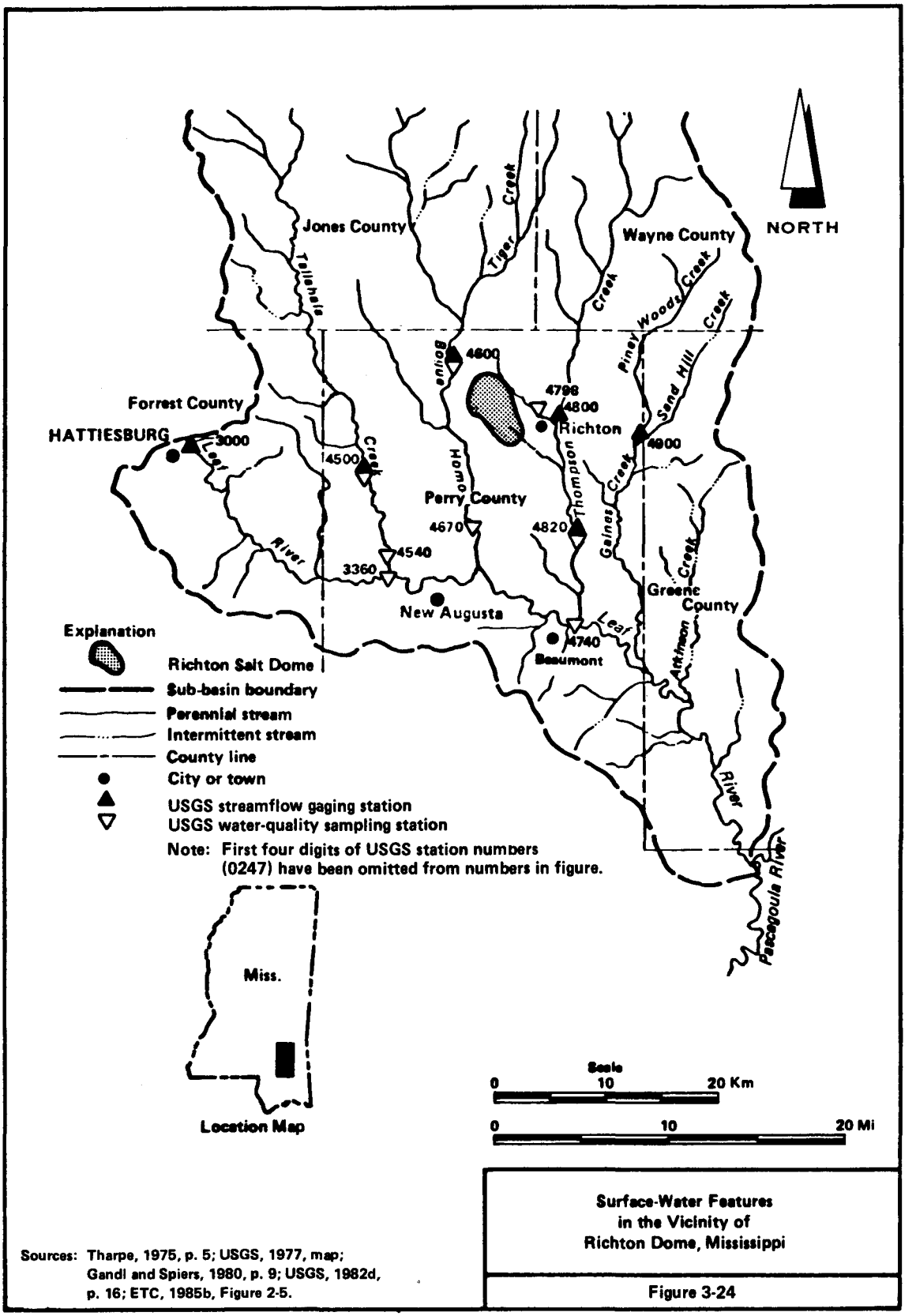
3.3.1.1 Hydrology

Richton Dome is situated in the Pascagoula River Basin, a major river basin that drains approximately 25,000 square kilometers (9,700 square miles) of southeastern Mississippi and southwestern Alabama into the Gulf of Mexico (U.S. Army Corps of Engineers, 1968, p. G-7). The area over the dome is located in a sub-basin of the Pascagoula River Basin, which is drained by the Leaf River, a major tributary of the Pascagoula River (USGS, 1977, map). The southern portion of the sub-basin and the major streams within it are shown in Figure 3-24.

The only major reservoir (storage capacity greater than 1.2 million cubic meters [1,000 acre-feet]) in the sub-basin is Lake Bogue Homo, located about 40 kilometers (25 miles) north of the dome (outside of the area shown in Figure 3-24). This lake has a maximum storage capacity of 28.9 million cubic meters (23,400 acre-feet) and is primarily used for recreation (Mississippi Department of Natural Resources, 1984, p. 3). Numerous other smaller lakes and ponds are scattered throughout the sub-basin.

Thompson Creek and Bogue Homo, two major streams located east and west of the dome, respectively, drain the area over the dome (Figure 3-24). These two streams flow southward into the Leaf River (LETCo, 1982, ONWI-120, p. 14-82).

The Bogue Homo drains 1,090 square kilometers (422 square miles) of Perry, Wayne, Jones, and Jasper Counties. This stream flows southward to its confluence with the Leaf River, approximately 5 kilometers (3 miles) northeast of New Augusta in Perry County. The Bogue Homo watershed is characterized by gently rolling to hilly topography and mature dendritic drainage. Surface elevations in the watershed range from 24 to 171 meters (80 to 560 feet) above MSL. The main channel has a low gradient, averaging 1 meter per kilometer (5.5 feet per mile). The Bogue Homo meanders across a 2.4-kilometer (1.5-mile)-wide floodplain. This broad floodplain, with its low gradient, has resulted in a swampy marsh along approximately 80 percent of its watercourse (LETCo, 1982, ONWI-120, p. 14-82).



Sources: Tharpe, 1975, p. 5; USGS, 1977, map; Gandl and Spiers, 1980, p. 9; USGS, 1982d, p. 16; ETC, 1985b, Figure 2-5.

Surface-Water Features in the Vicinity of Richton Dome, Mississippi

Figure 3-24

Thompson Creek drains 611 square kilometers (236 square miles) of Perry, Wayne, and Jones Counties. This stream flows southward approximately 72 kilometers (45 miles) to its confluence with the Leaf River near Beaumont in Perry County. The topography of the Thompson Creek watershed is similar to that of the Bogue Homo watershed. Surface elevations in the watershed range from 21 to 107 meters (68 to 350 feet) above MSL. The main channel has a low gradient, averaging 1.2 meters per kilometer (6.2 feet per mile). Thompson Creek meanders across a broad floodplain averaging 1.9 kilometers (1.2 miles) in width. This broad floodplain, with its low channel gradient, contains swampy marshes along the middle reaches of the stream (LETCo, 1982, ONWI-120, pp. 14-82, 14-83).

The area over the dome is drained by several streams that are tributaries of the Bogue Homo and Thompson Creek (Figure 3-25). The western portion is drained by Linda Creek, White Branch, and Harper Branch, all of which flow into the Bogue Homo. The eastern portion is drained by Pine and Fox Branches, Beaver Dam Creek, and two unnamed drainages, all of which flow into Thompson Creek. The tributary that drains the largest portion of the area over the dome is Pine Branch. It drains almost half the area defined by the surface projection of the -610 meters (-2,000 feet) MSL structural contour of the salt dome (LETCo, 1982, ONWI-120, pp. 14-83).

The average annual runoffs for the major drainages in the region range from 530 to 612 millimeters (20.88 to 24.08 inches), and represent 35 to 40 percent of the annual rainfall (Table 3-17) (USGS, 1982d, pp. 74, 81). The remainder of rainfall is lost to evaporation and infiltration. Rainfall and other climatic factors are discussed in detail in Section 3.4.3.4.

Streamflow Characteristics. Streamflow data are available for several USGS stream-gaging stations located in the sub-basin (USGS, 1982d, pp. 16, 17). The locations of these stations are shown in Figure 3-24, and the data are summarized in Table 3-17.

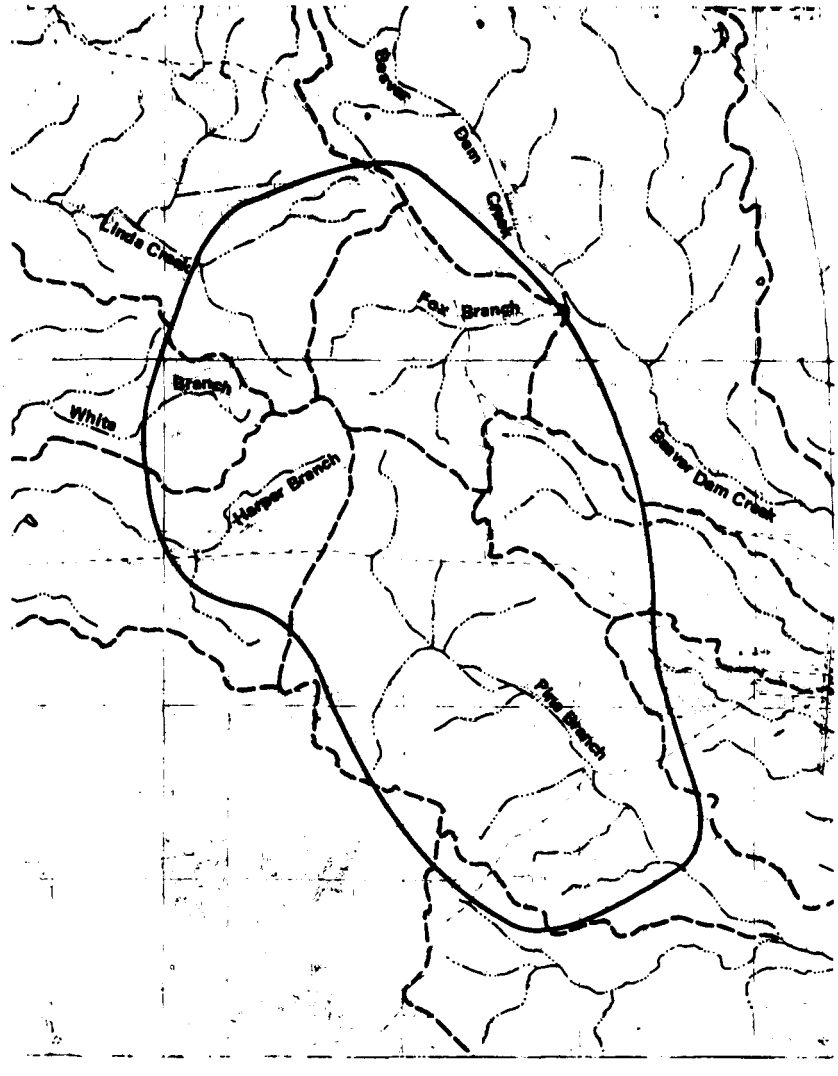
The largest stream in the sub-basin is the Leaf River. The average annual discharge recorded for the Leaf River at Hattiesburg, based on 43 years of record, is 76.10 cubic meters per second (2,687 cubic feet per second) (Table 3-17; USGS, 1982d, p. 74).

The variability of monthly and annual streamflow for Bogue Homo near Richton is illustrated in Figure 3-26. Approximately 85 percent of the annual discharge occurs during the 6-month period from December to May. Highest monthly mean flows occur during April; lowest monthly mean flows occur during August. Annual discharge is also highly variable. From 1971 to 1983, the annual discharge ranged from 8 cubic meters per second (240 cubic feet per second) in 1981 to 26 cubic meters per second (911 cubic feet per second) in 1974. The average annual discharge, based on 13 years of record, is approximately 17 cubic meters per second (592 cubic feet per second) (USGS, 1984b).

The 2-year, 7-day low flow, computed using historic low-flow data, is a value which largely reflects ground-water discharge (baseflow) in the sub-basin rather than surface runoff (Peirce, 1966, p. 99). Values computed for stations listed in Table 3-17 range from a low of 0.01 cubic meter per second (0.5 cubic foot per second) at Piney Woods Creek to a high of 14.26 cubic meters per second (504 cubic feet per second) at the Leaf River near Hattiesburg (Tharpe, 1975, pp. 27, 38). Values for the 2-year, 7-day low flow per square kilometer of drainage area are also presented in Table 3-17. The low values for Bogue Homo and Thompson Creek indicate that very little ground-water discharge occurs in the immediate vicinity of Richton Dome. For a more detailed discussion of ground-water discharge, see Section 3.3.2.1.

3.3.1.2 Surface-Water Quality

Surface water in the sub-basin has been classified by the State of Mississippi as either "Fish and Wildlife" waters or water for recreational use (Mississippi Department of Natural Resources, 1982, pp. A-8 through A-14). "Fish and Wildlife" waters are intended for fishing and for propagation of fish, aquatic life, and wildlife. The water-quality criteria for both types of water include four conditions: specific conductance should not exceed 1,000 micromhos per centimeter; total dissolved solids (TDS) concentrations should not exceed



Explanation

- Drainage divide
- Intermittent or ephemeral stream
- Approximate -2,000-foot MSL structural contour of salt

Scale

0 1 2 Km

0 1 2 Mi

Sources: USGS, 1973, map; USGS, 1982a, map; USGS, 1982b, map; USGS, 1982c, map; LETCo, 1982, ONWI-120, p. 14-84; ETC, 1985b, Figure 2-5.

Drainage Over Richton Dome, Mississippi

Figure 3-25

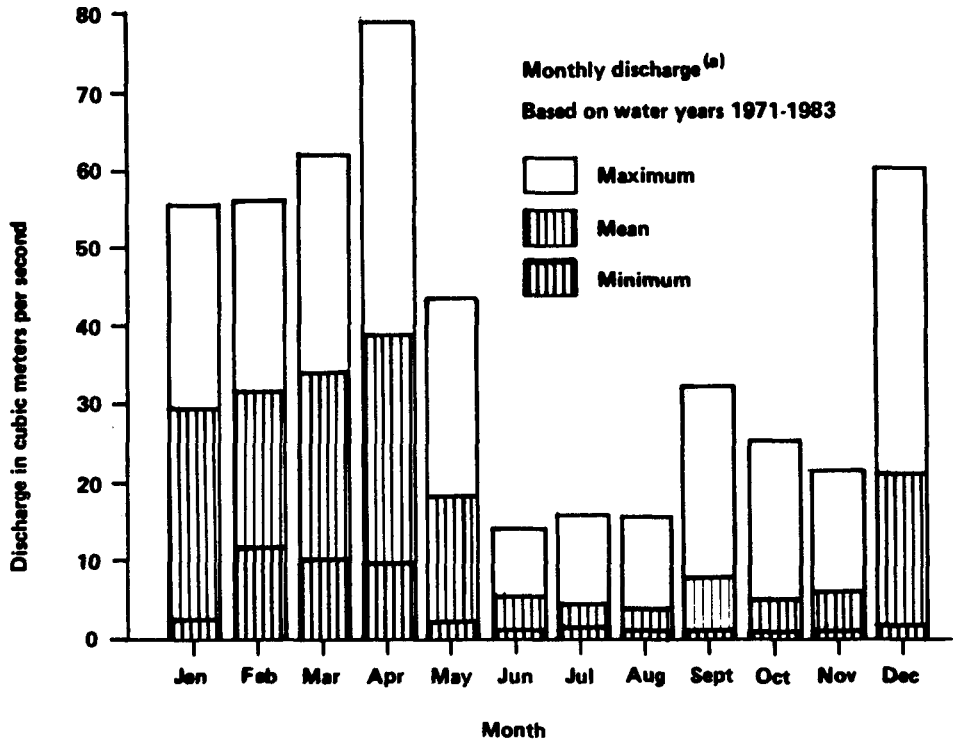
Table 3-17. Streamflow Characteristics at Selected U.S. Geological Survey Gaging Stations Near Richton Dome, Mississippi[a]

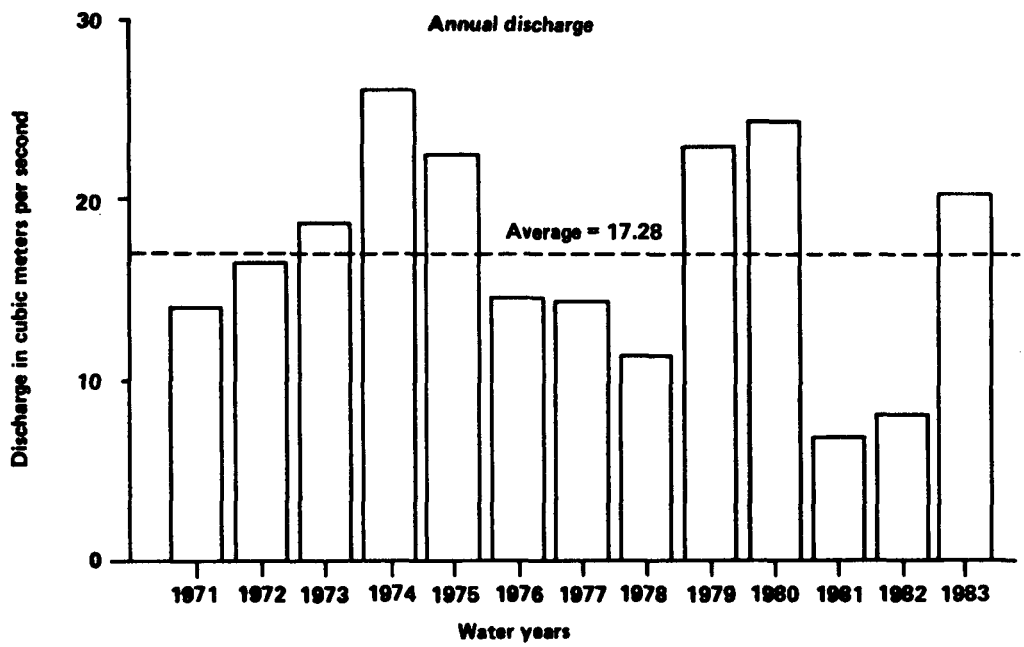
USGS Station Number	Stream Name and Location[a]	Drainage Area (km^2)	Period of Record[b]	Average Annual Discharge (m^3/s)	Average Annual Runoff (mm/yr)	Peak Discharge (m^3/s), Date Recorded	Minimum Discharge (m^3/s), Date Recorded	2-Year, 7-Day Low Flow (m^3/s)	2-Year, 7-Day Low Flow per Square Kilometer of Drainage Area ($m^3/s/km^2$)[c]
02473000	Leaf River (at Hattiesburg)	4,527	1939-1983	76.10	530	3,430 / 4/15/74	9.01 / 10/22/63	14.26	0.0031
02474500	Tallahala Creek (near Runnelstown)	1,585	1940-1983	26.88	535	929 / 2/24/61	0.82 / 10/31/63	1.73	0.0001
02474600	Bogue Homo (near Richton)	891	1970-1983	17.28	612	620 / 12/28/73	0.18 / 8/1, 2, 4, 5/81	0.28	0.0003
02474800	Thompson Creek	482	1943, 1951, 1953-1957, 1964-1965	ND	ND	ND	0.09 / 10/16/63	0.19[c]	0.0004
02474820	Thompson Creek (near Hintonville)	549	1964-1965	ND	ND	ND	0.23[g] / 1963	0.42[c]	0.0008
02474900	Piney Woods Creek (near Richton)	140	Unknown	ND	ND	ND	0.005 / 1952	0.01[c]	0.0001

Note: ND = No data

(a) Locations of stations shown on Figure 3-24.
(b) In water years (period of record of data used to compute 2-year, 7-day low flow value may differ from period of record shown in table).
(c) Data recorded fall within 1964 water year.

Sources: Tharpe, 1975, p. 38; USGS, 1982a, pp. 74, 80, 81; USGS, 1984b; U.S. Army Corps of Engineers, 1968, p. D-22.





(a) All values measured from zero.

(b) USGS station number 02474600.

Source: USGS, 1984a.

Annual and Monthly Discharges Recorded at Bogue Homo Near Richton, Mississippi[b]

Figure 3-26

750 milligrams per liter as a monthly average, nor exceed 1,500 milligrams per liter at any time; dissolved oxygen generally should not be less than 4.0 milligrams per liter; and pH should be between 6.0 and 8.5 (Mississippi Department of Natural Resources, 1982, pp. A-3 through A-7, A-14).

In general, streams in the sub-basin have met these water-quality criteria. Some problems have been observed with reported values of dissolved oxygen, pH, and bacteria in the Leaf River, and reported values of nutrients and bacteria on the Tallahala Creek (Mississippi Department of Natural Resources, 1982, p. 2). Chloride concentrations greater than 100 milligrams per liter have been observed intermittently in the sub-basin. Chloride concentrations as high as 600 milligrams per liter have been reported for Thompson Creek near Hintonville, Mississippi (Table 3-18). For a discussion of possible sources of chloride, see Section 3.2.5.7.

A summary of water-quality data collected in the sub-basin since 1958 is presented in Table 3-18. The average and range of all recorded values are provided. Values of pH have ranged from 4.4 to 7.6, indicating that the surface waters in the area are generally slightly acidic. Reported concentrations of dissolved oxygen have ranged from 5 to 12 milligrams per liter, and are well above the minimum criterion for "Fish and Wildlife" waters. Concentrations of total dissolved solids have been reported to range from 37 to 289 milligrams per liter. However, at Thompson Creek near Hintonville, Mississippi, where an equivalent chloride concentration of 600 milligrams per liter (based on a specific conductance level of 1,970 micromhos per centimeter) was reported, a concurrently measured TDS concentration would have been greater than 289 milligrams per liter.

3.3.1.3 Flooding

Although localized flooding may result from either summer thunderstorms or hurricanes, the largest and most widespread flooding in the sub-basin usually occurs in the winter or early spring, following a frontal storm which lasts several days. Rainstorms from January through April frequently saturate the ground, producing extensive overland runoff during an intense frontal storm. Generally, a 24-hour rainfall of 12 to 15 centimeters (5 to 6 inches) over a large area of the Pascagoula River Basin produces severe flooding, and 7 to 10 centimeters (3 to 4 inches) is sufficient to produce local flooding of small tributaries (BNI, 1982, ONWI-193, p. 29). Severe floodings were recorded in 1961 and 1974 in many streams in the Leaf River Basin. Many of the flood discharges recorded represent the extremes to date. The lower reaches of Bogue Homo and Thompson Creek are subject to flood damage (U.S. Army Corps of Engineers, 1968, p. D-44). The only flood record available for drainage basins in the vicinity of Richton Dome is at the Bogue Homo gaging station, approximately 10 kilometers (6 miles) upstream from Richton Dome. From 1970 to 1983, the maximum flood peak discharge was 620 cubic meters per second (21,900 cubic feet per second), recorded on December 28, 1973 (Table 3-17). Flood Hazard Boundary Maps have been published by the U.S. Department of Housing and Urban Development (1978, Maps). These maps show the estimated 100-year floodplain for unincorporated areas of Perry County. None of the area over the dome lies within the approximated 100-year floodplain.

Streams that drain the area over the dome were studied to delineate the area that would be inundated by the probable maximum flood (PMF) (ETC, 1985c). This flood was determined using the following:

- Published probable maximum precipitation values for the area
- Estimated hydrologic response characteristics of the watershed to the probable maximum precipitation
- The U.S. Army Corps of Engineers (1981) Flood Hydrograph Package, published as HEC-1.

The area of inundation is shown in Figure 3-27. Approximately 264 hectares (653 acres), or 10 percent of the area over the dome defined by the surface projection of the -610-meter

Table 3-18. Surface-Water-Quality Data from Selected U.S. Geological Survey Gaging Stations near Richton Dome, Mississippi[a]

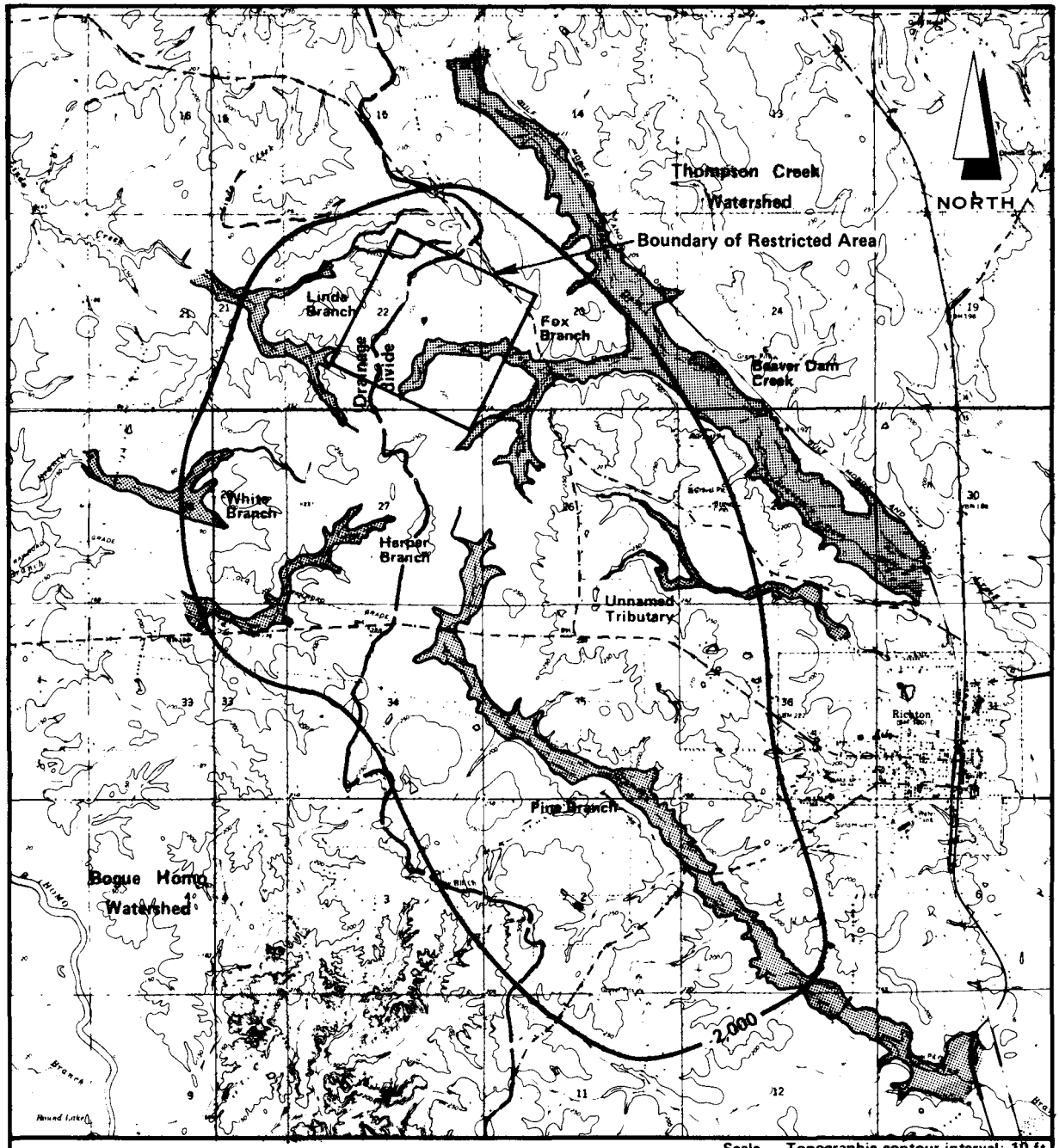
Station No.: Source Stream (Location): Parameter	02473360 Leaf River (near Mahned, MS)	02474500 Tallahala Creek (near Runnelstown, MS)	02474540 Tallahala Creek (near Mahned, MS)	02474600 Bogue Homo (near Richton, MS)	02474670 Bogue Homo (near New Augusta, MS)	02474740 Leaf River (at Beaumont, MS)	02474798 Beaver Dam Creek (at Richton, MS)	02474820 Thompson Creek (near Hintonville, MS)
Streamflow (cfs)								
Average	1465.6	802.5	534.7	544.1	134.0	1152.3	ND	18.4
Range	550-2750	8.0-8040	47-3700	4.7-3700	17.3-350	690-1790		8.0-30.3
Sampling period	08/65-11/71	01/58-07/73	10/63-11/71	10/63-07/71	10/63-11/71	01/65-11/71		10/63-11/71
No. of measurements	17	123	10	12	12	4		8
Temperature (°C)								
Average	20.2	18.2	20.4	19.8	19.4	19.5	22.3	18.2
Range	5.0-30.0	4.0-31.0	8.0-27.5	8.8-28.0	8.5-30.0	4.0-32.0	20.5-24.0	6.0-30.0
Sampling period	08/65-10/73	01/58-06/75	10/63-06/75	10/63-08/78	10/63-04/78	01/65-08/81	04/78-08/78	10/63-04/78
No. of samples	26	142	15	9	32	48	2	32
pH								
Average	6.2	6.3	6.1	6.2	6.2	6.6	6.3	5.4
Range	5.2-7.0	5.0-7.4	5.5-7.6	5.5-6.8	5.3-6.9	5.3-7.3	--	4.4-6.7
Sampling period	08/65-10/73	11/59-06/75	10/63-06/75	10/63-07/78	03.69-04/73	11/71-08/81	08/78	03/69-04/73
No. of samples	31	72	13	6	25	45	1	25
Dissolved oxygen (mg/l)								
Average	7.3	7.8	7.3	ND	8.9	8.0	8.8	8.6
Range	5.7-12.0	0.0-70.0[b]	6.5-9.5		7.1-11.6	5.0-12.0	--	6.3-11.3
Sampling period	10/69-10/73	10/69-06/75	11/71-06/75		11/69-04/78	11/71-08/81	04/78	11/69-04/78
No. of samples	23	63	7		24	44	1	15
Alkalinity (mg/l)								
Average	9.9	27.1	19.3	14.5	9.0	13/7	2.0	16.0
Range	6.0-22.0	5.0-167.0	9.0-36.0	7.0-36.0	--	11.0-15.0	--	--
Sampling period	08/65-09/70	11/59-04/75	10/63-03/69	10/63-08/78	03/69	10/77-10/79	08/78	03/69
No. of samples	12	29	6	6	1	3	1	1
Chloride (mg/l)								
Average	46.0	15.9	18.9	27.1	49.5	10.0	3.3	304.6
Range	5.0-160.0	4.5-34.0	7.1-38.0	6.7-103.0	34.0-65.0	8.2-12.0	--	9.1-600.0
Sampling period	08/65-11/71	11/59-04.75	10/63-11/71	10/63-08/78	03/69-11/71	11/71-06/81	08/78	03/69-11/71
No. of samples	5	19	7	6	2	5	1	2
Total hardness (mg/l)								
Average	14.9	29/6	19/5	21.0	34.0	12.3	5.0	18.0
Range	8.0-23.0	15.0-122.0	12.0-26.0	12.0-45.0	--	10.0-15.0	--	--
Sampling period	08/65-09/70	11/59-04/75	10/63-03/69	10/63-08/78	03/69	10/77-06/81	08/78	03/69
No. of samples	10	29	6	6	1	4	1	1

Table 3-18. Surface-Water-Quality Data from Selected U.S. Geological Survey Gaging Stations near Richton Dome, Mississippi[a]
(Page 2 of 2)

Station No.: Source Stream (Location):	02473360 Leaf River (near Mahned, MS)	02474500 Tallahala Creek (near Runnelstown, MS)	02474540 Tallahala Creek (near Mahned, MS)	02474600 Bogue Homo (near Richton, MS)	02474670 Bogue Homo (near New Augusta, MS)	02474740 Leaf River (at Beaumont, MS)	02474798 Beaver Dam Creek (at Richton, MS)	02474820 Thompson Creek (near Hintonville, MS)
Parameter								
Nitrate as dissolved NO_3 (mg/l)								
Average	0.5	0.2	0.4	0.4	0.0	ND	ND	0.0
Range	0.0-1.5	0.0-0.8	0.1-1.0	0.2-1.0	0.0-0.1			0.0-0.1
Sampling period	08/65-10/69	11/59-07/73	10/63-03/69	10/63-11/65	03/69-11/72			03/69-11/72
No. of samples	5	19	6	5	3			3
Sodium (mg/l)								
Average	30.5	21.2	15.4	16.4	25.0	8.3	2.0	122.7
Range	3.2-99	2.4-71.0	4.1-35.0	4.0-51.0	18.0-32.0	7.0-9.7	--	5.4-240.0
Sampling period	08/65-11/71	11/59-07/73	10/63-11/71	10/63-08/78	03/69-11/71	11/71-06/81	08/78	03/69-11/71
No. of samples	12	22	7	6	2	5	1	2
Sulfate (mg/l)								
Average	11.3	8.9	5.7	4.8	4.2	4.0	1.3	2.2
Range	1.2-55.0	3.2-58.0	3.6-9.2	2.2-9.2	--	2.1-5.8	--	--
Sampling period	08/65-09/70	11/59-04/75	10/63-03/69	10/63-08/78	03/69	10/77-06/81	08/78	03/69
No. of samples	12	27	6	6	1	4	1	1
Total dissolved solids (mg/l)								
Average	187.5	75.5	65.7	32.0	127.0	ND	21.0	43.0
Range	86.0-289.0	59.0-92.0	37.0-92.0	--	--		--	--
Sampling period	11/65-03/69	11/59-06/69	10/63-03/69	08/78	03/69		08/78	03/69
No. of samples	2	2	6	1	1		1	1
Specific conductance at 25°C (micromhos/cm)								
Average	140	124	114	338	223	72	25	118
Range	40-675	13-300	63-282	60-1300	28-1250	30-230	--	10-1970
Sampling period	08/65-10/73	11/59-06/75	10/63-06/75	10/63-08/78	10/65-04/78	01/65-08/81	04/78-08/78	10/63-04/78
No. of samples	33	132	17	13	32	48	2	31
Suspended sediment (mg/l)								
Average	ND	76.0	ND	ND	ND	76.9	ND	ND
Range		24.0-195.0				7.0-390.0		
Sampling period		09/74-06/75				10/77-08/81		
No. of samples		9				43		

Note: ND = No data
(a) Locations of stations shown in Figure 3-24.
(b) Both extremes are considered questionable and possibly invalid.

Source: EPA, 1984.



Explanation

-2,000- Approximate -2,000-foot MSL structural contour of salt

Area inundated by Probable Maximum Flood

Scale Topographic contour interval: 10 ft.

0 1 2 km

0 1 2 mi

Sources: USGS, 1973, map; U.S. Department of Housing and Urban Development, 1978; LETCo, 1982, ONWI-120, p. 14-87; USGS, 1982a, map; USGS, 1982c, map; ETC, 1985b, Figure 2-5.

Floodplain Delineation
Richton Dome, Mississippi

Figure 3-27

(-2,000-foot) MSL structural contour of the salt dome, would be inundated by a PMF event (ETC, 1985c). Backwater effects from Bogue Homo and Thompson Creek were found to be insignificant in comparison with the PMF stages caused by site drainage alone.

3.3.2 Ground Water

This section discusses the hydrology modeling and general ground-water quality for the area around Richton Dome.

3.3.2.1 Hydrology

The following section describes the geohydrologic units identified for this evaluation of the regional ground-water system, and the flow through these units.

3.3.2.1.1 Geohydrologic Units. Six principal geohydrologic units have been identified following the review of published information on the lithology and hydraulic properties of the geologic units within the Richton Dome area (Table 3-19). The geologic formations that constitute each of these principal geohydrologic units exhibit similar water-transmitting characteristics and each unit acts as a single hydraulic unit in the dome vicinity. The six units identified are as follows:

- The Upper Aquifer unit
- The Vicksburg-Jackson confining unit
- The Upper Claiborne aquifer unit
- The Lower Claiborne confining unit
- The Wilcox aquifer unit
- The Midway confining unit.

The hydraulic nature (i.e., aquifer or confining unit) of each unit was determined by water budget analyses of each unit and evaluation of the existing geohydrologic data (Ertec, 1983, ONWI-456, pp. 9-24; ETC, 1985d, pp. 66-68, 72-75, 104-105, 128-130).

A summary of the stratigraphic components, lithologies, and hydraulic properties of the geohydrologic units is provided in Table 3-19. Figure 3-28 shows the outcrop patterns of the generalized geologic units that correspond with these geohydrologic units. Limited data exist to define porosity values of the units listed above. Values of total porosity were obtained from laboratory analysis of sidewall cores (Slaughter et al., 1983, ONWI-356, pp. 35, 36). These values are presented below. Values of effective porosity, the ratio of the volume of drainable pore space to the total volume of rock or soil (Todd, 1959, p. 23), have not been specifically measured. Only the geohydrologic units listed in Table 3-19 were considered in this evaluation of the ground-water flow system. The Midway unit was chosen as the lower boundary of the ground-water system because, regionally, it serves as an effective barrier to ground-water flow (Ertec, 1983, ONWI-456, p. 24). A stratigraphic column of the Richton Dome area is given in Figure 3-9. The geologic conditions (i.e., structural features and stratigraphic relationships) are described in Section 3.2.

The Upper Aquifer unit is the uppermost water-bearing unit and consists of formations of late Oligocene to early Pleistocene age. The Pleistocene and Holocene-age unconsolidated deposits are underlain by the Citronelle Formation. The Citronelle Formation is generally discontinuous and often occurs as isolated outcrops on the crests of hills. It is difficult to distinguish between the Pascagoula, and Hattiesburg formations on a regional basis, or to identify the contact between the Catahoula Formation and the Pascagoula and Hattiesburg formations in the subsurface (Newcome, 1975, Sheet 1). The Tatum Limestone member at the base of the Catahoula Formation is distinguishable from the more permeable upper Catahoula.

Permeabilities of the formations in the Upper Aquifer unit are variable. However, there is sufficient contrast (2 to 3 orders of magnitude) in permeability between the underlying Vicksburg-Jackson confining unit and any of the overlying formations to warrant grouping these upper formations into a single Upper Aquifer geohydrologic unit. Additionally, ground-water

Table 3-19. Description of Geohydrologic Units, Richton Dome, Mississippi

GEOHYDROLOGIC UNITS	GEOLOGIC UNITS[a][b][c]	LOCAL RANGE IN THICKNESS[b] (Meters)	LITHOLOGIC CHARACTER[c]	WATER-BEARING CHARACTERISTIC[d]	HYDRAULIC CONDUCTIVITY (m/day)		TRANSMISSIVITY,[f] (m^3/day/m)
					Horizontal[a]	Vertical[e]	
Upper Aquifer	Alluvium	297–402	Quartz sand, chert and quartz gravel, and silty clay	Furnishes water supplies for domestic wells	3–30	0.23	0.5–4,460
	Terrace Deposits			Well yields from 20 to 510 gpm			
	Citronelle		Silty, clayey sand grading into gravel				
	Pascagoula-Hattiesburg		Interbedded gravelly sand, sand, silty clay, and lignite	Supplies, many municipal and industrial water users			
	Catahoula		Silt, clay, fine- to medium-grained sand, gravel, lignite and a marker Heterostegina Zone (Tatum limestone member)	Well yields range from 2 to 1,484 gpm			
Vicksburg-Jackson Confining Unit	Chickasawhay	116–167	Argillaceous to sandy limestone, interbedded with clay and marl	Supplies some domestic wells in northern Mississippi. Well yields range from 5 to 385 gpm	$3x10^{-4}$–$3x10^{-2}$	$1.5x10^{-4}$	62–310
	Vicksburg Group		Limestone, sandstone, and clay				
	Forest Hill Sand/ Red Bluff Clay		Sandy to silty carbonaceous clay and partially indurated fossiliferous marl				
	Jackson Group		Variably limy, glauconitic, sandy and silty clay, with basal chalky limestone (Ocala Facies)	Contains slightly saline water in the vicinity of the dome			
Upper Claiborne Aquifer	Cockfield	130–180	Limestone, sand streaked, lignitic-bearing clay and silt	Contains saline water	$3x10^{-2}$–$3x10^{-1}$	$1.5x10^{-3}$	0.004–990
	Cook Mountain		Loosely cemented, porous carbonate sand, glauconitic clay shale, and calcarenitic limestone	Well yields where fresh range from 20 to 1,000 gpm			
	Kosciusko (Sparta)		Limestone with thin beds of clay, locally sandy				
Lower Claiborne Confining Unit	Zilpha Clay	116–163	Interbedded glauconitic clay shale, chalk, and chalky limestone	Confining unit	$3x10^{-5}$–$3x10^{-3}$	$3.0x10^{-6}$	—
	Winona Sand		Clay shale containing chalk or marl lenses				
	Tallahatta Formation[g]		Glauconitic and limy siltstone and claystone interbedded with clay shale				
Wilcox Aquifer	Meridian Sand	685–793	Sand with sandy shale and lignitic clay	Well yields 75 to 750 gpm	0.3–15	0.003–0.1	2.4–1,490
	Wilcox Group		Silty, lignitic shale interbedded with silt, sand, lignitic siltstone, and fine- to medium-grained sandstone	Contains saline water Well yields 150 to 1660 gpm			
Midway Confining Unit	Porters Creek Clay	241–273	Interbedded shales, lignite, silt, siltstone, and sandstone	Confining unit	—	—	—
	Clayton		Sandy, glauconitic marl, marly chalk, or calcareous clay.				

(a) – Ertec, 1983, ONWI-456, pp. 8, 16.

(b) – Figure 3-9.

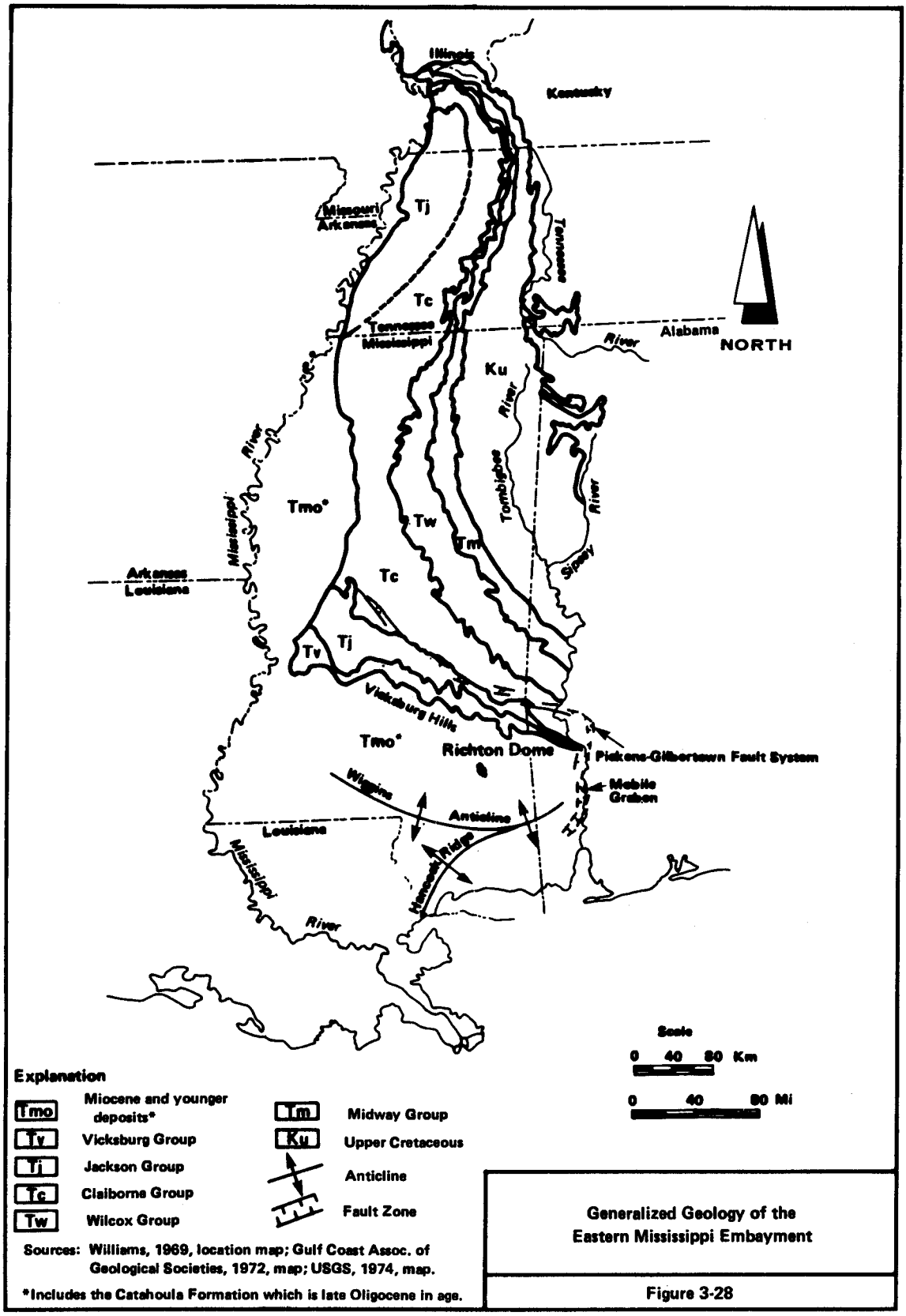
(c) – LETCo, 1982, ONWI-120, pp. 12-23.

(d) – Shows et al., 1966, pp. 58-61
Newcome, 1976, Plate 1
Boswell, 1976a, Plate 1
Boswell, 1976b, Plates 1, 3
Spiers, 1977, Plate 2
Boswell, 1979, Plate 1
Gandl, 1979, Plate 2
Spiers and Gandl, 1980, Table 1.

(e) – Ertec, 1983, ONWI-484, p. 72, Table 4-3.

(f) – Shows et al., 1966, p. 62
Taylor et al., 1968, p. 66
Newcome, 1971, pp. 11-13, 20, 22, 23, 27-43
Luper et al., 1972, p. 171
May et al., 1974, p. 264
LETCo, 1982, ONWI-120, Vol. VII, pp. A-4-15, C-1-10 through C-1-15.

(g) – The Meridan Sand is actually the base of the Tallahatta Formation but is included as part of the Wilcox aquifer unit for this report.



Generalized Geology of the Eastern Mississippi Embayment

Figure 3-28

flow directions and ground-water divides are the same for all formations in the Upper Aquifer unit based on an analysis of shallow and deep water levels (ETC, 1985d, pp. 124-128).

The Upper Aquifer unit is exposed from northwestern Mississippi to the Gulf of Mexico (Figure 3-28). The thickness of this unit increases toward the Gulf of Mexico (Brown et al., 1944, Plates 2, 7, 10). Porosity values obtained from laboratory analyses of sidewall cores for this unit range from 0.25 to 0.29 (Slaughter et al., 1983, ONWI-356, pp. 35, 36, 41-46). Published estimates of storativity range from 0.0001 to 0.01, suggesting mixed, confined, and unconfined aquifer conditions.

The Vicksburg-Jackson confining unit underlies the Upper Aquifer unit (Figure 3-28). The unit consists of sand, silt, and clay in central Mississippi, grading to clay in the south (Ertec, 1983, ONWI-456, p. 15). The Vicksburg-Jackson unit dips southward from its outcrop area in north-central Mississippi (north of Richton Dome). Near the outcrop area, the Forest Hill Sand Formation and other geologic members serve as minor aquifers, primarily for domestic and farm use. The sand content within the Vicksburg-Jackson unit decreases rapidly in the downdip direction several miles south of the outcrop area. North of the dome the Forest Hill Sand grades into the Red Bluff Clay (Gandl, 1979, Sheet 1). In effect, the unit changes from a minor aquifer to a confining unit. Transmissivity values given in Table 3-18 are based on data from northern areas where the unit acts locally as a minor aquifer. Transmissivities in the vicinity of the dome are probably significantly lower because of the decreased sand content in this direction. Porosity values obtained from laboratory analyses of sidewall cores range from 0.22 to 0.35 (Slaughter et al., 1983, ONWI-356, pp. 35, 36, 41-46). A storativity value of 0.0001 has been reported for the Vicksburg-Jackson unit, based on aquifer test data obtained from a well in Rankin County (Newcome, 1971, p. 38).

The Upper Claiborne aquifer unit underlies the Vicksburg-Jackson unit and dips to the southwest from its outcrop area in northern and central Mississippi (Figure 3-28). Generally, the Upper Claiborne unit is composed of fine- to medium-grained sand, with minor amounts of silt and clay; down dip, this unit consists of sand, glauconite, chalky limestone, and limestone interbedded with glauconitic clayey shale (Dinkins, 1967, pp. 209-211). The Sparta (Kosciusko) and Cockfield formations are aquifers in the northern outcrop areas. They are separated by the Cook Mountain Formation, which is not considered an aquifer. The three formations have been lumped together to form the Upper Claiborne aquifer unit because both the Sparata and Cockfield formations decrease uniformly in sand percentage to the south and because inflow from the outcrop area is the primary source for vertical leakage through the Lower Claiborne and Vicksburg-Jackson confining units. Porosity values obtained from laboratory analyses of sidewall cores ranged from 0.27 to 0.37 (Slaughter et al., 1983, ONWI-356, pp. 35, 36, 41-46). Storativity values based on aquifer test data obtained in Madison, Smith, and Rankin Counties northwest of Richton Dome range from 0.0003 to 0.0008 (Newcome, 1971, pp. 33, 38, 39).

The Lower Claiborne confining unit consists of geologic formations of relatively uniform fine-grained lithology underlying the Upper Claiborne unit. This unit dips west to southwest from its outcrop area in central Mississippi (Figure 3-28). Too few data exist to quantify the hydrologic characteristics of the Lower Claiborne, but its confining nature, based on lithologic descriptions, is well documented (Dinkins, 1967).

The Wilcox aquifer unit underlies the Lower Claiborne confining unit and is composed of the Meridian Sand and Wilcox Group. The Meridian Sand is the basal portion of the Tallahatta Formation (geologically grouped with the overlying Lower Claiborne confining unit), but is estimated to have hydraulic properties similar to the Wilcox Group. The nonmarine Naheola Formation of the underlying Midway Group is transitional between the Porter's Creek clay and the sand of the overlying Wilcox Group (ETC, 1985d, pp. 46). Therefore, the Meridian Sand and Naheola Formation are included as part of the Wilcox unit in this ground-water system evaluation. From central Mississippi the Wilcox aquifer unit dips southward from its outcrop area toward the Gulf Coast (Figure 3-28). The unit is composed of predominantly nonmarine sediments. The wide ranges in conductivity and transmissivity values shown in Table 3-19 are caused by the increased silt and clay content downdip. Porosity values obtained from

laboratory analyses of sidewall cores ranged from 0.25 to 0.38 (Slaughter et al., 1983, ONWI-356, pp. 35, 36, 41-46).

The Midway confining unit underlies the Wilcox unit. The Midway unit crops out as a relatively narrow band in the northeastern portion of Mississippi (Figure 3-28). Although the hydraulic properties of this unit are poorly documented, the lateral thickness of the fine-grained materials suggests that it is an effective confining barrier to vertical ground-water movement (Ertec, 1983, ONWI-456, pp. 21, 24).

3.3.2.1.2 Ground-Water Flow. The regional ground-water flow regime in the Richton Dome area is discussed in terms of flow within and between geohydrologic units that are described above and summarized in Table 3-19. Each unit is recharged over its outcrop area by precipitation. Downdip of surface exposures, additional recharge is generally available to each unit by vertical leakage through overlying units. Recharge for the Claiborne and Wilcox aquifer units occurs over outcrop areas in central Mississippi. Recharge to the Upper Aquifer unit occurs over the southern portion of Mississippi; recharge zones, however, are interspersed with local discharge zones near the larger rivers and streams. Locally, recharge areas for the Upper Aquifer unit occur over and adjacent to Richton Dome.

Initial estimates of recharge to the geohydrologic units were determined from (1) a surficial hydrologic budget considering precipitation, total runoff, and evapotranspiration; and (2) water budget analyses of the units. Long-term averages of monthly and annual precipitation and evapotranspiration were determined from published records of 23 precipitation and 3 pan evaporation stations in the study area. Ground-water runoff as base flow to streams and surface-water runoff were determined by hydrograph separation analysis of a representative gaging station record (ETC, 1985d, pp. 22-30).

As discussed in Section 3.2.3, the sediments in the region generally dip to the south as a result of subsidence of the Gulf Basin. Regional ground-water flow within the aquifer units underlying the Vicksburg-Jackson confining unit is generally in the downdip (southerly) direction from aquifer outcrop (recharge) areas (Table 3-19) to discharge areas along the Gulf Coast and in the Gulf of Mexico (Ertec, 1983, ONWI-484, p. 67). In the southern portion of the system, regional ground-water flow in these aquifer units has a significant vertical component due to structural controls and decreasing permeability. Local variations in the regional flow pattern occur as a result of ground-water withdrawal, vertical aquifer recharge, and discharge to streams. These local variations are most prominent in the outcrop (recharge) areas of the lower aquifer units. Ground-water flow direction in the Upper Aquifer unit is controlled by topography and the location of major drainages where ground-water discharge occurs. Regional ground-water flow in the confining units is generally southward in outcrop (recharge) areas. To the south, and in the Richton Dome vicinity, ground-water flow in the confining units is primarily vertical.

The geohydrologic data base used for characterization of the regional ground-water flow system in the vicinity of Richton Dome included published or available information in the form of aquifer tests, water-level measurements, water-use data, sand percentage maps, lithologic and geophysical logs, and petroleum information cards. The number of data points for the primary data types is summarized by geohydrologic unit in Table 3-20. This table is based on data summarized in ETC (1985d, pp. 37-130). All data points are located within the area approximated by Figure 3-29.

Data on ground-water levels and flow in the units have been collected from available publications, which include a current monitoring program (Ertec, 1984, BMI/ONWI-525, pp. 3-17) and the USGS water-well data base (USGS, 1984a). These data indicate that the flow potential in the confining units is predominantly in the vertical direction and in the aquifer units it is predominantly in the horizontal direction.

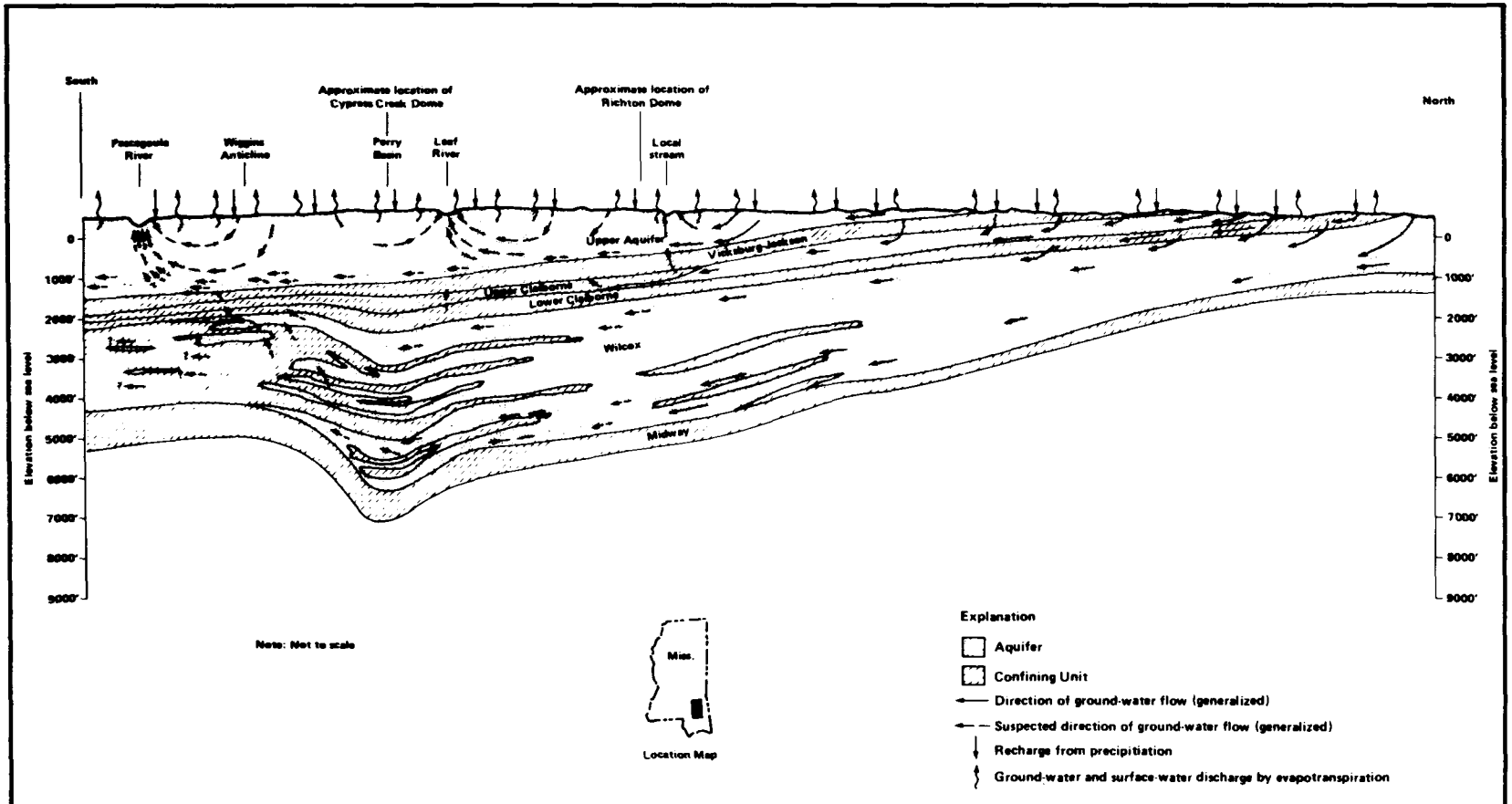
A water-level contour map (Figure 3-30) has been prepared for the Upper Aquifer unit based on water-level data as summarized in Table 3-20 (Ertec, 1983, ONWI-456, p. 26). Data points were fairly evenly distributed throughout the outcrop area. The ground-water table is a subdued expression of the surface topography, with ground-water mounds evident in areas of

Table 3-20. Summary of Primary Geohydrologic Data
Richton Dome, Mississippi

Type of Data	Number of Data Points by Geohydrologic Unit				
	Wilcox	Lower Claiborne	Upper Claiborne	Vicksburg-Jackson	Upper Aquifer
Aquifer Tests	15	0	37	6	135
Water Levels (No. of Wells)	8	0	13	0	5,840
Water Use Pumping (a)	3	0	7	0	21
Injection(b)	26	(c)	9	(c)	(c)

(a) Number of counties -- data available only by county.
(b) Number of injection fields for which data were available.
(c) No injection.

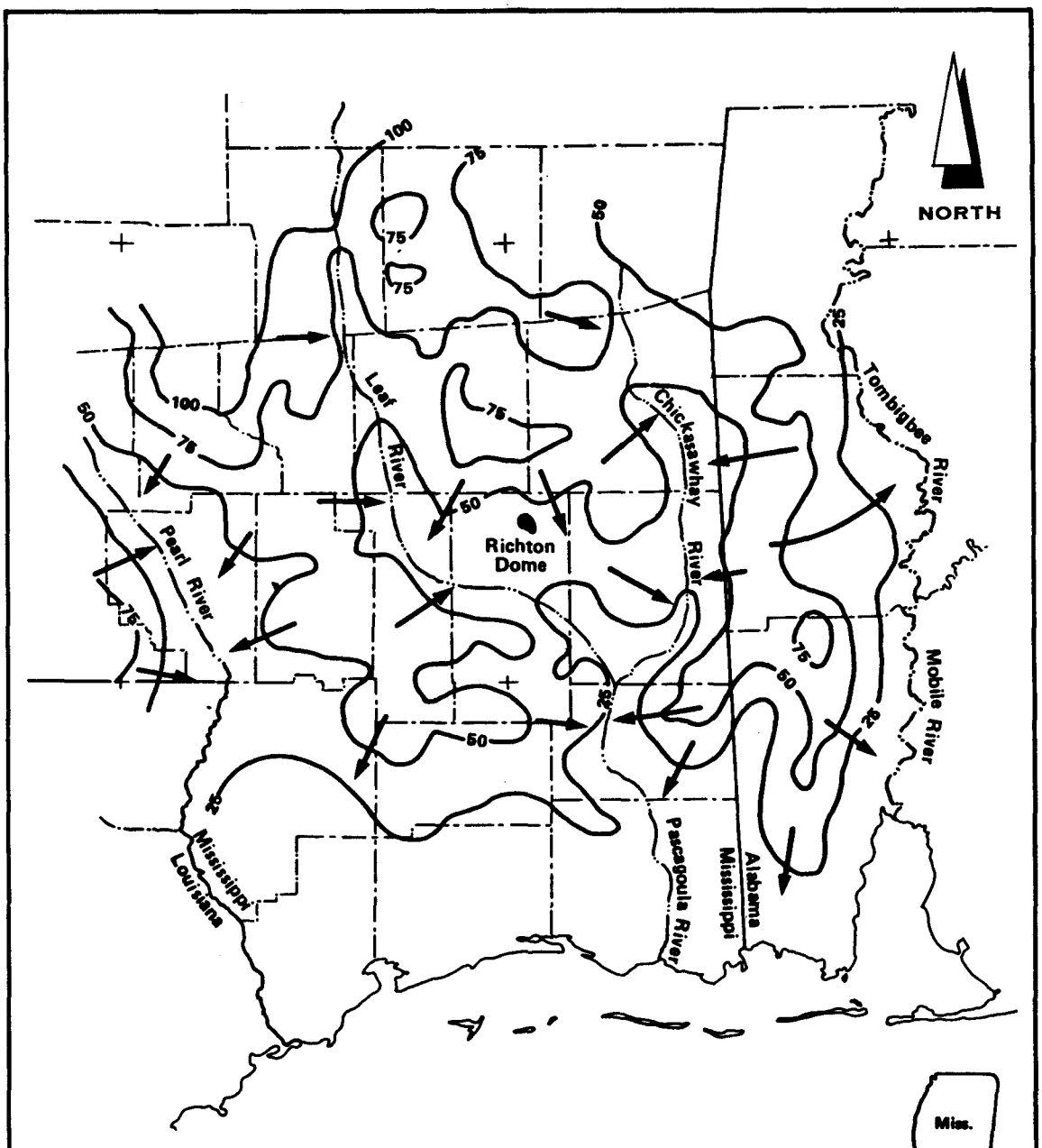
Source: ETC, 1985d, pp. 37-130.



Adapted from: Williams, 1969, Map.

Schematic Cross Section of the Regional Ground-Water Flow System in the Vicinity of Richton Dome, Mississippi

Figure 3-29



Sources: Ertec, 1983, ONWI-456, p. 26; ETC, 1984, BMI/ONWI-511, Figure 5.

Ground-Water Flow Directions and Head Distribution in Upper Aquifer Unit Richton Dome, Mississippi

Figure 3-30

higher topographic elevation and local ground-water flow toward major drainages (Ertec, 1983, ONWI-484, p. 67). Ground-water discharge occurs as direct inflow (baseflow) to the streams (Ertec, 1983, ONWI-456, p. 25). Hydraulic properties of the Upper Aquifer unit were defined based on results of 135 aquifer tests.

The Vicksburg-Jackson unit represents the uppermost confining layer in the sedimentary sequence in the Richton Dome area. As discussed in Section 3.3.2.1, members of the Vicksburg-Jackson unit grade into a fine-grained facies confining the underlying Upper Claiborne unit. Ground-water flow in this unit near Richton Dome is predominantly upward (Ertec, 1983, ONWI-484, p. 79, 80). Limited aquifer test data were available to define hydraulic properties of the unit. The existing data were from the northern area of outcrop where the unit is locally an aquifer.

The dominant direction of ground-water flow in the Upper Claiborne unit is from its outcrop area (Figure 3-28) toward the south and southeast. In the Upper Claiborne unit, a diversion of the regional ground-water flow to the southwest has been induced by pumping near Jackson, Mississippi, located 157 kilometers (98 miles) northwest of the dome (Wasson, 1981, map; Wasson, 1980a, map). Data from 37 aquifer tests were interpreted to define the hydraulic properties of the Upper Claiborne unit. These data were generally concentrated in the vicinity of the dome and to the north, near the outcrop area of the unit.

The Lower Claiborne unit separates the Upper Claiborne aquifer unit from the Wilcox aquifer unit. Although sparse data exist on the hydraulic properties of the Lower Claiborne unit, available data suggest that appreciable horizontal flow does not occur through this unit. Based on preliminary modeling results, flow within the Lower Claiborne south of Richton Dome is predominantly upward (Ertec, 1983, ONWI-484, p. 79).

The majority of data on water levels and aquifer properties in the Wilcox unit are limited to the vicinity of its outcrop area north of the dome (Figure 3-28) (Wasson, 1980b, map; Wasson, 1980c, map) and to monitoring wells near the dome. These data suggest that ground-water flow is southward in the Wilcox unit. More detailed definition of ground-water flow directions and aquifer properties south of the outcrop area and south of the dome will require additional data points.

In southern Mississippi, water tends to move from deeper aquifers upward into the overlying units. As discussed above, upward leakage from confining layers is believed to occur throughout most of the Richton Dome area. In central Mississippi, vertical leakage tends to be downward due to ground-water recharge from rainfall over the outcrop areas.

The regional ground-water flow system has been conceptualized based on the geologic and geohydrologic data presented above, and is shown schematically in Figure 3-29. Ground-water flow originates as recharge from precipitation over each unit's outcrop area. Additional recharge is generally available to each unit just downdip of its surface exposure by leakage through overlying units. Flow proceeds laterally in the downdip direction, with some local or areal variations that are dependent on (1) ground-water withdrawal; (2) geologic structures (e.g., the Perry Basin, the Wiggins Anticline, and the Pickens-Gilbertown Fault System [Table 3-19]); and (3) the spatial variation of permeability within each unit. Ground-water movement in the deeper aquifer units has a significant upward component in the southern portion of the system. In central and southern portions of the system, upward leakage is predominant in confining units. This upward leakage results from a combination of the decreased permeability in the downdip direction within each unit caused by lithologic facies changes, and lower hydraulic heads in the Upper Aquifer unit near major rivers. This upward movement of water from deeper aquifers, which are generally more saline, may contribute to the reported high total dissolved solids and chloride concentrations south of Richton Dome (see Section 3.2.5.7).

3.3.2.1.3 Caprock and Salt Stock Hydrogeology. Descriptions of the stratigraphy and structure of Richton Dome are provided in Section 3.2.3. In general, data on salt dome hydrologic characteristics are limited; for Richton Dome, data include extrapolated, direct, and indirect estimates of porosity, permeability, hydraulic conductivity, and flow potential.

Site-specific information on the hydrologic characteristics of the Richton Dome caprock is presented in Werner (1985a, pp. 54-57 and 1985b, pp. 11-64) and LETCo (1982, ONWI-120, pp. 13-117 to 13-118, 14-93). Testing, performed by LETCo at DOE well MRIG-9, yielded hydraulic conductivity values for the undifferentiated caprock of 0.2 meter per day (0.8 foot per day) (LETCo, 1982, ONWI-120, p. 14-93).

The potential for ground-water flow within Richton Dome caprock is dictated principally by the pattern of open fractures and, to a lesser extent, by dissolution vugs and solution channels (Werner, 1985a, p. 74). According to interpretations of driller's logs, permeability within Richton Dome caprock occurs in discrete zones at the top of the caprock, primarily within the limestone portion and near the top of the anhydrite, and does not appear to occur deeper into the caprock (Werner, 1985a, pp. 67-68). Intervening zones of the caprock not disrupted by fractures appear to be relatively impermeable. Ground water from overlying sediments, primarily the Upper Aquifer unit, could enter and exit the caprock through the limestone portion of the caprock and zones of open fractures.

There have been two observations of the occurrence of granular anhydrite and salt at the base of the caprock at Richton Dome. This condition is not believed to be present everywhere at the interface (Werner, 1985b, p. 68). Interpretations of swabbing operations performed on this interval in the MRIG-9 borehole indicate a value for hydraulic conductivity of 0.15 meter per day (0.5 foot per day) (LETCo, 1982, ONWI-120, p. 14-93). Porosity and permeability estimates for a similar interface at Gyp Hill Dome indicate values of 20 percent and 45 millidarcies, respectively (Kreitler and Dutton, 1983, p. 13). Based on the absence of dissolution features on anhydrite grains and the occurrence of highly saline water, flow within the interface appears to be restricted or very slow even though the granular anhydrite may be permeable (Werner, 1985b, p. 65).

There are no studies or data documenting ground-water occurrences or movement in the Richton Dome salt stock. Therefore, an initial assessment of the hydrogeology of the Richton Dome salt stock must be based on general information and data from mines or boreholes in other salt domes. Anomalous conditions in salt domes (including water occurrences) are described in Sections 3.2.3.2.4 (Description) and 3.2.6.1.2 (Mining considerations). Water has been encountered in some salt domes which have been mined. Mining of coastal domes of the Five Island group has identified water occurrences from several locations within the domes. Of the interior domes, the mine in Winnfield Dome encountered brine inflows when workings were advanced close to the edge of the dome. Mines in the Grand Saline and Hockley domes (interior domes) are reportedly dry (Kumar, 1981; Michalski, 1985). Available records suggest that internal water reservoirs in domal salt (when encountered) tend to be significantly smaller than in bedded salt.

Water that has been encountered in mines in domal salt can be grouped into two categories: internal (nonmeteoric or formation) and external (meteoric) water. The majority of fluid occurrences in domal salt mines have isotopic signatures and characteristics of old or isolated formation water. Internal water occurrences are generally isolated (not connected internally or to external sources of water) (Bateman, 1985). The largest internal water occurrence documented in Gulf Coast salt domes occurred in the Jefferson Island mine, was on the order of 25 meters (32 feet) in diameter, and discharged 190 cubic meters (6,170 cubic feet) of water. Internal water flows in Gulf Coast salt domes are generally less than 1 liter per minute (0.3 gallons per minute) and commonly cease within less than 2 years (Bateman, 1985). The association of water occurrences with specific structural features of the dome interior is poorly understood (Bateman, 1985; Michalski, 1985).

The number of reported inflows to domal salt mines from external water sources is small compared to internal water sources, but the inflow rates are generally orders of magnitude higher. However, documented inflows of external water have been related to mining activities and were not associated with naturally occurring fluid pathways through the salt. Reported causes of inflows from external water sources include shaft seal failures or shaft maintenance activities, mining-induced deformation, inadvertent mining too close to the salt stock boundary, and the existence of open boreholes connected to an external water source (Bateman, 1985).

The sandstone-bearing central anomalous zone at the Avery Island mine has had significant water leaks at the shallow mining level (152 meters [500 feet]); the water from the leaks was analyzed as meteoric. This central anomalous zone projects vertically upward to sediments above the dome (Kumar, 1981, p. 43), and the salt is reportedly more fractured (MSHA, 1978, p. 8). A shallow extraction depth (152 meters [500 feet]) and decades of mining with openings of considerable size may have contributed to the formation of passages for infiltration of meteoric water. The first significant leak developed in 1961 (Kumar, 1981, p. 39), some 60 years after mining of the 152-meter (500-foot) level began. A deeper mining level (274 meters [900 feet]) is virtually dry (Kumar, 1981, p. 45), attesting to the effects of depth on the hydraulic integrity of domal salt mines.

There are no data documenting ground-water movement through undisturbed domal salt. Ground water or included fluids could move by Darcian flow, by diffusion, or by migration along stress or thermal gradients. Fluid movement by diffusion or migration along stress gradients would be very slow. Movement by Darcian flow requires that the salt be permeable to some degree. Permeability test data compiled for domal and bedded salt (both laboratory and in situ) indicate a range for salt permeability of from approximately 10^{-12} to about 10^{-22} square meters (1.07×10^{-11} to 1.07×10^{-21} square feet) (Bateman, 1985). Both laboratory and in situ data show a wide variation. Because of the techniques used to obtain salt samples and to perform in situ tests, there is no documented measurement of the permeability of undisturbed bedded or domal salt. Given the available data, it can be assumed that the permeability of undisturbed domal salt is very low.

3.3.2.2 Modeling

Numerical computer models have been used to simulate regional ground-water flow in the vicinity of Richton Dome (Ertec, 1983, ONWI-456, pp. 1, 2; INTERA, 1984, ONWI-502; Metcalfe and Andrews, 1984). These models have provided a useful way to understand the basic water fluxes of the regional ground-water system.

The numerical model developed by The Earth Technology Corporation (Ertec, 1983, ONWI-456; ETC, 1985d) was used to assist in defining the regional ground-water flow system encompassing Richton Dome. The numerical model was applied to refine a conceptual model of the regional flow system developed by detailed analysis of the existing geohydrologic data base. Specific system components evaluated include inflows, outflows, and permeabilities for each geohydrologic unit, vertical leakage between units, and recharge.

The numerical model developed by INTERA (1984, ONWI-502) and Metcalfe and Andrews (1984) was used to evaluate ground-water flow paths and travel times through the host rock and adjacent geohydrologic units. The model was also used for sensitivity and uncertainty analyses on geohydrologic parameters and boundary conditions with respect to simulated ground-water flow paths and travel times.

The major features of the ground-water system that have been incorporated into the models are as follows:

- Heterogeneous and anisotropic aquifer properties
- Surface-water and ground-water interactions (e.g., rivers, recharge from rainfall, and ground-water evapotranspiration)
- Leakage between aquifers
- Variable boundary conditions (e.g., prescribed head or flux, and mixed conditions involving potential leakage)
- Injection into, and withdrawal from, wells.

The conceptual geohydrologic system, described earlier in this section, was approximated by a three-dimensional grid consisting of five layers of elements that correspond to the upper

five geohydrologic units. This numerical approximation of the conceptual system was the framework for the hydrologic modeling. Hydraulic properties and parameters that define the hydrologic system include the geometry and hydraulic conductivities of the geohydrologic units (Figure 3-28), effective precipitation (rainfall minus runoff), potential evapotranspiration, soil moisture characteristics, river flow characteristics, and locations and rates of pumping and injection. These data are presented in Ertec (1983, ONWI-456, pp. 50-70, Appendix B). A similar conceptualization is presented by INTERA (1984, ONWI-502) and Metcalfe and Andrews (1984).

The existing data base was adequate to define a conceptual distribution for most of the input parameters. Data for the hydraulic conductivities of the geohydrologic units did not allow the development of a statistical distribution. Aquifer test data, for all units except the Upper Aquifer unit, were generally limited to the northern outcrop areas and the vicinity of the dome. These data were extrapolated over the regional model area based on published sand percentage maps and lithologic descriptions and available lithologic and geophysical logs from wells completed through the various geohydrologic units. These extrapolations were refined and confirmed by water budget analyses (ETC, 1985d, pp. 66-68, 72-75, 104-105, 128-130).

To test the validity of the conceptual geohydrologic system, heads calculated by The Earth Technology Corporation model have been compared with heads measured in wells which are referred to here as calibration wells. Calibration of the model involves varying selected input parameters over reasonable ranges to improve the agreement between calculated and measured heads. The model results discussed below are considered preliminary, pending improved calibration of the model. However, preliminary results indicate that the conceptual model forms a good approximation of the regional hydrologic system (Ertec, 1983, ONWI-484, pp. 73-85).

The modeling results have produced a qualitative and, to a large extent, quantitative preliminary understanding of the ground-water flow system. The flow regime suggested by the modeling results corresponds closely to the flow pattern discussed above and shown schematically in Figure 3-29. Ground-water flow is predominantly horizontal and southward in the Upper Aquifer, Upper Claiborne, and Wilcox units. Flow is predominantly vertical in the Vicksburg-Jackson and Lower Claiborne units. As shown in Figure 3-29, flow in the Upper Aquifer unit develops an upward component, discharging to the Leaf and Pascagoula Rivers south of the dome (Ertec, 1983, ONWI-484, pp. 73-85). Table 3-21 summarizes modeling results by presenting estimates of the hydraulic head gradients and directions of flow down gradient of the dome. These generalized flow directions are schematically illustrated in Figure 3-31.

Based on preliminary modeling results, approximately 80 percent of the ground water in the modeled system originates as infiltration into the outcrop areas within the modeled area. The remainder represents inflow across the northern model boundaries in the Upper Claiborne and Wilcox units. Some water in the Upper Claiborne and Wilcox units flows through these units and discharges into the Gulf of Mexico, but approximately 95 percent of it flows eventually into the Upper Aquifer unit south of the dome, in the vicinity of the Wiggins Anticline (assumed to be coincident with the facies change in the Wilcox unit). Discharge to the major rivers in central and southern Mississippi accounts for approximately 60 percent of the discharge from the ground-water system (Ertec, 1983, ONWI-456, pp. 134-135).

3.3.2.3 Ground-Water Quality

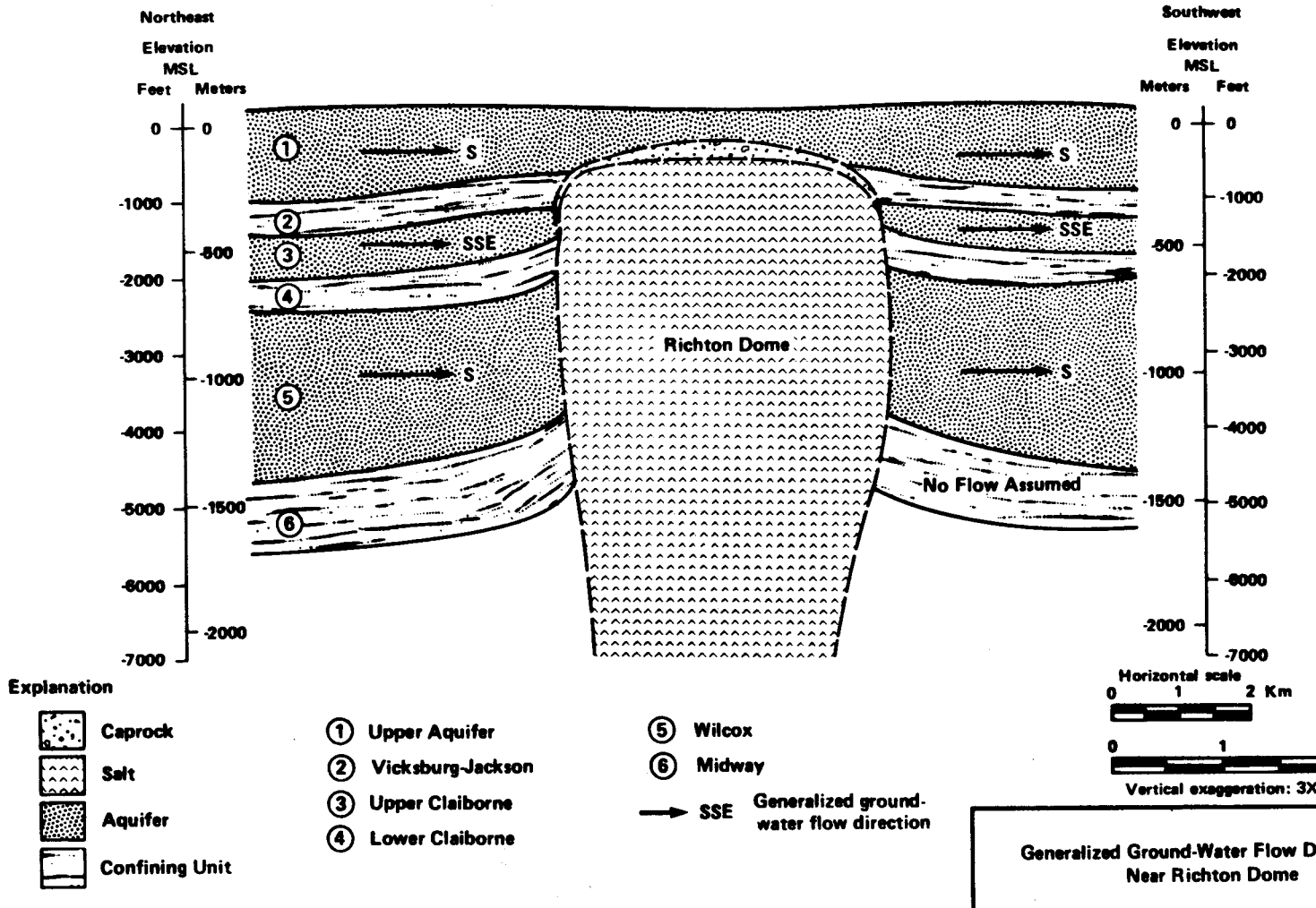
This section presents an overview of the ground-water quality of the three principal aquifer units discussed under Hydrology in Section 3.3.2.1. Water quality is discussed in terms of suitability for human, agricultural, and livestock needs. Water quality standards are presented in Hem (1970, pp. 219, 321-336) and Todd (1959, pp. 184-191). Water suitability has been determined using the following criteria. Domestic water use suitability is based on the total dissolved solids (TDS) concentration. TDS concentrations greater than 1,000 milligrams per liter are considered saline (Hem, 1970, p. 219) and are not desirable for domestic use. Iron concentrations in excess of 0.3 milligrams per liter are not recommended for public water supplies based on the U.S. Public Health Service's 1962 standards (Hem, 1970, p. 322).

Table 3-21. Estimates of Hydraulic Gradient and Direction of Flow in the Vicinity of Richton Dome

Hydrogeologic Unit	Horizontal Gradient[a]	Flow Direction	Vertical Gradient[a]	Flow Direction
Upper Aquifer	6.0×10^{-4}	SSE	2.1×10^{-3}	Slightly Downward
Vicksburg-Jackson	--	--	-9.2×10^{-2}	Upward
Upper Claiborne	1.4×10^{-3}	SSE	-1.6×10^{-3}	Slightly Upward
Lower Claiborne	--	--	-2.7×10^{-2}	Upward
Wilcox	2.1×10^{-4}	Southward	3.5×10^{-4}	Slightly Downward

(a) "Hydraulic gradient" means the change in the hydraulic head per unit of distance in the direction of flow. Values were determined from modeling results by dividing the darcian velocity by the hydraulic conductivity.

Source: Derived from Ertec, 1983, ONWI-484, pp. 72-85.



Sources: Schematic geologic section based on LETCo, 1982, ONWI-117, pp. 13-111, 14-91; flow directions based on Table 3-12.

Generalized Ground-Water Flow Directions Near Richton Dome

Figure 3-31

Upper limits for livestock water range from 2,860 to 12,900 milligrams TDS per liter dependent on the type of livestock (Hem, 1970, p. 324). Some investigators recommend an upper limit of TDS concentrations near 5,000 milligrams per liter for livestock water. Water suitability for irrigation is based on sodium percentage (Todd, 1959, p. 191) and boron concentration. Mitigative measures can be taken, such as adding gypsum to soil to counteract the effects of high sodium levels, thus allowing water to be suitable for irrigation. Sodium percentages for water discussed in this section were calculated using the median concentration values presented in Bentley (1983, pp. 28-32). Conclusions presented in this section are based on the calculated sodium percentages and the median boron concentrations that have been compared to the "Quality Classification of Water for Irrigation" table presented in Todd (1959, p. 191). Based on the above standards, water within the Upper Aquifer unit is fresh and of suitable chemical quality for most uses (Bentley, 1983, pp. 26, 30-32). However, the Upper Claiborne and the Wilcox units contain saline water with up to 198,000 milligrams per liter TDS (Hem, 1970, p. 219; Bentley, 1983, pp. 28-29). In general, ground-water quality deteriorates with depth and down gradient from recharge areas.

The U.S. Geological Survey has collected and analyzed water samples from a number of wells drilled near Richton Dome (Bentley, 1983, p. 26). Table 3-22 summarizes the selected major constituents in ground water from these wells. The results are grouped by geohydrologic unit, with ranges and median values provided for each constituent.

Although water in the Upper Aquifer unit generally is considered fresh and has TDS less than 1,000 milligrams per liter, locally, ground water contains TDS concentrations up to 9,410 milligrams per liter at well MRIH-11D, immediately south of and closest to the dome (refer to Figure 3-18 and Table 3-5), and 130,000 milligrams per liter at MCCH-3C, located 29 kilometers (18 miles) south of the dome (Bentley, 1983, pp. 30-32). Median TDS values for water samples collected from the formations in the Upper Aquifer unit range from 36 to 150 milligrams per liter. Iron concentrations in one-third to one-half of the samples exceed the recommended upper limit for iron in drinking water of 0.3 milligram per liter (Bentley, 1983, pp. 30-32; Hem, 1970, p. 322). Water in the Upper Aquifer unit is suitable for livestock (Hem, 1970, p. 324). The high percentage of sodium in the water makes the water questionable for irrigation (Bentley, 1983, pp. 30-32; Todd, 1959, p. 191).

Upper Aquifer unit water samples from wells MRIH-11D, MH-4D, MCCG-2, and MCCH-3C,D (locations shown in Figure 3-18) have TDS concentrations that vary from 1,680 to 130,000 milligrams per liter. The major ions in these samples are sodium and chloride, with high concentrations of boron and strontium. The high chloride concentrations are discussed further in Section 3.2.5.7. Some of this water may be used for livestock (Hem, 1970, p. 324), but because of the high percentage of sodium and the boron concentration (Bentley, 1983, pp. 30-32), it is generally not recommended for irrigation (Todd, 1959, p. 191).

Water samples collected down gradient of the recharge areas of the Upper Claiborne and Wilcox aquifer units are saline and contain high concentrations of sodium and chloride (Bentley, 1983, pp. 26, 28-29). Figures 3-32 and 3-33 show the regional TDS concentrations in ground water in the Upper Claiborne and Wilcox units, respectively. In Perry County, TDS concentration increases in the south along the flow path in both aquifer units.

TDS concentrations for both the Upper Claiborne and the Wilcox units are shown in Table 3-22. Unusually high TDS and chloride concentrations are listed in Table 3-4 and discussed in Section 3.2.5.7. The high concentrations of TDS and boron and the high percentage of sodium in these units make the water unsuitable for domestic and agricultural supply. The Wilcox is unsuitable for livestock usage; the Upper Claiborne is not recommended for livestock usage.

3.3.3 Water Supply

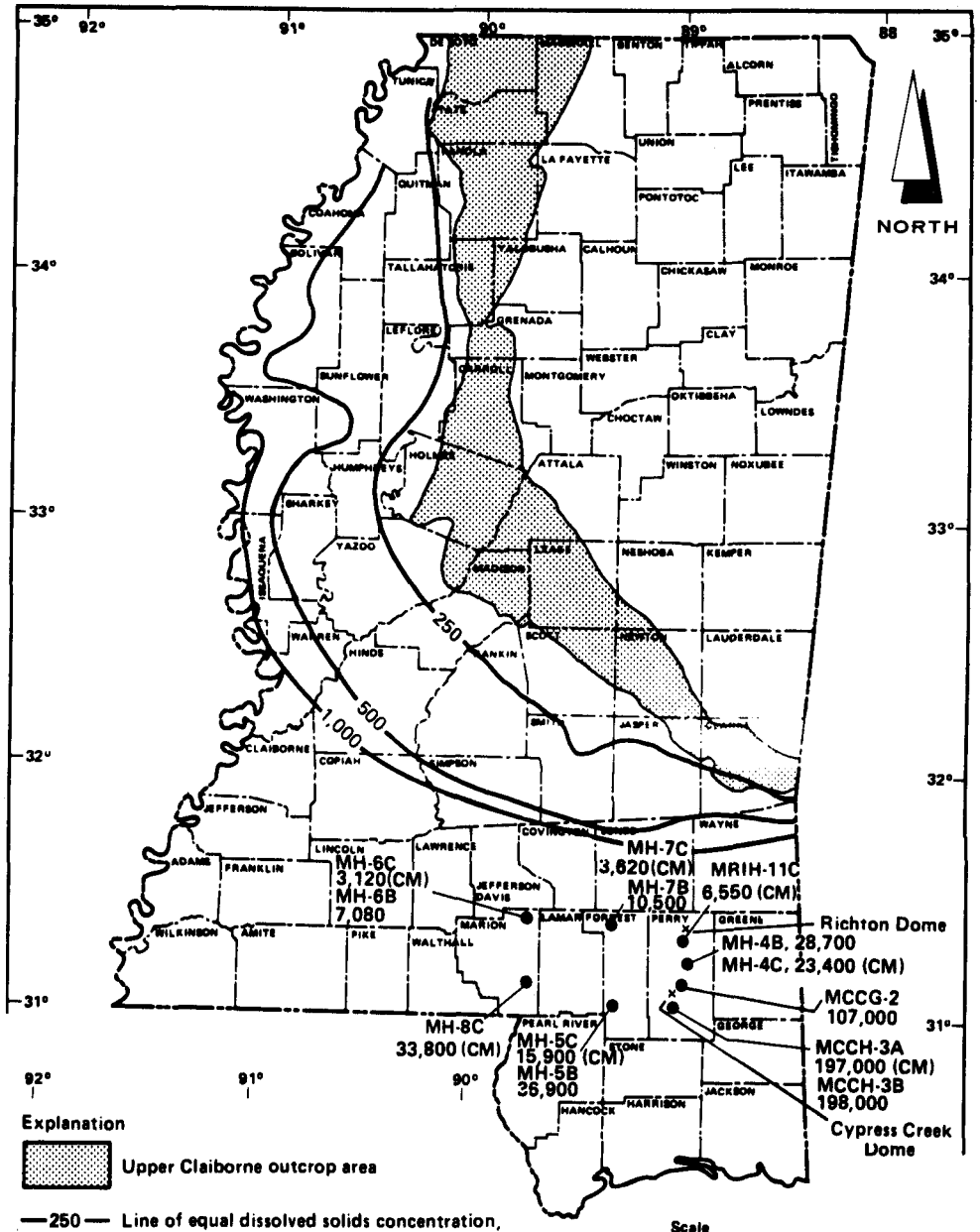
This section discusses water supply and water use patterns (both ground water and surface-water) around Richton Dome for a 12-county area in Mississippi and a 2-county area in Alabama. Data for the two Alabama counties (Washington and Mobile) are very limited, with the

Table 3-22. Summary of Dissolved Chemical Constituents in Ground Water Near Richton Dome[a]

	Geologic Unit	Range in Depth to Top of Interval, feet	Number of Samples	Statistic	Dissolved Constituents, milligrams per liter					
					Iron	Sodium	Calcium	Chloride	Bicar-bonate	Total Dissolved Solids[b]
Upper Aquifer	Citronelle Formation	19 to 200	15	Median:	0.6	2.8	1.5	3.0	9	36
				Range:	0-5.8	1.5-17	0.7-12	1.0-27	0-70	20-138
	Hattiesburg Formation	54 to 1,250	35	Median:	0.1	16	4.6	3.4	71	120
				Range:	0-6.0	2.3-660	0.1-22	1.2-670	3-420	26-1,680
	Catahoula Sandstone Formation	353 to 1,833	22	Median:	0.4	40	7.0	2.9	120	150
				Range:	0-8.9	5.2-54,000	0.4-290	1.6-73,000	9-1,580	60-130,000
Upper Claiborne	Cook Mountain Formation	1,579 to 3,101	7	Median:	0.4	6,000	37	9,500	290	15,900
				Range:	0.03-2.8	1,200-73,000	1.9-410	1,100-120,000	78-1,140	3,120-197,000
	Kosciusko Formation	1,940 to 3,470	6	Median:	0.9	12,000	240	20,000	200	32,000
				Range:	0.2-8.5	2,900-76,000	13-510	3,300-119,000	70-1,540	7,080-198,000
Wilcox	Wilcox Group	2,505 to 4,226	8	Median:	3.4	7,400	98	11,000	670	19,200
				Range:	0.4-18.0	4,100-39,000	1.8-1,500	5,300-63,000	190-1,390	10,600-104,000

(a) Includes adjacent areas in Marion, Lamar, Forrest, and Perry Counties.
(b) Sum of dissolved constitutents.

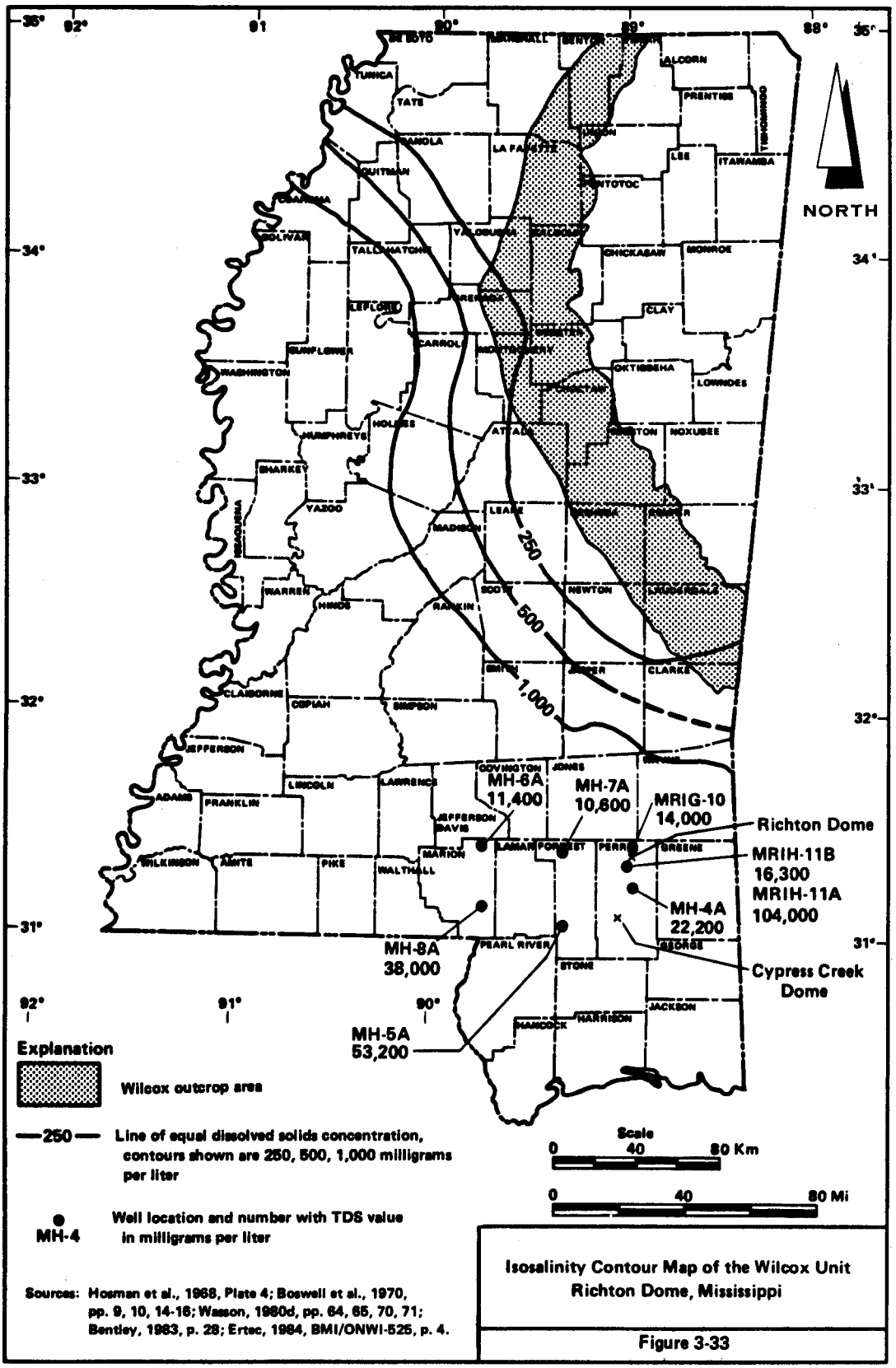
Source: Bentley, 1983, pp. 28-32.



Sources: DeVries et al., 1963, pp. 76, 77; Shows et al., 1966, pp. 49, 63-67; Boswell et al., 1970, pp. 9, 10, 14-16; Luper et al., 1972, pp. 160, 166-168; Newcome, 1976, Sheet 3; Spiers, 1977, Sheet 3; Wasson, 1980d, pp. 46, 47, 52, 53; Bentley, 1983, pp. 28-29; Ertec, 1984, BMI/ONWI-525, p. 4.

Isosalinity Contour Map of the Upper Claiborne Unit Richton Dome, Mississippi

Figure 3-32



Sources: Hosman et al., 1968, Plate 4; Boswell et al., 1970, pp. 9, 10, 14-16; Wasson, 1980d, pp. 64, 65, 70, 71; Bentley, 1983, p. 28; Ertec, 1984, BMI/ONWI-525, p. 4.

Isosalinity Contour Map of the Wilcox Unit
Richton Dome, Mississippi

Figure 3-33

exception of the City of Mobile. Inventoried counties in Mississippi are Jones, Wayne, Lamar, Forrest, Perry, Greene, Pearl River, Stone, George, Hancock, Harrison, and Jackson.

Table 3-23 lists the estimated surface-water and ground-water use for the 12 counties in Mississippi for 1980. The estimated total water use in this area in 1980 was 3.4×10^9 liters per day (901.8 million gallons per day). Surface-water use accounted for 89 percent of this total. The remaining 11 percent was attributed to ground-water use. As the table indicates, Harrison and Jackson Counties (south of Richton Dome) and Forrest County (west of Richton Dome) accounted for 99.8 percent of the total surface-water use in 1980.

According to Callahan (1983, Table 1), ground water is used to meet municipal, rural, agricultural, industrial, and aquacultural (fish farming) demands. Ground water is withdrawn primarily from the Upper Aquifer unit for the 12-county area around Richton Dome (Callahan, 1983, Table 2). In Jones and Wayne Counties (north of Richton Dome), ground water is also withdrawn from the Upper Claiborne unit and the Vicksburg-Jackson unit, which acts locally as an aquifer in this area (Geohydrologic Units, Section 3.3.2.1). Two wells in Wayne County also pump from the Wilcox aquifer unit. The distribution of wells in the vicinity of Richton Dome is shown by aquifer unit on Figures 3-34 through 3-37. Data on these wells are presented in Table 3-24.

Surface water is used primarily for generation of electricity and industrial consumption (Callahan, 1983, Table 1). Mobile, Alabama, is the only municipality within the region surrounding Richton Dome that uses surface water as its only source of supply.

The U.S. Water Resources Council (1978, pp. 24, 52) reported water use in 1975 and projected population trends and water requirements for the years 1985 and 2000 in the Pascagoula and Pearl River basins, which includes the 12-county area (Table 3-25). These projections do not distinguish between surface-water and ground-water requirements. The study projects a 16 to 22 percent increase in population from 1975 to 2000. The projected water withdrawal for 1985 for the Pascagoula and Pearl River basins is 3.46×10^9 liters per day (915 million gallons per day), reflecting an increase of about 28 percent from 1975 values. The projected water withdrawal for the year 2000 for the Pascagoula and Pearl River Basins is 2.73×10^9 liters per day (720 million gallons per day), indicating a decrease in water withdrawal compared with 1985 projections. The projected decrease results from anticipated advances in electrical power generation technology (U.S. Water Resources Council, 1978, p. 38). However, the water consumption projections indicate a different trend. The projected water consumption for 1985 is 0.74×10^9 liters per day (196 million gallons per day), indicating an increase of about 43 percent over the 1975 values. For the year 2000, the water consumption projection is 1.02×10^9 liters per day (269 million gallons per day), an increase of about 37 percent over the 1985 projection.

In the Mobile and Tombigbee River basins, a region that includes the two-county area in Alabama, the total water withdrawal for 1975 was 1.41×10^{10} liters per day (3,720 million gallons per day) (Table 3-26). The projected water withdrawal for the years 1985 and 2000 is 1.38×10^{10} liters per day (3,646 million gallons per day) and 7.78×10^9 liters per day (2,054 million gallons per day), respectively (U.S. Water Resources Council, 1978, p. 52). This represents a decrease of 2 percent and 45 percent, respectively, from 1975 values. As in the Pascagoula and Pearl River basin study, the projected decrease in water use results from projected advances in electrical power generation technology (U.S. Water Resources Council, 1978, p. 38). Again, the water consumption projections show a different trend. The projected water consumptions for the years 1985 and 2000 are 1.17×10^9 liters per day (310 million gallons per day) and 1.67×10^9 liters per day (442 million gallons per day), respectively. This represents an increase of 55 and 121 percent, respectively, over the 1975 rate of 0.76×10^9 liters per day (200 million gallons per day).

3.4 ENVIRONMENTAL SETTING

This section describes the environmental setting of the Richton Dome area with respect to land use; terrestrial and aquatic ecosystems; air quality and weather conditions; noise;

Table 3-23. Water Use in 1980 for the Vicinity of Richton Dome, Mississippi

County	Water Use, Million Gallons per Day		
	Ground Water	Surface Water	Total
Forrest	19.6	79.8	99.4
George	1.1	< 0.1	1.2
Greene	0.7	< 0.1	0.7
Hancock	4.8	< 0.1	4.8
Harrison	24.2	502.2	526.4
Jackson	21.9	215.0	236.9
Jones	14.8	0.2	15.0
Lamar	6.9	0.1	7.0
Pearl River	4.2	0.2	4.4
Perry	1.2	0.4	1.6
Stone	2.3	< 0.1	2.4
Wayne	1.9	0.1	2.0
Total	103.6	798.4	901.8

Note: Water use reported from public supplies, rural self-supplies, industrial self-supplies, thermo-electric power, irrigation, aquaculture, and waterfowl impoundments. Figures are rounded to one decimal place.

Sources: Callahan, 1983, Table 1; BNI, 1984, ONWI-499, pp. 63-65.

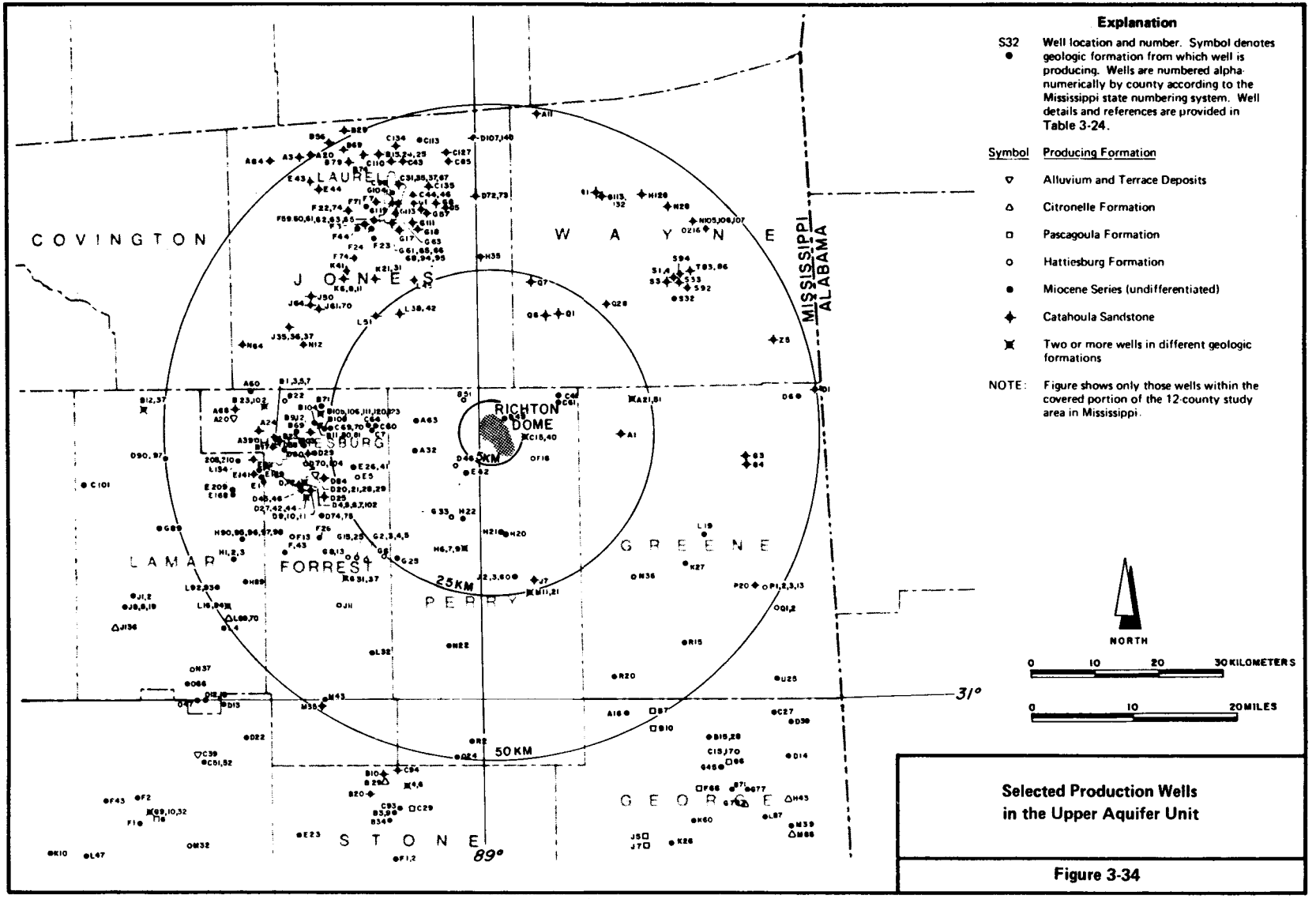
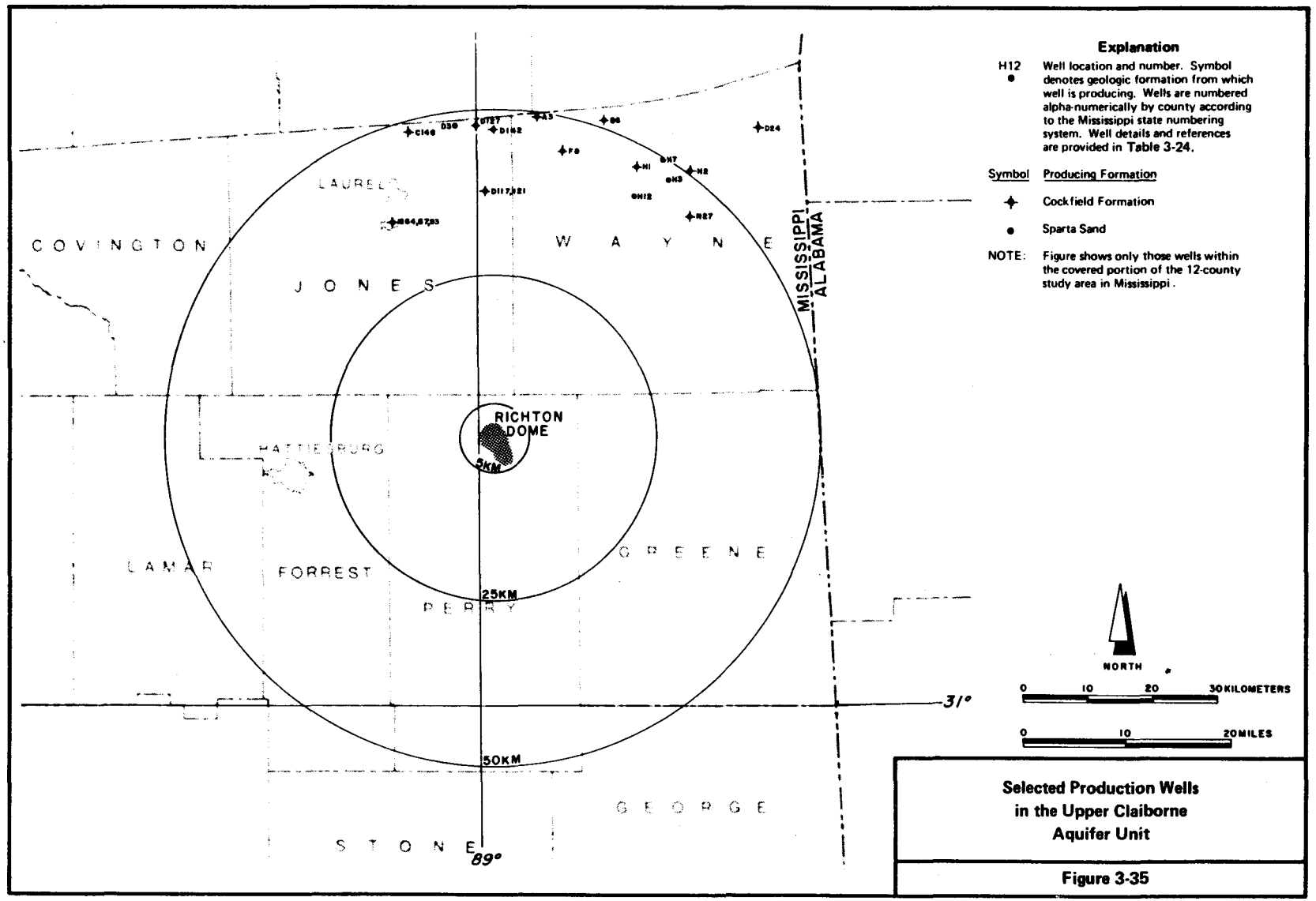
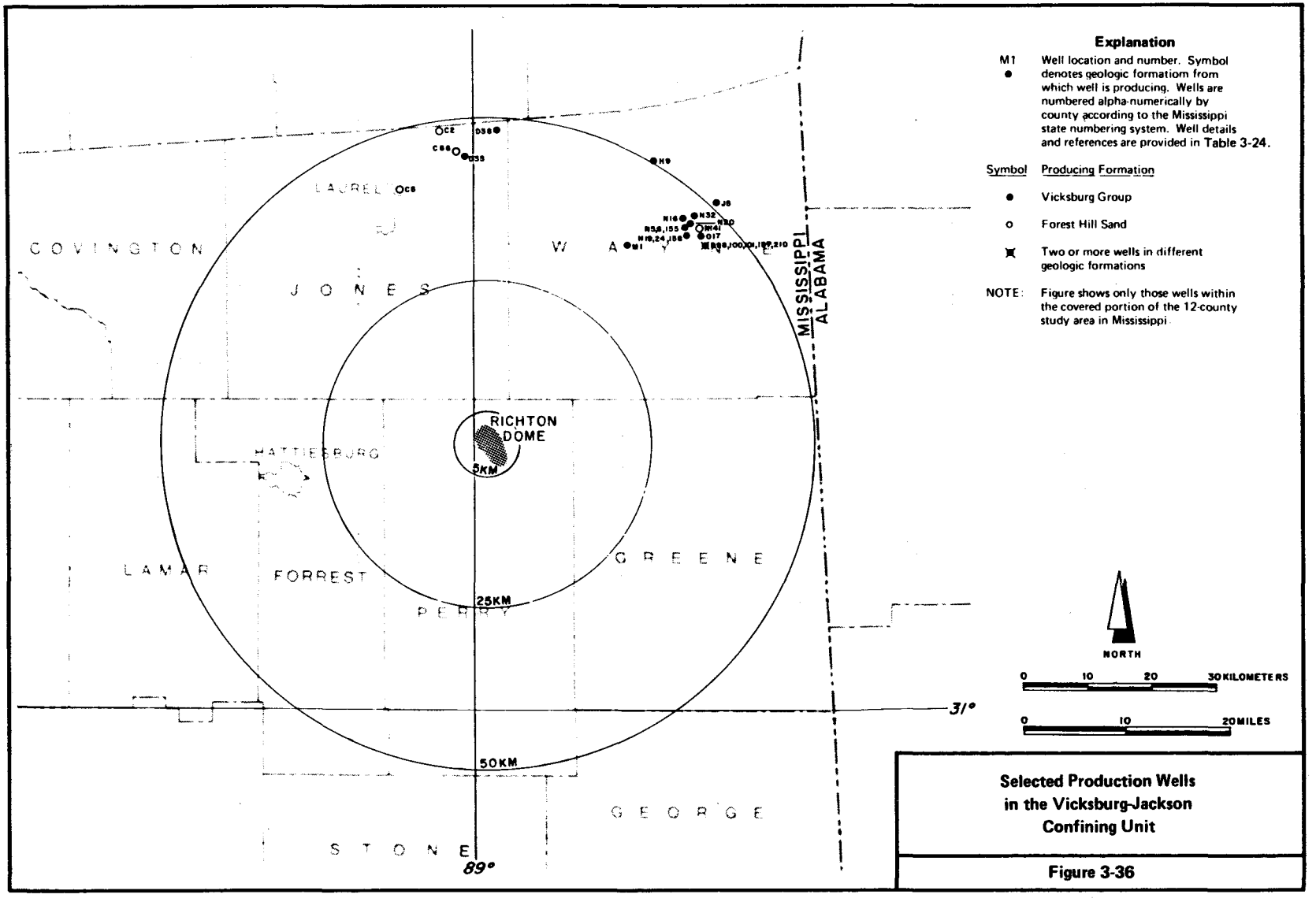

COVINGTON
JONES
LAUREL
WAYNE
MISSISSIPPI
ALABAMA
RICHTON DOME
5KM
25KM
50KM
HATTIESBURG
LAMAR
FORREST
PERRY
GREENE
STONE
GEORGE
31°
89°
Explanation
S32 Well location and number. Symbol denotes geologic formation from which well is producing. Wells are numbered alpha-numerically by county according to the Mississippi state numbering system. Well details and references are provided in Table 3-24.
Symbol Producing Formation
Alluvium and Terrace Deposits
Citronelle Formation
Pascagoula Formation
Hattiesburg Formation
Miocene Series (undifferentiated)
Catahoula Sandstone
Two or more wells in different geologic formations
NOTE: Figure shows only those wells within the covered portion of the 12-county study area in Mississippi.
NORTH
0 10 20 30 KILOMETERS
0 10 20 MILES
Selected Production Wells in the Upper Aquifer Unit

Figure 3-34


Explanation
H12
Well location and number. Symbol denotes geologic formation from which well is producing. Wells are numbered alpha-numerically by county according to the Mississippi state numbering system. Well details and references are provided in Table 3-24.
Symbol
Producing Formation
Cockfield Formation
Sparta Sand
NOTE: Figure shows only those wells within the covered portion of the 12-county study area in Mississippi.
COVINGTON
JONES
WAYNE
LAUREL
HATTIESBURG
LAMAR
FORREST
PERRY
GREENE
GEORGE
STONE
MISSISSIPPI
ALABAMA
RICHTON DOME
5KM
25KM
50KM
31°
89°
NORTH
0 10 20 30 KILOMETERS
0 10 20 MILES
Selected Production Wells in the Upper Claiborne Aquifer Unit
Figure 3-35



Selected Production Wells in the Vicksburg-Jackson Confining Unit

Figure 3-36

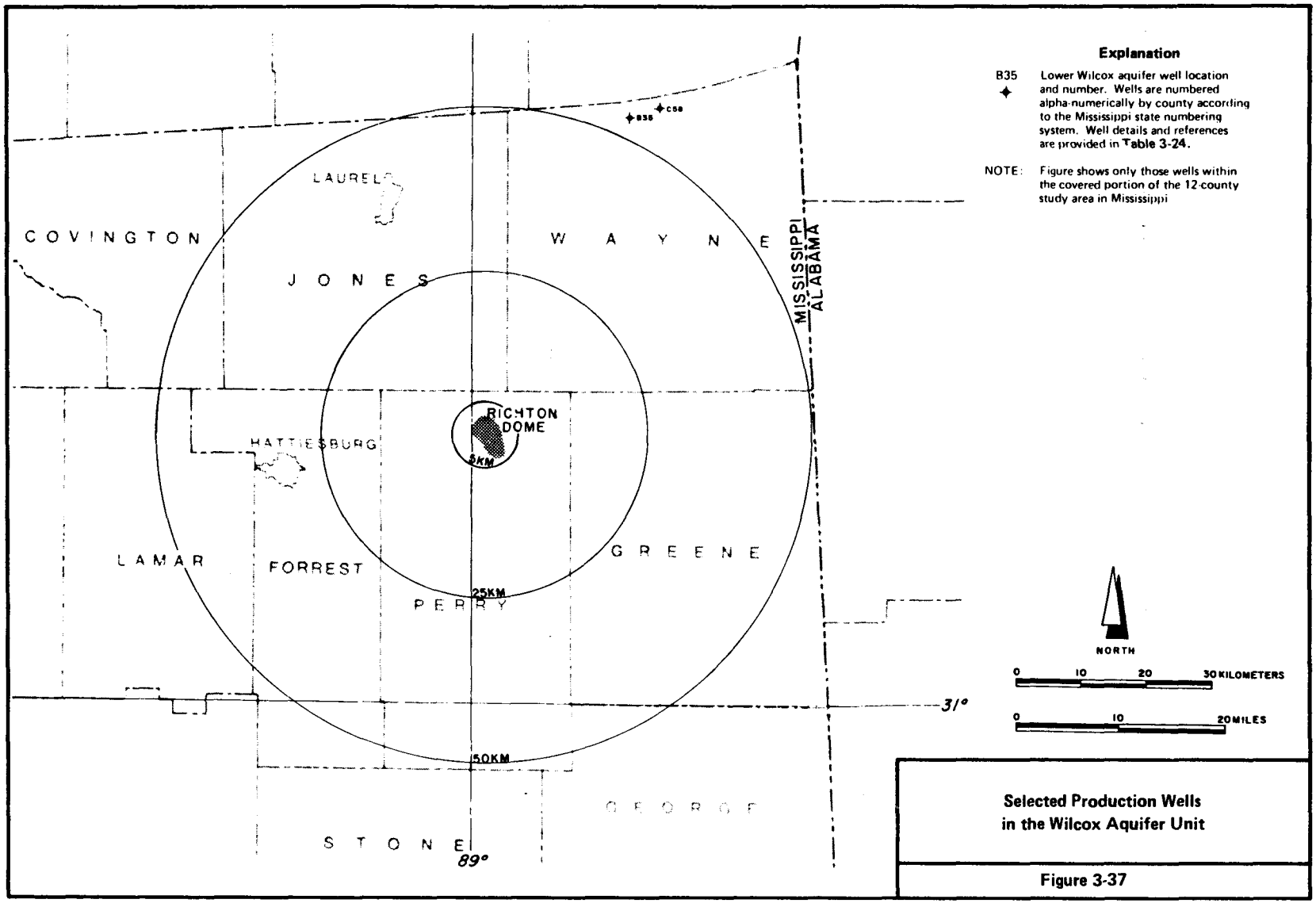

Explanation
B35 Lower Wilcox aquifer well location and number. Wells are numbered alpha-numerically by county according to the Mississippi state numbering system. Well details and references are provided in Table 3-24.
NOTE: Figure shows only those wells within the covered portion of the 12-county study area in Mississippi
B35
C58
LAUREL
COVINGTON
JONES
WAYNE
MISSISSIPPI
ALABAMA
RICHTON DOME
5KM
HATTIESBURG
LAMAR
FORREST
PERRY
GREENE
25KM
50KM
31°
89°
STONE
GEORGE
NORTH
0 10 20 30 KILOMETERS
0 10 20 MILES
Selected Production Wells in the Wilcox Aquifer Unit
Figure 3-37

Table 3-24. Selected Production Wells

County	Well No.	Owner	Year Drilled	Well Depth (ft)[a]	Water Use[b]	Reference
		Alluvium and Terrace Deposits[c]				
Forrest	A20	Gray-Mar Farms	1963	85	I	1
Forrest	D20	Miss. Power Co.	1948	110	I	2
Forrest	D21	Miss. Power Co.	1963	112	I	2
Forrest	D28	E. Forest Utl.	1955	124	P	2
Forrest	D29	E. Forest Utl.	1962	134	I	2
Pearl R.	C39	Marvis Ladner	1950	63	P	3
		Citronelle Formation[c]				
George	G78	Vernon Howell	1977	98	I	2
George	H43	V Tanner	1975	112	I	2
George	M88	Agricola School	1974	80	P	3
Lamar	J136	Baxterville	1967	200	P	2, 4
Lamar	L69	Lakeview Wtr. Co.	1962	54	P	2, 4
Lamar	L70	Lakeview Wtr. Co.	1960	46	P	2, 4
Stone	B29	G'Port Creasot	1969	95	I	3
Stone	4	Wiggins	1930	197	P	5
		Pascagoula and Hattiesburg Formations[c]				
Forrest	A39	Rawls Sprgs W.A.	1972	680	P	2, 4
Forrest	B22	Eatonville H.S.	Unk	100	P	4
Forrest	B80	Enterprise Prod.	1971	320	I	2, 4
Forrest	B81	Enterprise Prod.	1971	352	I	2, 4
Forrest	B120	Warren Petro.	1978	372	I	2, 4
Forrest	D44	Plmrs. Cross W.A.	1965	642	I	1, 2, 4
Forrest	D70	Murray Envelope	1968	422	I	2, 4
Forrest	D104	MS Tank Co.	1980	700	I	2

Table 3-24. Selected Production Wells
(Page 2 of 15)

County	Well No.	Owner	Year Drilled	Well Depth (ft)[a]	Water Use[b]	Reference
Forrest	E5	Sunrise School	1958	240	P	1, 4
Forrest	F13	Dixie School	Unk	397	P	4
Forrest	G2	Camp Shelby	1950	550	P	1, 2
Forrest	G3	Camp Shelby	1950	400	P	1, 2
Forrest	G4	Camp Shelby	1950	400	I	2
Forrest	G5	Camp Shelby	1950	400	P	1, 2
Forrest	G6	Camp Shelby	1950	400	P	1, 2
Forrest	G8	Camp Shelby	1940	432	P	1, 2
Forrest	G13	Camp Shelby	Unk	410	P	4
Forrest	G15	Camp Shelby	Unk	406	P	4
Forrest	G25	Camp Shelby	Unk	319	P	4
Forrest	J11	Paul Johnson S. Pk.	Unk	328	P	4
George	B7	A. W. Byrd	1953	400	P	6
George	B10	C. H. Guy	1953	400	P	6
George	C15	Lucedale	1950	1012	P	2, 3, 6
George	C17	Lucedale	1959	1008	P	2, 3, 6
George	F66	Central School	1971	270	I	3
George	G6	Singing River Ed	1960	343	I	2, 3
George	J5	Walter J. Green	1914	93	P	3
George	J7	Black Creek Lmb.	1940	140	I	3, 6
Greene	N36	Neely Utility	1971	300	P	2
Greene	P1	Leaksville	1962	140	P	1, 2
Greene	P2	Leaksville	1950	125	P	1, 2
Greene	P3	Leaksville	1950	140	P	1, 2
Greene	P13	Leaksville	1965	240	P	2
Greene	Q1	Leaksville Clr. Sc.	1960	160	P	1
Greene	Q2	Leaksville Clr. Sc.	1960	160	P	1

Table 3-24. Selected Production Wells
(Page 3 of 15)

County	Well No.	Owner	Year Drilled	Well Depth (ft)[a]	Water Use[b]	Reference
Lamar	B37	Sumrall	1963	382	P	2, 4
Lamar	L16	Purvis	1961	975	P	2, 4
Lamar	N37	N. Lumberton W. A.	1970	650	P	2
Pearl R.	6	Unknown	1929+	536	P	3
Pearl R.	G32	Poplarville	1973	608	P	2, 3
Pearl R.	M32	Center W.A.	1980	1076	P	2
Perry	B51	Unknown	Unk	391	I	4
Perry	D46	Runnelstown Ut Dist	1978	512	P	2, 4
Perry	G33	Leaf R Forest Prod.	1982	498	I	2
Perry	F16	County Hospital	Unk	94	P	4
Stone	6	Unknown	1927	Unk	I	5
Stone	C29	Int. Paper Co.	1970	990	I	2
		Miocene Series (undifferentiated)[c]				
Forrest	A60	Rain Nurseries	Unk	169	I	4
Forrest	B69	Glendale W.A.	1969	654	P	2, 4
Forrest	B71	Eastabuchie W.A.	1968	810	P	2, 4
Forrest	B102	Glendale Util. Dst.	1977	895	P	2, 4
Forrest	B103	Mobile Oil Corp.	1977	254	I	2, 4
Forrest	B104	Delta Underground	1977	340	I	2, 4
Forrest	B105	Hattisburg Sto. Fac.	1977	215	I	2, 4
Forrest	B106	Hattisburg Sto. Fac.	1978	330	I	2, 4
Forrest	B108	Hattisburg Sto. Fac.	1978	312	I	2, 4
Forrest	B111	Enterprise Prod.	1974	390	I	2, 4

Table 3-24. Selected Production Wells
(Page 4 of 15)

County	Well No.	Owner	Year Drilled	Well Depth (ft)[a]	Water Use[b]	Reference
Forrest	B123	Union Texas Pet.	1980	256	I	2
Forrest	C7	Barrontown Util	1967	900	P	2
Forrest	C60	Barrontown W.A.	1973	900	P	2, 4
Forrest	C64	Barrontown Util.	1979	885	P	2, 4
Forrest	C69	Petal	1981	722	P	2
Forrest	C70	Petal	1981	735	P	2
Forrest	D74	Masonite Corp.	1968	160	I	2
Forrest	D75	Masonite Corp.	1968	160	I	2
Forrest	D102	Marshall Duban	1980	672	I	2
Forrest	E26	Sunrise Util.	1968	900	P	2
Forrest	E41	Sunrise Util.	1972	894	P	2
Forrest	F26	Dixie W.A.	1969	897	P	2
Forrest	F43	Dixie W.A.	1975	164	P	2
Forrest	G37	McLaurin	1979	260	P	2
Forrest	L32	Brooklyn W.A.	1976	850	P	2, 4
Forrest	M43	Carnes Util. Assoc.	1977	830	P	2
George	A16	H. R. Mizell	Unk	430	P	3
George	B15	Bexley Util.	1966	600	P	2, 3, 6
George	B28	Bexley Util.	1972	585	P	2, 3
George	C27	Rocky Creek Util.	1967	1060	P	2, 3, 6
George	D14	Rocky Creek util.	1967	625	P	2, 3, 6
George	D39	Rocky Cr. Util	1982	1172	I	2
George	G45	Florida Gas Co.	1971	126	I	3
George	G71	Country Club	1974	375	P	3
George	G77	Combined Util.	1977	1044	P	2
George	K26	Albritton No. 3	1969	222	P	3
George	K60	Singing River Ed	1979	390	I	2
George	L87	Ruri-Mar Dairy	1981	300	I	2
George	M39	Grower Purvis	1972	114	I	3

Table 3-24. Selected Production Wells
(Page 5 of 15)

County	Well No.	Owner	Year Drilled	Well Depth (ft)[a]	Water Use[b]	Reference
Greene	A51	Beat 3 W.A. (#2)	1973	486	P	2
Greene	D6	State Line	1972	252	P	2
Greene	K27	Beat 3 W.A.	1979	240	P	2
Greene	L19	Beat 3 W.A.	1979	360	P	2
Greene	R15	McLain	1970	180	P	2
Greene	R20	Leaf W.A.	1975	338	P	2
Greene	U25	SE Greene	1979	994	P	2
Jones	C96	Laurel	1970	410	P	2
Jones	C113	Sharon W.A.	1972	248	P	2
Jones	F23	Pleasant Ridge	1966	413	P	2
Jones	F24	Pleasant Ridge	1967	394	P	2
Jones	F44	Laurel	1970	500	P	2
Lamar	B12	Sumrall	1968	358	P	2, 4
Lamar	C101	Sun Oil Co.	Unk	546	I	4
Lamar	D90	West Lamar W.A.	1972	431	P	2, 4
Lamar	D97	West Lamar W.A.	1974	425	P	2, 4
Lamar	E1	North Lamar W.A.	1966	165	P	2, 4
Lamar	E82	Arnold Line W.A.	1968	786	P	2, 4
Lamar	E168	North Lamar W.A.	1972	180	P	2, 4
Lamar	E189	Lamar Park W.A.	1973	714	P	2, 4
Lamar	E205	Arnold Line W.A.	1975	802	P	2, 4
Lamar	E209	North Lamar W.A.	1979	187	P	2, 4
Lamar	E210	Lamar Park W.A.	1979	740	P	2, 4
Lamar	G89	Sun Oil Co.	Unk	777	I	4
Lamar	H1	Amerada Hess	1956	911	I	2, 4
Lamar	H2	Amerada Hess	1956	890	I	2, 4
Lamar	H3	Amerada Hess	1957	904	I	2, 4

Table 3-24. Selected Production Wells
(Page 6 of 15)

County	Well No.	Owner	Year Drilled	Well Depth (ft)[a]	Water Use[b]	Reference
Lamar	H89	Kaiser Aluminum	1959	910	I	4
Lamar	H90	S. Miss. Elec. Pwr.	1975	784	I	2, 4
Lamar	H95	S. Miss. Elec. Pwr.	1975	774	I	2, 4
Lamar	H96	S. Miss. Elec. Pwr.	1975	773	I	2, 4
Lamar	H97	Amerada Hess	1976	793	I	2, 4
Lamar	H98	Amerada Hess	1976	771	I	2, 4
Lamar	J1	U.S. Atom. Ener. Cmsn.	Unk	782	Unk	4
Lamar	J2	U.S. Atom. Ener. Cmsn.	Unk	1130	I	4
Lamar	J8	U.S. Atom. Ener. Cmsn	Unk	820	I	4
Lamar	J9	U.S. Atom. Ener. Cmsn.	Unk	1000	I	4
Lamar	J19	U.S. Atom. Ener. Cmsn.	Unk	783	Unk	4
Lamar	L4	Bass Mem. Acad.	1962	480	I	2
Lamar	L92	Progress W.A.	1975	265	P	2, 4
Lamar	L93	Progress W.A.	1975	264	P	2, 4
Lamar	L94	Purvis	1978	261	P	4
Lamar	O12	Lumberton	1951	875	P	2
Lamar	O13	Lumberton	1962	876	P	2
Lamar	O47	Lumberton	1971	874	P	2
Lamar	O66	Southland Oil Co.	1977	847	I	2
Pearl R.	C51	Lake Hillsdale	1974	340	P	2, 3
Pearl R.	C52	Lake Hillsdale	1974	340	P	2, 3
Pearl R.	D13	Standard Oil Co.	1969	70	P	3
Pearl R.	D22	SAGA Petroleum	1975	441	I	3
Pearl R.	F1	W. Poplarville	1966	1050	I	3
Pearl R.	F2	Sunny Oak W.A.	1968	1010	P	2, 3
Pearl R.	F43	U.S.D.A.	1974	611	I	3
Pearl R.	G9	Poplarville	1969	540	P	2, 3
Pearl R.	G10	Poplarville	1969	620	P	2, 3
Pearl R.	K10	Poplarville	1962	535	P	3
Pearl R.	L47	Pearl R. Cent. W.A.	1981	1350	I	2

Table 3-24. Selected Production Wells
(Page 7 of 15)

County	Well No.	Owner	Year Drilled	Well Depth (ft)[a]	Water Use[b]	Reference
Perry	A32	Runnelstown Fsh.	1969	295	I	2,4
Perry	A63	Runnelstown Ut Dist	1974	380	P	2,4
Perry	B49	F. Heywood	Unk	325	P	4
Perry	C40	Richton	1968	660	P	2,4
Perry	C41	N.E. Perry W.A.	1968	520	P	2,4
Perry	C61	N.E. Perry W.A.	1975	475	P	2,4
Perry	E42	Noel Matthews	1980	100	I	2
Perry	G25	Jordon-O'Brien	Unk	560	I	4
Perry	H9	New Augusta	1968	1090	P	2
Perry	H20	Pel Tex Oil	Unk	336	P	4
Perry	H21	Pel Tex Oil	Unk	324	P	4
Perry	H22	Leaf River Frt.Pr.	1978	225	I	2,4
Perry	J2	Perry Plywood C.	1947	585	I	2
Perry	J3	Perry Plywood C.	1948	585	I	2
Perry	J60	Beaumont	1976	550	P	2,4
Perry	M11	Beaumont	1964	666	P	2,4
Perry	N22	Janice W.A.	1978	571	P	2,4
Perry	Q24	Janice W.A.	1978	952	P	2
Perry	R2	Florida Gas Co.	1959	745	I	2
Stone	B3	Wiggins	1952	408	P	2,3
Stone	B9	Wiggins	1966	954	P	2,3
Stone	B34	Standard Oil Co.	1968	129	I	3
Stone	C93	Dunn Paper Co.	1980	560	I	2
Stone	E23	Stone Co. W.A.	1981	1125	P	2
Stone	F1	Perk Jr. College	1959	951	I	2,3
Stone	F2	Perk Jr. College	1926	247	I	2
Wayne	S32	Clara W.A.	1966	342	P	2

Table 3-24. Selected Production Wells
(Page 8 of 15)

County	Well No.	Owner	Year Drilled	Well Depth (ft)[a]	Water Use[b]	Reference
		Catahoula Sandstone[c]				
Forrest	A24	Rawls Sprgs. W.A.	1966	705	P	1,2
Forrest	A68	Rawls Sprgs. W.A.	1982	910	P	2
Forrest	B1	Hattiesburg	1941	419	P	1,2
Forrest	B3	Hattiesburg	1930	610	P	1,2,4
Forrest	B5	Hattiesburg	1931	621	P	1,2,4
Forrest	B7	Hattiesburg	1952	635	P	1,2,4
Forrest	B9	Union Tex. Co.	1956	260	I	2,4
Forrest	B11	Warren Petr. Co.	1954	292	I	2,4
Forrest	B12	Warren Petr. Co.	1955	289	I	2,4
Forrest	B17	Hattiesburg	1964	292	I	2,4
Forrest	B23	Hattiesburg	1966	607	P	2,4
Forrest	D4	Hattiesburg	1960	485	P	1,2,4
Forrest	D5	Hattiesburg	1960	678	P	1,2,4
Forrest	D6	Hattiesburg	1960	673	P	1,2,4
Forrest	D7	Hattiesburg	1960	688	P	1,2,4
Forrest	D9	Marshal Durbin	1959	678	I	1,2,4
Forrest	D10	Marshal Durbin	1963	678	I	1,2,4
Forrest	D11	Dixie Pine Prod	1950	740	I	1,2,4
Forrest	D25	E.Travillion H.S.	1957	580	P	1,4
Forrest	D27	Cen Forrestater	Unk	360	P	4
Forrest	D38	Hercules Pwr. Co.	1965	687	I	1,2,4
Forrest	D42	Plmrs. Cross W.A.	1965	642	P	1,2,4
Forrest	D45	Central Util.	1965	694	I	1,2,4
Forrest	D46	Central Util.	1965	672	I	1,2,4
Forrest	D60	Hercules Pwd. Co.	1967	671	I	2
Forrest	D72	Pine Burr. Pk. Co.	1968	662	I	2,4
Forrest	D84	Marshal Durbin	1970	684	I	2,4
Forrest	G31	McLaurin Assoc.	Unk	630	P	4
Forrest	M35	Carnes Utility	1970	820	P	2

Table 3-24. Selected Production Wells
(Page 9 of 15)

County	Well No.	Owner	Year Drilled	Well Depth (ft)[a]	Water Use[b]	Reference
Greene	A1	Sand Hill Sch.	1949	535	P	1
Greene	A21	Beat 3 W.A. (#1)	1971	507	P	2
Greene	D1	State Line	1961	252	P	1,2
Greene	G3	J.M. Clark	1935	190	I	1
Greene	G4	J.M. Clark	1957	155	P	1
Greene	P20	Leakesville	1969	541	P	2
Jones	A3	Soso W.A.	1965	470	P	1,2
Jones	A20	Soso W.A.	1968	405	P	2
Jones	A64	Hatten W.A.	1972	480	P	2
Jones	B15	Shady Grove W.A.	1965	384	P	2
Jones	B24	Shady Grove W.A.	1965	370	P	1,2
Jones	B25	Shady Grove W.A.	1965	360	P	1,2
Jones	B29	Matthews-Moss W.A.	1966	336	P	2
Jones	B56	Matthews-Moss W.A.	1969	340	P	2
Jones	B69	Matthews-Moss W.A.	1974	340	P	2
Jones	B74	Dairy Fresh	1978	196	I	2
Jones	B79	Calhoun W.A.	1981	392	P	2
Jones	C31	Laurel	1954	318	P	2
Jones	C35	Laurel	1949	483	P	1,2
Jones	C37	Laurel	1954	343	P	1,2
Jones	C43	Sharon W.A.	1965	228	P	2
Jones	C44	Powers W.A.	1965	385	P	1,2
Jones	C46	Powers W.A.	1966	385	P	1,2
Jones	C67	Laurel	1950	322	P	1,2
Jones	C85	Errata W.A.	1968	295	P	2
Jones	C110	Univ. Utility Co.	1971	326	P	2
Jones	C127	Errata W.A.	1974	255	P	2
Jones	C134	Christian Ind Pk.	1977	227	I	2
Jones	C135	Powers W.A	1978	370	P	2

Table 3-24. Selected Production Wells
(Page 10 of 15)

County	Well No.	Owner	Year Drilled	Well Depth (ft)[a]	Water Use[b]	Reference
Jones	D72	Myrick-Mill Cr.	1966	347	P	2
Jones	D73	Myrick-Mill Cr.	1966	352	P	2
Jones	D107	Sandersville	1970	160	P	2
Jones	D140	Sandersville	1979	155	P	2
Jones	E43	Pleasant Rdg. W.A.	1981	398	I	2
Jones	E44	Pleasant Rdg. W.A.	1982	398	P	2
Jones	F3	Laurel Airport	1942	471	P	1
Jones	F7	Laurel Coun. Club	1964	246	I	1
Jones	F22	Calhoun W.A.	1966	482	P	1,2
Jones	F59	Laurel	1971	466	P	2
Jones	F60	Laurel	1971	474	P	2
Jones	F61	Laurel	1971	480	P	2
Jones	F62	Laurel	1971	480	P	2
Jones	F63	Laurel	1971	449	P	2
Jones	F65	Pleasant Rdg.	1972	385	P	2
Jones	F71	Calhoun W.A.	1974	460	P	2
Jones	F74	Calhoun W.A.	1982	491	P	2
Jones	G1	C.P. Clark	1963	326	P	1
Jones	G5	Greater Laurel Util.	1959	368	P	1,2
Jones	G8	Powers Sch.	1962	309	P	1
Jones	G17	Glade W.A.	1965	475	P	1,2
Jones	G18	Glade W.A.	1965	529	P	1,2
Jones	G57	Masonite Corp.	1968	225	I	2
Jones	G61	Masonite Corp.	1961	220	I	1,2
Jones	G63	Masonite Corp.	1958	230	I	1,2
Jones	G65	Masonite Corp.	1964	209	I	1,2
Jones	G66	Masonite Corp.	1964	413	I	1,2
Jones	G68	Masonite Corp.	1964	409	I	1,2
Jones	G94	Masonite Corp.	1955	179	I	1,2
Jones	G95	Masonite Corp.	1963	226	I	1,2
Jones	G104	Laurel	1945	396	P	1,2

Table 3-24. Selected Production Wells
(Page 11 of 15)

County	Well No.	Owner	Year Drilled	Well Depth (ft)[a]	Water Use[b]	Reference
Jones	G111	Glade W.A.	1972	490	P	2
Jones	G113	Greater Laurel	1973	355	P	2
Jones	G119	Masonite Group	1974	228	I	2
Jones	H35	M & M W.A.	1976	540	P	2
Jones	J35	So. Miss. Power	1969	278	I	2
Jones	J36	So. Miss. Power	1969	264	I	2
Jones	J37	So. Miss. Power	1969	263	I	2
Jones	J50	W.A. of Pine	1971	674	P	2
Jones	J61	Oak Grove W.A.	1973	672	P	2
Jones	J64	W.A. of Pine	1973	677	P	1,2
Jones	J70	Oak Grove W.A.	1981	688	P	2
Jones	K6	Ellisville Sch.	1956	552	I	1,2
Jones	K8	Ellisville Sch.	1963	548	I	1,2
Jones	K11	Ellisville	1964	550	P	1,2
Jones	K21	Ellisville	1967	576	P	2
Jones	K31	Ellisville	1969	548	P	2
Jones	K41	Ellisville	1982	562	P	2
Jones	L38	J & P Utility	1970	760	P	2
Jones	L42	J & P Utiliey	1971	772	P	2
Jones	L45	Lifeway Farms	1973	290	I	2
Jones	L51	J-P W.A.	1979	813	P	2
Jones	N12	Moselle W.A.	1968	754	P	2
Jones	N64	Moselle W.A.	1972	722	P	2
Lamar	E134	Arnold Line W.A.	1971	770	P	1,2
Lamar	E141	Lamar Park W.A.	1971	714	P	1,2
Perry	C15	Richton	1966	736	P	2,4
Perry	H6	New Augusta	1960	723	P	1,2,4
Perry	H7	New Augusta	1963	721	P	2,4

Table 3-24. Selected Production Wells
(Page 12 of 15)

County	Well No.	Owner	Year Drilled	Well Depth (ft)[a]	Water Use[b]	Reference
Perry	J7	W.M. Lott	1964	573	P	1
Perry	M21	Beaumont Cons. Sch.	1935	460	P	1
Stone	B10	Bond Utility	1966	888	P	2
Stone	B20	New Zion W.A.	1968	954	P	2
Stone	C94	Wiggins	1980	935	P	2
Wayne	A11	Hess Pipeline	1970	586	I	2
Wayne	G1	Whistler W.A.	1973	212	P	7
Wayne	G113	Whistler W.A.	1973	210	P	2
Wayne	G132	Whistler W.A.	1977	206	P	2
Wayne	H126	Humble Oil Co.	1970	732	I	2
Wayne	N28	Mid State Pvng. Co.	1972	92	I	7
Wayne	N105	Scotch Plywood	1969	117	I	2
Wayne	N106	Scotch Plywood	1969	125	I	2
Wayne	N107	Scotch Plywood	1970	131	I	2
Wayne	O216	Scotch Plywood	1979	132	I	2
Wayne	Q1	U.S. Fors. Ser Wausau	1965	640	P	7
Wayne	Q6	U.S. Fors. Ser Wausau	1962	210	P	7
Wayne	Q7	U.S.A. No. 1	1965	375	I	7
Wayne	Q28	SW Wayne W.A.	1978	631	I	2
Wayne	S1	Clara W.A. No. 1	1966	342	P	7
Wayne	S3	Clara Cons. Sch.	1962	148	P	7
Wayne	S4	Clara W.A. No. 2	1966	340	P	7
Wayne	S33	Clara W.A.	1966	330	P	2
Wayne	S92	Clara W.A.	1976	338	P	2
Wayne	S94	Clara W.A.	1981	346	P	2
Wayne	T83	Bucatunna	1977	352	P	2

Table 3-24. Selected Production Wells
(Page 13 of 15)

County	Well No.	Owner	Year Drilled	Well Depth (ft)[a]	Water Use[b]	Reference
Wayne	T86	Bucatunna	1977	358	P	2
Wayne	Z5	Terry Revette	1967	366	P	7
		Vicksburg Group[d]				
Jones	D35	Sandersville	1963	130	P	1, 2
Jones	D38	Humble Oil Co.	1960	80	I	1
Wayne	H9	John Doherty	1969	132	P	7
Wayne	J5	Babe Davis	1967	184	P	7
Wayne	M1	Nancy Anderson	1969	425	S	7
Wayne	N5	Waynesboro No. 1	1958	118	P	1, 2
Wayne	N6	Waynesboro No. 6	1957	118	P	1, 2
Wayne	N16	Waynesboro	1973	82	P	2, 7
Wayne	N19	Waynesboro	1973	138	P	7
Wayne	N20	Waynesboro	1953	122	P	7
Wayne	N24	Waynesboro	1973	122	P	7
Wayne	N32	Waynesboro	1958	118	P	7
Wayne	N155	Waynesboro	1973	138	P	2
Wayne	N158	Waynesboro	1973	122	P	2
Wayne	O17	Waynesboro	1957	118	P	2
Wayne	O157	Scotch Plywood	1972	125	I	2
Wayne	O210	Long For Prod	1975	131	I	2
		Forest Hill Sand[d]				
Jones	C2	Trans. Con. Gas	1950	235	I	2
Jones	C5	Trans. Con. Gas	1950	173	I	2
Jones	C66	Sandersville	1967	181	P	2

Table 3-24. Selected Production Wells
(Page 14 of 15)

County	Well No.	Owner	Year Drilled	Well Depth (ft)[a]	Water Use[b]	Reference
Wayne	N141	Scotch Plywood	1972	126	I	2
Wayne	098	Long For Prod	1968	240	I	2
Wayne	0100	Scotch Plywood	1969	132	I	2
Wayne	0101	Scotch Plywood	1969	128	I	2
		Cockfield Formation[e]				
Jones	C146	Sharon W.A.	1982	730	I	2
Jones	D117	Beaver Meadow W.A.	1971	612	P	2
Jones	D121	Beaver Meadow W.A.	1971	600	P	2
Jones	D127	Southland Ref.	1972	600	I	2
Jones	D142	Beaver Meadow W.A.	1979	651	I	2
Jones	G64	Masonite Corp.	1960	1068	I	1, 2
Jones	G67	Masonite Corp.	1964	1064	I	1, 2
Jones	G93	Masonite Corp.	1944	1065	I	1, 2
Wayne	A3	Hess Pipeline	1970	596	I	7
Wayne	B6	Larco Drlg. Co.	1966	419	I	7
Wayne	D24	Amerda Hess	1974	220	I	2
Wayne	F8	Humble Oil Co.	1945	574	I	2
Wayne	H1	Humble Oil Co.	1970	732	I	7
Wayne	H2	Mid. State Paving	1971	450	I	7
Wayne	N27	Waynesboro	1900	580	P	7
		Sparta Sand[e]				
Jones	D3	Southland Ind.	1946	640	I	2
Wayne	H3	Warren L. Sims	1972	697	P	7
Wayne	H7	S & W Hog Farm	1962	670	P	7
Wayne	H12	Humble Oil Co.	1963	544	I	2

Table 3-24. Selected Production Wells
(Page 15 of 15)

County	Well No.	Owner	Year Drilled	Well Depth (ft)[a]	Water Use[b]	Reference
		Lower Wilcox Aquifer[f]				
Wayne	B35	Hiwannee W.A.	1981	2777	P	2
Wayne	C58	Waynesboro	1982	2402	P	2

(a) Measured from ground surface.

(b) Water Use: P = public supply (includes municipal and rural domestic use); I = industrial and institutional (includes agricultural and electrical generation use); Unk = unknown.

(c) See Figure 3-34 for locations corresponding to well numbers.

(d) See Figure 3-36 for locations corresponding to well numbers.

(e) See Figure 3-35 for locations corresponding to well numbers.

(f) See Figure 3-37 for locations corresponding to well numbers.

Sources:

(1) Shows et al., 1966, pp. 58-61

(2) Callahan, 1975, and written communication, 1984

(3) Brahana and Dalsin, 1977

(4) LETCo, 1982, ONWI-120, Table 14-5

(5) Brown et al., 1944

(6) Williams, 1969

(7) May et al., 1974.

Table 3-25. Water Requirements for Offstream Uses Pascagoula-Pearl Subregion, Mississippi[a]

Use Category	Total Withdrawals (MGD)			Total Consumption (MGD)		
	Reported	Projected		Reported	Projected	
	1975	1985	2000	1975	1985	2000
Agriculture	17	22	28	16	22	27
Steam Electricity Generation	24	103	45	3	14	5
Manufacturing	168	171	177	33	63	136
Domestic	110	127	144	39	43	47
Commercial	26	28	57	10	10	11
Minerals	48	58	56	35	43	41
Public Lands	1	1	2	1	1	2
Fisher Hatcheries	1	1	1	0	0	0
Total Fresh Water	394	510	509	137	196	269
Total Saline	323	405	211	(b)	(b)	(b)
Total Water Requirement	717	915	720	137	196	269

(a) Includes surface-water and ground-water requirements; instream flow required to maintain aquatic habitats is not included.

(b) Most saline water withdrawals are for once-through cooling, which has little or no consumption.

Source: U.S. Water Resources Council, 1978, Vol. 3, Appendix II, p. 52.

Table 3-26. Water Requirements for Offstream Uses Mobile-Tombigbee Subregion, Alabama[a]

Use Category	Total Withdrawals (MGD) Reported 1975	Projected 1985	Projected 2000	Total Consumptions (MGD) Reported 1975	Projected 1985	Projected 2000
Agriculture	16	21	26	15	20	25
Steam Electricity Generation	2692	2721	1217	20	33	16
Manufacturing	697	513	443	121	207	346
Domestic	146	166	185	26	30	33
Commercial	51	55	58	5	5	5
Minerals	61	71	81	13	15	17
Public Lands	1	1	1	1	1	1
Fish Hatcheries	1	1	1	0	0	0
Total Fresh Water	3663	3547	2010	200	310	442
Total Saline Water	57	99	44	(b)	(b)	(b)
Total Water Requirements	3720	3646	2054	200	310	442

(a) Includes surface-water and ground-water requirements; instream flow required to maintain aquatic habitats is not included.

(b) Most saline water withdrawals are for once-through cooling, which has little or no consumption.

Source: U.S. Water Resources Council, 1978, Vol. 3, Appendix II, p. 52.

aesthetic resources; archaeological, cultural, and historical resources; and natural radiation.

3.4.1 Land Use

Richton Dome is located in Perry County, Mississippi. Land is used in Perry County primarily for agriculture and forestry (Table 3-27). The primary crops are soybeans, corn, sorghum, and wheat (Table 3-28). Most of the forest land in this area is covered by longleaf-slash pine and hardwood trees. Approximately 46 percent of the forest land in Perry County lies within De Soto National Forest (BNI, 1982, ONWI-193).

The Richton Dome area occupies approximately 2,222 hectares (5,490 acres). Based on 1983 infrared aerial photographs, approximately 65 percent (1,434 hectares [3,543 acres]) of the dome area is forest, 28 percent (629 hectares [1,554 acres]) is cleared, 6 percent (139 hectares [343 acres]) is agricultural (including some tree crops), and less than 1 percent (17 hectares [42 acres]) is residential (including the town of Richton) (Figure 3-38). A site reconnaissance in March 1984 indicated that an additional amount of the forested land within the proposed restricted area had been cleared recently. Some of the cleared areas have been replanted and are being managed for timber (Brooks, 1985b).

In Perry County, 83 percent of the land is forested. Approximately one-half of the forested land contains sawtimber, one-fifth poletimber, and the remainder saplings and seedlings. Sawtimber is defined as live trees that are of commercial species, contain at least a 12-foot saw log, and meet regional specifications for freedom from defect. Softwoods must be at least 22.5 centimeters (9 inches) in diameter at breast height and hardwoods at least 27.5 centimeters (11 inches). Poletimber is defined as growing-stock trees of commercial species at least 12.5 centimeters (5 inches) in diameter at breast height, but smaller than sawtimber size.

In the Perry County area, the average yearly net growth of sawtimber in 1976 was estimated as 155 boardfeet per acre (Forest Service, 1978). At the present average lumber price of $200 per 1,000 boardfeet (standing), this growth rate produces $31 yearly average income per acre.

Agricultural crop yields and values in Perry County (for which county data are available) are presented in Table 3-28. The 1982 hay yield in Mississippi was approximately 2.1 tons per acre, and the value of baled hay was $55 per metric ton ($50 per ton) (USDA, 1982, pp. 15, 23, 25, 29, 57); hence gross income was about $105 per acre per year.

Based on consultation with the U.S. Soil Conservation Service (Brooks, 1985a, and Neff, 1985), approximately 2.3 percent of the soils within the dome is classified as prime farmland in accordance with the Farmland Protection Policy Act (7 CFR Part 658, 7 USC Sections 1901-1912).

The town of Richton, located at the southeastern edge of the dome area, and approximately 3.2 kilometers (2.0 miles) from the restricted area boundary, comprises approximately 2.6 square kilometers (1 square mile) of land. Of this total area, 42 percent is in residential, commercial, transportation, and industrial land uses; the remaining area within the corporate limits is undeveloped. The controlled area of the repository overlaps the corporate boundary of the town of Richton, thus encompassing about 10 hectares (25 acres) of the Richton community. This land is zoned for residential use but includes only a few residences and an abandoned church. The areas of Richton adjacent to the controlled area are also zoned residential.

Three farm dwellings are located within the dome area, one immediately north of the restricted area boundary and two others within approximately 1,400 meters (1,500 yards) of that boundary. Numerous single family dwellings are located within the eastern portion of the dome area, west of the town of Richton. The density of these dwellings declines substantially along the county road proceeding from Richton to the restricted area.

Table 3-27. Land Uses in Perry County, Mississippi

Land Use	Acreage	Percentage
Urban	3,955	1.0
Agriculture	54,980	13.2
Forest	347,700	83.4
Transportation and Communication	2,290	0.5
Other (includes water, marshland, stripmines, quarries, and transitional areas)	7,710	1.9
Total	416,635	100.0

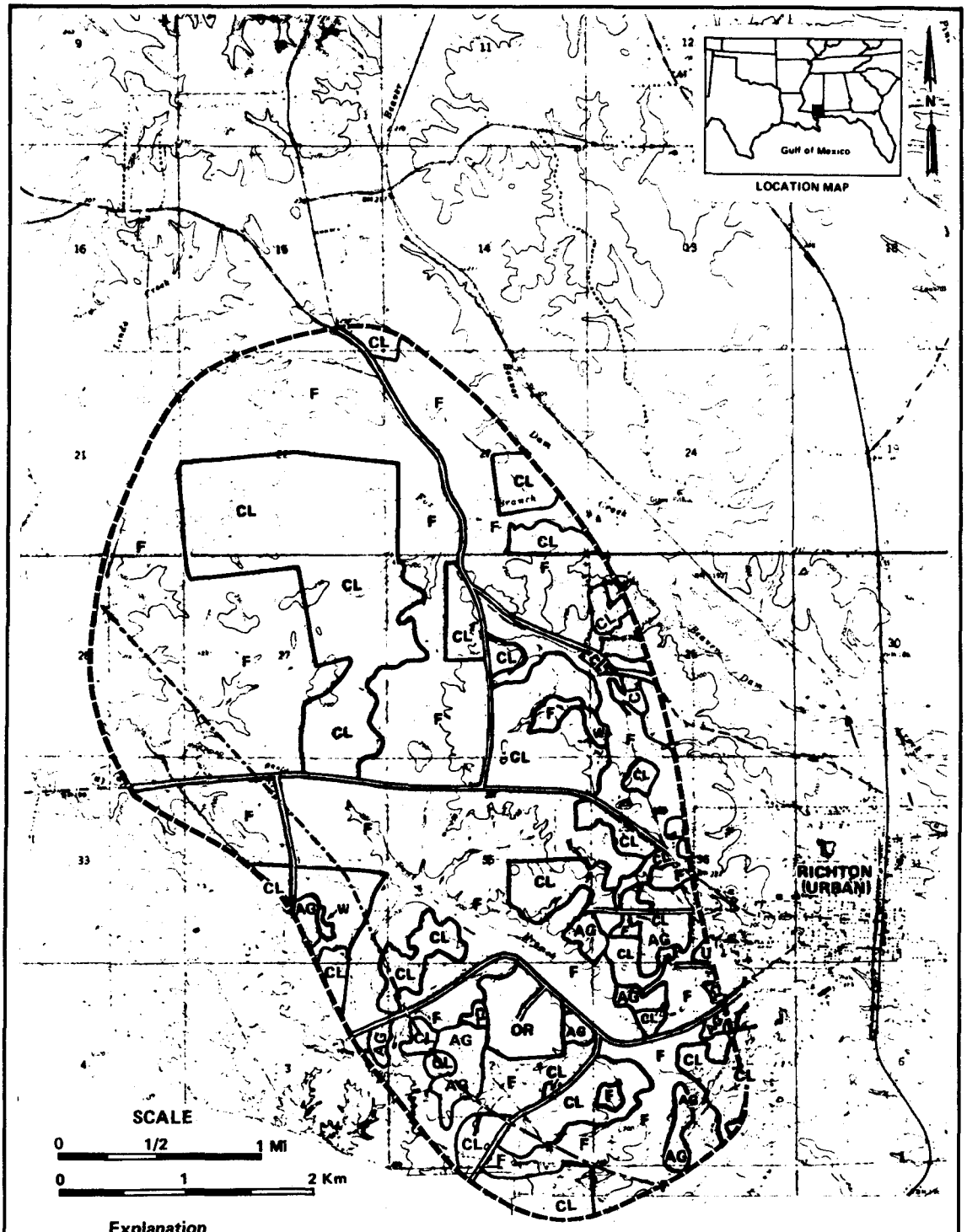
Source: USDA, 1979, p. 19.

Table 3-28. Major Crop Yields in Perry County, Mississippi

Crop	Area, Acres	Yield, Bushels per Acre	Unit Price, $ per Bushel	Gross Income, $ per Acre per Year
Corn	1,900	66	2.85	188
Sorghum	800	52	3.75	195
Soybeans	16,000	22.3	5.55	124
Wheat	4,500	37.2	3.00	112

Note: The following conversions may be used: Corn - 25.4 kg/bushel; Sorghum - 25.4 kg/bushel; Soybean - 27.2 kg/bushel; Wheat - 27.2 kg/bushel.

Source: Mississippi Department of Agriculture and Commerce and U.S. Department of Agriculture Statistical Reporting Service, 1983, p. 15, 23, 25, 29, 47.

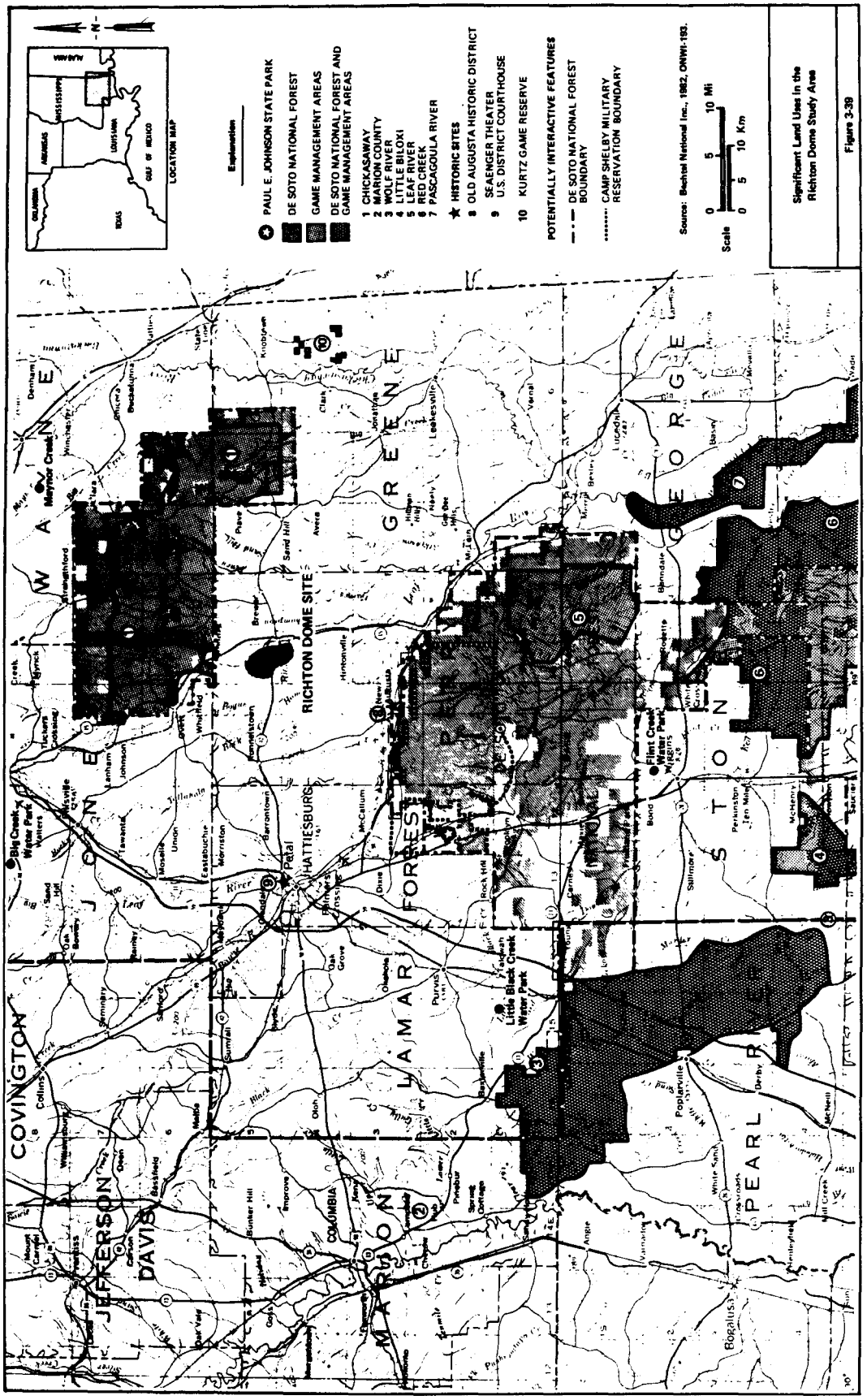


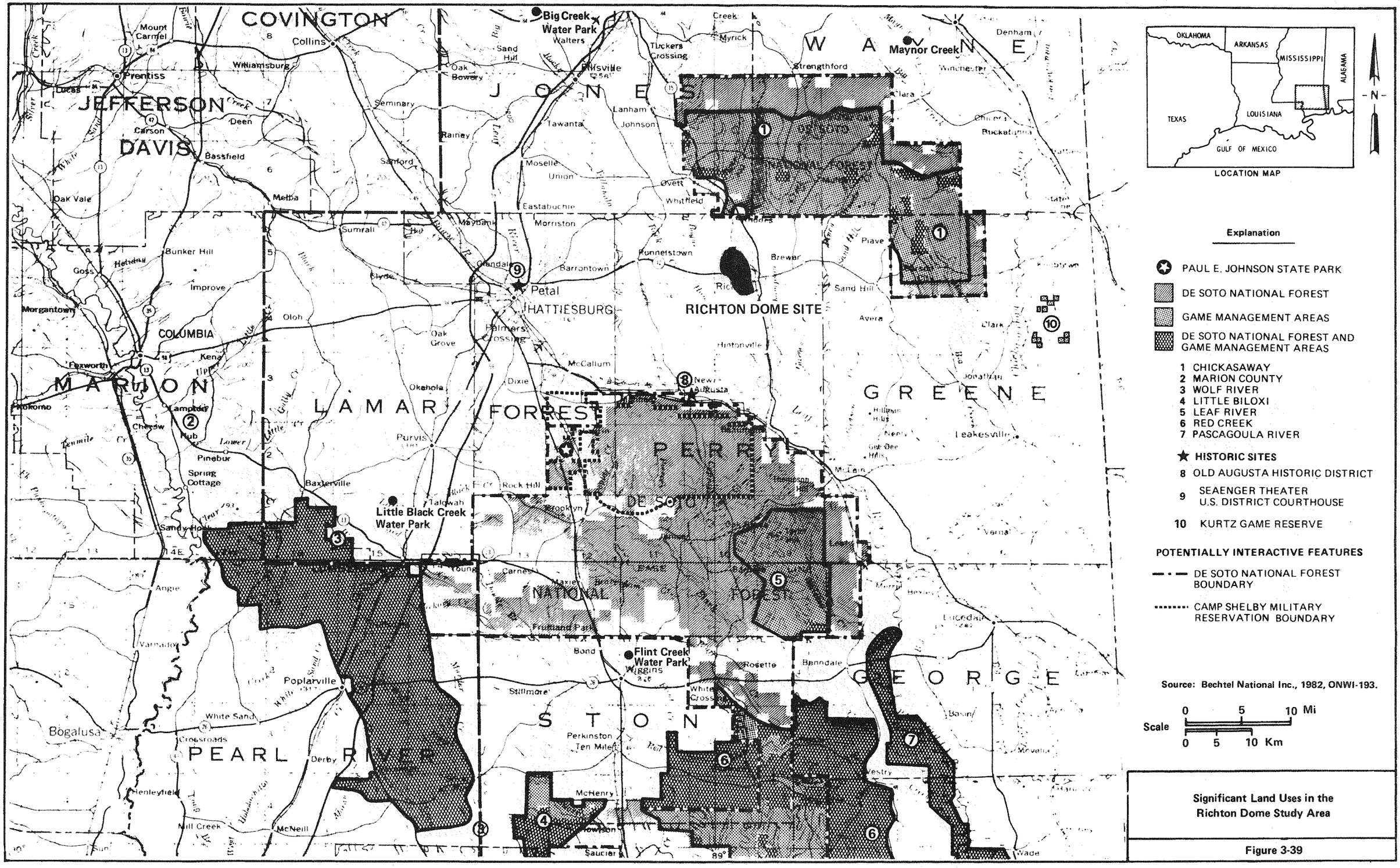
Source: Airborne Systems, Inc., 1983.

Land Use, Richton Dome

Figure 3-38

A larger reproduction of this figure appears at the back of this volume.




COVINGTON
JEFFERSON DAVIS
JONES
WAYNE
MARION
LAMAR
FORREST
PERRY
GREENE
GEORGE
STONE
PEARL RIVER
DE SOTO
NATIONAL FOREST
Big Creek Water Park
Maynor Creek
Little Black Creek Water Park
Flint Creek Water Park
RICHTON DOME SITE
HATTIESBURG
COLUMBIA
Petal
Prentiss
Bassfield
Sumrall
Bunker Hill
Improve
Morgantown
Foxworth
Purvis
Baxterville
Poplarville
Bogalusa
Perkinston
Ten Mile
Wiggins
Lucedale
Leakesville
Avera
Brewer
Runnelstown
Barrontown
Maybank
Morriston
Eastabuchie
Moselle
Union
Ovett
Whitfield
Rawls Springs
Lanham
Johnson
Tawanta
Seminary
Rainey
Sanford
Oak Vale
Melba
Carson
Deen
Williamsburg
Collins
Mount Carmel
Oak Bowery
Tuckers Crossing
Myrick
Strengthford
Winchester
Clara
Buckatunna
Denham
Oloh
Oak Grove
Palmers Crossing
McCallum
Dixie
Okahola
Hinton ville
Jonathan
Clark
Sand Hill
Richton
Pinebur
Spring Cottage
Sandy Hook
Angie
Varnado
Fruitland Park
Bond
Rosette
Banndale
Stillmore
White Cross
White Sand
Crossroads
Derby
Henleyfield
Mill Creek
McNeill
McHenry
Saucier
Wade
Rock Hill
Brooklyn
Carnes
Young
Mayes
Beaumont
Evans
Hillman Hills
Gee Dee Hills
Neely
Thompson Hill
McLain
Vernal
Lucedale
Basin
Moselle
Westry
Tatum
Kena
Lumberton
Hub
Cherokee
Mokomo
Lampton
Tatum
Pennile Cr
Little Creek
Gully Cr
Black Creek
Leaf River
Chickasawhay River
Okatoma Creek
Bowie Creek
Big Creek
Sand Hill Creek
Rock Creek
Mill Creek
Red Creek
Hollow Creek
Goss
Clyde
Glendale
Richton
Talowah
Pinebur
Lucas
Prentiss
Carson
Deen
Williamsburg
Collins
Mount Carmel
Oak Bowery
Tuckers Crossing
Myrick
Strengthford
Winchester
Clara
Buckatunna
Denham
Seminary
Rainey
Sanford
Oak Vale
Melba
Bassfield
Sumrall
Bunker Hill
Improve
Morgantown
Foxworth
Purvis
Baxterville
Poplarville
Bogalusa
Perkinston
Ten Mile
Wiggins
Lucedale
Leakesville
Avera
Brewer
Runnelstown
Barrontown
Maybank
Morriston
Eastabuchie
Moselle
Union
Ovett
Whitfield
Lanham
Johnson
Tawanta

Other land uses include two state highways and two utility corridors which cross the dome (Sections 3.5.1 and 3.5.5). A portion of De Soto National Forest containing the Chickasawhay Wildlife Management Area is located approximately 4.8 kilometers (3.0 miles) north of the dome area (Figure 3-39). The De Soto National Forest, 5.5 kilometers (3.5 miles) from the center of the Richton Dome site, is administered by the Forest Service. As part of the National Forest System, the De Soto National Forest is subject to provisions of the National Forest Organic Legislation, 16 USC Section 475; Multiple-Use Sustained Yield Act (16 USC Sections 528-531); and Forest and Rangeland Renewable Resources Planning and Research Act (16 USC Sections 1600-1676), which includes the National Forest Management plans and the Renewable Resource Extension programs. The Leaf Wilderness, Federally designated under the Wilderness Act (16 USC Sections 1131-1136), comprises approximately 380 hectares (940 acres), and is located in the De Soto National Forest. The Black Creek Wilderness, also Federally designated as a wilderness area under the Wilderness Act, was established simultaneously with the Leaf Wilderness, and is also located in the De Soto National Forest. The Black Creek Wilderness comprises about 1,847 hectares (4,560 acres) and is located approximately 21 kilometers (13 miles) west of the Leaf Wilderness. The Richton Dome site is approximately 40 kilometers (25 miles) north of both the Leaf and Black Creek Wilderness Areas (Braddock, 1985).

Segments of Black Creek, including the segment in Perry County located approximately 40 kilometers (25 miles) south of the Richton Dome site and segments of the Escatawpa River in Mississippi located approximately 72 kilometers (45 miles) east of the site, are currently under consideration as additions to the Wild and Scenic River System under provisions of the Wild and Scenic Rivers Act (16 USC Sections 1271-1287). There are no other rivers in Mississippi that are designated in, or are potential additions to, the Wild and Scenic River System (Hess, 1985; 16 USC Sections 1271-1287). The Richton Dome site is not situated within the watershed of Black Creek or the Escatawpa River and has no drainage connections with them.

The project site area does not contain land within the National Wildlife Refuge System, established by the National Wildlife Refuge System Administration Act of 1966 (16 USC Sections 668dd-668ee). The U.S. Fish and Wildlife Service has confirmed that existing or proposed units of the National Wildlife Refuge System do not occur within an 80-kilometer (50-mile) radius of the proposed site (Aycock, 1985). The closest National Wildlife Refuge is Mississippi Sandhill Crane National Wildlife refuge, located approximately 88 kilometers (55 miles) from the site (Aycock, 1985).

There are no designated, proposed, or potential National Park, National Recreation, National Historic or National Scenic Trails within a 32-kilometer (20-mile) radius of the Richton Dome site. The closest National Trail to the site is the Black Creek Trail, located about 38 kilometers (24 miles) to the southeast at its closest point (Hess, 1985; Forest Service, 1975). Paul E. Johnson State Park is located approximately 32 kilometers (20 miles) from the site, and contains 326 hectares (805 acres) (BNI, 1982, ONWI-193, p. 139).

Camp Shelby Military Reservation is located about 16 kilometers (10 miles) south of the dome in De Soto National Forest (Figure 3-39). Camp Shelby is a State-owned training site for the National Guard Reserves and has been designated a U.S. Army Forces Command Mobilization Station in case of national emergency or war. Camp Shelby is operated by the Mississippi National Guard under a special-use permit granted by the U.S. Forest Service. The facility occupies approximately 54,904 hectares (135,670 acres) within Forrest and Perry Counties. The Mississippi National Guard has permission under this special-use permit to use portions of the Camp Shelby field training area as a bomb-firing range and tank field. The Camp averages 8,900 troops during the annual training period (May-August). During peak periods usage reaches 18,000 troops (Aron, 1985). The Camp is used for training 50 weekends each year and four full months during the summer (Thomasovsky and Brackeen, 1985). Major access routes to the Camp Shelby facilities are U.S. Highway 98 and U.S. Highway 49, with Mississippi State Highway 29 as another access road. A restricted airspace for the De Soto Military Operation Area (MOA), extends over the southern part of the dome area (BNI, 1982, ONWI-193, p. 155). Section 3.5.3 contains additional information on airports in the dome area.

All land within the dome area is privately owned. Fifty-eight percent of the land is in small, 16- to 40-hectare (40- to 100-acre) parcels. U.S. Gypsum is the largest land owner. The State owns Section 16 in each township in the vicinity of Richton Dome. No state or local agency has developed a land-use plan or land controls for the site area.

3.4.2 Terrestrial and Aquatic Ecosystems

This section provides a general description of major plant communities, terrestrial and aquatic habitats, associated fauna, game species, and threatened and endangered species in the areas surrounding Richton Dome. Descriptions of terrestrial and aquatic fauna provided below are based on existing published and unpublished data for the site and surrounding region. Preliminary onsite investigations indicate a high similarity between onsite habitats and habitats in the surrounding region.

3.4.2.1 Terrestrial and Aquatic Habitats

The forestland of the region is classified as southern mixed forest (Kuchler, 1975). Four distinct vegetative communities are identified within this forest zone: (1) longleaf-slash pine, (2) loblolly-shortleaf pine, (3) oak-pine, and (4) oak-gum-cypress (Mississippi Forestry Commission, 1976, p. 3).

Natural vegetation of the Richton Dome area is typified by longleaf-slash pine forests (BNI, 1982, ONWI-193, p. 62). The dominant tree species is longleaf pine, although slash pine has been planted in the area. Virgin timber had been harvested from the dome area by the early part of the century. Today, the forests within and surrounding Richton Dome are generally less than 50 years old and include large areas of young pine plantations (Eco-Inventory Studies, Inc., 1983, p. 2). On Richton Dome, much of the land has been disturbed by agriculture, forestry, and urban activities, especially in the southern half of the dome area. Most of the proposed restricted area has been recently clear-cut of all woody vegetation. No unique ecosystems are known to occur on Richton Dome.

In addition to the dominant longleaf pine and slash pine, significant numbers of loblolly pine, shortleaf pine, and other southern pines exist in the area as either natural associates of the plant community or as a result of commercial reforestation. Common hardwood associates occurring along drainages include water oak and laurel oak (Society of American Foresters, 1980, p. 28). Sand pine, bald cypress, pond cypress, black gum, and water tupelo are characteristic associates on intermittent drainages or wetlands. Narrow bands of hardwood vegetation exist along many of the small intermittent creeks that cross the dome area. Hardwood tree species such as tulip tree, tupelo, sweet bay, and red bay are scattered throughout these riparian areas. Shrub and ground cover are thick. Dominant shrubs include titi and wax myrtle (BNI, 1982, ONWI-193, pp. 69-70).

Grasses either dominate the understory or share dominance with shrub vegetation in the Richton Dome area; bluestem grasses provide most of the herbage. Other important grasses include panicums, paspalums, and dropseeds. Gallberry, saw palmetto, wax myrtle, and shining sumac are predominant among the shrubs (BNI, 1982, ONWI-193, Table 2.4-1).

3.4.2.2 Terrestrial and Aquatic Fauna

Longleaf-slash pine forests provide habitat for a wide variety of animal life. Common species are discussed here; threatened and endangered species are discussed in Section 3.4.2.3. The white-tailed deer is the only large indigenous mammal; the black bear has been encountered but is extremely rare. Common small mammals include raccoon, opossum, tree squirrels, rabbits, and numerous species of ground-dwelling rodents. Terrestrial game birds include bobwhite, wild turkey, quail, woodcock, and mourning dove. Both resident and migratory nongame-bird species are numerous, as are species of migratory waterfowl. Site surveys will be conducted to identify the locations of migratory birds and/or their nests protected under the "Migratory Bird Treaty Act" (16 USC Sections 703-711). Information on the occurrence of protected golden eagles, and their nests or eggs ("Bald and Golden Eagle Protection Act," 16 USC Sections 668-668d) on site and in the vicinity will be obtained from

the Fish and Wildlife Service and the appropriate State resource agency. Watersnakes, cottonmouths, and several frog species occur in the dome area and are typical of the longleaf-slash pine ecosystem. Further information on plant and animal species expected to be found in habitats in the Richton Dome vicinity is presented by BNI (1982, ONWI-193, pp. 66-68).

Based on extensive land clearing that has occurred recently, the numbers and diversity of terrestrial species within the restricted area are expected to be low.

Regional data have been used to develop the following description for the aquatic biota in the intermittent streams in the dome area in Thompson and Bogue Homo Creeks.

The Pascagoula River and its tributaries contain an aquatic biota largely characteristic of that found in other parts of the Coastal Terrace (Cook, 1959, p. 16). Downstream from the dome area, the meandering of the Pascagoula River has left a number of oxbow lakes in George and Jackson Counties that support good sport (bass, sunfish, catfish, crappie) and commercial fisheries. Access to some of the lakes is controlled by private interests (Coleman, 1969, p. 59). Channel catfish are the most sought-after fish, but there is also heavy fishing for bass. (BNI, 1982, ONWI-193, Table 2.4-4, p. 80, contains a species list of the Pascagoula River system.)

The dome area is drained by two intermittent streams which flow into Bogue Homo and Thompson Creeks, immediately west and east, respectively, of the dome area. Channel catfish and bass are the most popular catches in both streams. However, because of the shallow water created by gravel pit operations, fishing has declined on the lower part of Thompson Creek south of Richton (BNI, 1982, ONWI-193, p. 79).

In a recent field survey, conducted near the confluence of the Leaf River and Thompson Creek about 24 kilometers (15 miles) downstream from the site, 30 fish species were collected. The most abundant species were the sunfish family (Centrarchidae), the minnow family (Cyprinidae), and 10 other families (Dames & Moore, 1981, pp. 3-30, 3-31).

3.4.2.3 Threatened and Endangered Species and Other Special Status Species

No threatened or endangered species or critical habitats are known to occur in areas to be occupied by the project facilities. However, several threatened or endangered species proposed or listed by the Federal government have occurred historically in the general vicinity. Based on habitat availability (Table 3-29), some of these species may be present in the dome area. The Mississippi Natural Heritage Program (Mississippi Museum of Natural Science, 1978, pp. 1-2) has prepared a list of rare, endangered, threatened, peripheral, and special-concern species for the State of Mississippi, using criteria adapted from Federal regulations.

The red-cockaded woodpecker has been reported to inhabit portions of the longleaf-slash pine forest in the region. The nearest known red-cockaded woodpeckers colonies are in the De Soto National Forest approximately 16 kilometers (10 miles) south of the dome area (Jordan, 1983, p. 1). The red-cockaded woodpecker is an inhabitant of open, park-like stands of mature pines infected with red-heart disease (Jackson, 1977). The American alligator, an endangered species in Mississippi, occurs 8 to 24 kilometers (5 to 15 miles) south and west of the dome area in the vicinity of the Tallahala and Bogue Homo Creeks (Jordan, 1983, p. 1). This animal is threatened as a result of human activities such as wetlands alteration and hunting. Since becoming protected, however, it has recovered much of its natural range (Cliburn and Jackson, 1975). On the basis of habitat availability, the occurrence of the endangered bald eagle and gray bat in the dome area is possible but not expected. The dome area could also contain flatwoods salamander, black pine snake, and gopher tortoise, all of which inhabit mesic pine flatwoods (Jordan, 1982, pp. 1-3). These species are not currently protected but are rare and may be listed in the future by the Federal government.

Vertebrate and invertebrate species classified as threatened or endangered by the State of Mississippi and protected by state legislation include the yellow-blotched map turtle, gopher tortoise, black pine snake, rainbow snake, southern hognose snake, and two mussel species. Vertebrate and invertebrate species of other classifications and all plant species

Table 3-29. Threatened and Endangered Animal Species Historically Present in the Richton Dome Vicinity

Common Name	Species	Designation[a]	Potentially Present In or Near Dome Area[b]
American alligator	Alligator mississippiensis	FE, SE	
Bald eagle	Haliaeetus leucocephalus	FE, SE	X
American peregrine falcon	Falco peregrinus anatum	FE, SE	
Ivory-billed woodpecker	Campephilus principalis	FE, SE	
Red-cockaded woodpecker	Picoides borealis	FE, SE	X
Bachman's warbler	Vermivora bachmanii	FE, SE	
Gray bat	Myotis grisescens	FE, SE	X
Florida panther	Felis concolor-coryi	FE, SE	
Eastern indigo snake	Drymarchon corais couperi	FT, SE	X
Yellow-blotched map turtle	Graptemys flavimaculata	FEP, ST	X
Atlantic sturgeon	Acipenser oxyrhynchus	FTP, SE	
Crystal darter	Ammocrypta asprella	FTP, SE	
Freckled darter	Percina lenticula	FTP	
Flatwoods salamander	Ambystoma cingulatum	FTP	X
Dusky gopher frog	Rana aerolata sevosa	FTP	X
Gopher tortoise	Gopherus polyphemus	FTP, ST	X
Alligator snapping turtle	Marcrochelys temmincki	FTP	
Black pine snake	Pituophis melanoleucus lodingi	FTP, SE	X
Bachman's sparrow	Aimophila aestivalis	FTP	X
Swallow-tailed kite	Elanoides forficatus	FTP	X
Frecklebelly madtom	Noturus munitus	SE	
Rainbow snake	Farancia erytrogramma	SE	X
Southern hognose snake	Heterodon simus	SE	X
Species of mussel	Elliptio arcus	ST	
Species of mussel	Obovaria unicolor	ST	X
Ringed sawback turtle	Graphtemys oculifera	ST	
Cliff swallow	Petrochelidon pyrrhonota	ST	
Black bear	Ursus americanus	ST	

(a) Designation: F = Federal; S = State; T = Threatened; E = Endangered; P = Proposed.

(b) Based on habitat availability, some aquatic species may not occur in or near the dome area, but they may occur in downstream drainages potentially affected by project activities.

Sources: Eco-Inventory Studies, Inc., 1983, pp. 4-6
Norquist and Dawson, 1985.

Table 3-30. Threatened and Endangered Plant Species Potentially Present in the Richton Dome Vicinity

Species	Common Name	Designation[a]
Heterophyllium haldanianum		SE
Cooperia drummondii		SE
Lachnocaulon digynum	Bog button	ST
Alophia drummondii	Purple pleatleaf	SE
Erythrodes quercetifolia		SE
Habenaria integra	Yellow fringeless orchid	F (under review)
H. lacera	Fringe orchid	ST
Aristida simpliciflora	Three-awn grass	ST, F (under review)
Xyris flabelliformis	Yellow-eyed grass	ST
X. drummondii	Yellow-eyed grass	SR, F (under review)
X. scabrifolia	Yellow-eyed grass	SE, F (under review)
Ruellia noctiflora		ST
Oxypolis ternata	Dropwort	ST
Ilex amelanchier	Holly	ST, F (under review)
Panax quinquefolius	Ginseng	ST
Matelea carolinensis	Spiny pod	ST
Vaccinium tenellum	Blueberry	ST
Quercus arkansana	Arkansas oak	ST
Nymphoides cordata	Floating heart	ST
Lindera subcoriacea	Spicebush	ST
Magnolia tripetala	Umbrella tree	ST
Callirhoe alcaeoides	Plains poppy mallow	ST
Sarracenia purpura	Pitcher plant	ST
S. rubra var. *wherryi*	Pitcher plant	SE, F (under review)
Parnassia casroliniana	Grass-of-parnassus	SE, F (under review)
Gordonia lasianthus	Loblolly bay	ST
Lindera subcoreacea		F (under review)
Agrimonia incisa		F (under review)
Pinguicula primuliflora	Butterwort	SR

(a) Designation: S = State; F = Federal; T = Threatened; E = Endangered; R = Rare.

Sources: Rogers, 1983, pp. 1-5
Norquist and Dawson, 1985
Norquist, 1985.

are not protected under current State legislation dealing with threatened and endangered species (Jacobs, 1979).

Twenty-nine threatened or endangered plant species could potentially occur in the Richton Dome area (Table 3-30). Nine species are currently under review by the Fish and Wildlife Service and are considered as possible additional species for Federal protection. The only plant on the list known to occur in Perry County is Xyris scabrifolia, a Category 2 Candidate Species (Mongan, 1985).

No Federal or State designated or proposed critical habitat is known to occur in the vicinity of Richton Dome (Eco-Inventory Studies, Inc., 1983, p. 30; Rogers, 1983, p. 7). The De Soto National Forest, located approximately 2.4 kilometers (1.5 miles) north of the dome, is the only protected natural area in the Richton Dome vicinity.

Because of the habitat requirements and expected distribution of the various species described above, and because of the extensive land clearing that has occurred recently in the dome area in general, and specifically within the restricted area, it is unlikely that unique habitats for any terrestrial threatened or endangered species will be found.

3.4.3 Air Quality and Climatology

The air quality of the Richton Dome site is described using attainment status determined by the U.S. Environmental Protection Agency (EPA) relative to Federal and State air quality standards, and using available ambient air quality monitoring data. These data were collected at locations around population centers and therefore represent man-made activities associated with urban areas (Table 3-31). The data may not accurately represent ambient conditions in more rural areas like the Richton Dome site. However, ambient concentrations applicable specifically to a rural site have been proposed by the Mississippi Department of Natural Resources (MDNR).

The climatological description of the site is based on data primarily from the first-order National Weather Service (NWS) station at Jackson, Mississippi. Meteorological data collected at this station are also used to represent dispersion characteristics in the site area. Data from the Jackson NWS station are considered to be representative of conditions at the site because of the similarity in terrain (gently rolling) and the station's general proximity to the site.

3.4.3.1 Existing Air Quality

The Richton Dome site is located in Air Quality Control Region 5 and is designated "attainment" or is unclassified by the EPA for total suspended particulates (TSP), nitrogen dioxide (NO_2), sulfur dioxide (SO_2) and carbon monoxide (CO) (40 CFR 81.325). These are the pollutants emitted during site characterization, and repository construction and operation activities. Table 3-32 lists the National Ambient Air Quality Standards for these criteria pollutants which establish limits for the protection of public health (Primary Standard) and welfare (Secondary Standard) (40 CFR Part 50). These same limits apply within the State of Mississippi (Air and Water Pollution Control Law for Mississippi, 1984). The EPA's Prevention of Significant Deterioration (PSD) program under the Clean Air Act (42 USC Sections 7401-7642) applies to major sources located in areas determined to be in attainment with the NAAQS. The project is not considered to be a major source during site characterization and repository construction and operation activities. Therefore, for the purposes of this EA, the DOE concludes that the project is not subject to Federal PSD requirements (see Sections 4.2.1.3.3 and 5.2.5.3).

The Richton Dome site is located in a predominately rural area removed from major emission sources. The MDNR (Banks, 1983) has provided air quality data for TSP, SO_2, and nitrogen oxides (NO_x) from several nearby cities for the five-year period from 1978 through 1982 (see Table 3-31). Because these data are measured in urban areas, they do not represent realistic estimates of ambient air quality for a rural area like the Richton Dome site. The

Table 3-31. Air Quality Monitoring Data From Cities Near Richton Dome

Location	Total Suspended Particulate Data ($\mu g/m^3$)									
	1978		1979		1980		1981		1982	
	Highest 24-Hour Value	Annual Geometric Mean	Highest 24-Hour Value	Annual Geometric Value	Highest 24-Hour Mean	Annual Geometric Value	Highest 24-Hour Mean	Annual Geometric Value	Highest 24-Hour Value	Annual Geometric Mean
Biloxi	96	31	77	30	80	33	93	36	107	27
Gulfport	126	55	120	47	128	51	128	54	78	39
Hattiesburg	103	45	100	44	109	50	190	52	82	38
Pascagoula	134	48	77	42	101	50	139	51	71	42

Location	Sulfur Dioxide Data ($\mu g/m^3$)									
	1978		1979		1980		1981		1982	
	Highest 24-Hour Value	Annual Arithmetic Mean	Highest 24-Hour Value	Annual Arithmetic Mean	Highest 24-Hour Value	Annual Arithmetic Mean	Highest 24-Hour Value	Annual Arithmetic Mean	Highest 24-Hour Value	Annual Arithmetic Mean
Vicksburg	60	18	87	15	49	17	26	16	NA	NA
Pascagoula	50	20	104	17	125	22	79	16	37	15
Meridian	NA	NA	NA	NA	NA	NA	NA	NA	36	14

Location	Oxides of Nitrogen Data ($\mu g/m^3$)			
	1978	1979	1980	1981
	Annual Arithmetic Mean	Annual Arithmetic Mean	Annual Arithmetic Mean	Annual Arithmetic Mean
Jackson	35	24	28	34
Yazoo City	20	22	NA	NA

NA = Not available
Source: Banks, 1983.

Table 3-32. National and Mississippi State Ambient Air Quality Standards

Criteria Pollutant	Averaging Time	Primary Standards[a] ug/m^3	Secondary Standards[a] ug/m^3
Carbon Monoxide (CO)	8-hour[b]	10,000	10,000
	1-hour[b]	40,000	40,000
Nitrogen Dioxide (NO_2)	Annual	100	100
Total Suspended Particulates (TSP)	Annual[c]	75	60[d]
	24-hour[b]	260	150
Sulfur Dioxide (SO_2)	Annual	80	--
	24-hour[b]	365	--
	3-hour[b]	--	1,300

(a) Primary standards are for protection of health; secondary standards are for protection of welfare. Concentration units: ug/m^3 = micrograms per cubic meter.

(b) Not to be exceeded more than once per year.

(c) Geometric mean; all other annual standards are arithmetic means.

(d) Guideline; not a standard. To be used in assessing implementation plans to achieve the 24-hour standard.

Sources: Clean Air Act; 40 CFR 50; Mississippi Air and Water Pollution Control Act, Mississippi Code Annotated Sections 49-17.

Table 3-33. Climatological Means and Extremes for the Richton Dome Area

Parameter	Mean Annual Value	Extreme Values
Hattiesburg Municipal Airport Data, 1901-1964		
Temperature, Fahrenheit	66.7	106, -1
Precipitation, inches		
Total precipitation (water equivalent)	58.8	12 (100-year, 24-hour)
Snowfall	0.4	
Days of 0.1 inch or greater	90	
Days with thunderstorms	76	
Days with reduced visibility(a)	45	
Days with heavy fog(b)	24	

(a) Days on which visibility of under 0.5 mile was observed.
(b) Days on which fog with less than 0.25 mile visibility was observed.

Source: U.S. Weather Bureau, 1965.

Table 3-34. Jackson Climatological Data: Normals, Means, and Extremes

Month	Temperatures °F: Normal: Daily maximum	Daily minimum	Monthly	Extremes: Record highest	Year	Record lowest	Year	Normal Degree days Base 65 °F: Heating	Cooling	Precipitation in inches: Water equivalent: Normal	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Snow, ice pellets: Maximum monthly	Year	Maximum in 24 hrs.	Year	Relative humidity pct.: Hour 00 (Local time)	Hour 06	Hour 12	Hour 18	Wind: Mean speed m.p.h.	Prevailing direction	Fastest mile #: Speed m.p.h.	Direction	Year	Pct. of possible sunshine	Mean sky cover, tenths, sunrise to sunset	Mean number of days: Sunrise to sunset: Clear	Partly cloudy	Cloudy	Precipitation .01 inch or more	Snow, ice pellets 1.0 inch or more	Thunderstorms	Heavy fog, visibility ¼ mile or less	Temperatures °F: Max. (b) 90° and above	32° and below	Min. 32° and below	0° and below	Average station pressure mb. Elev. 331 feet m.s.l.
(a)				18		18				18		18		18		18		18		16	18	18	18	18	18		5	5		17	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	9
J	58.9	35.8	47.1	82	1972	6	1977	569	14	4.53	14.10	1979	0.86	1969	5.63	1979	5.8	1977	3.2	1977	84	87	65	72	8.6		28	35	1978	46	6.7	8	5	18	11	*	2	4	0	1	15	0	1009.2
F	61.7	37.8	49.8	84	1977	11	1970	442	17	4.62	8.35	1979	1.43	1976	3.46	1974	3.6	1968	3.6	1968	82	86	59	62	8.6		30	25	1981	55	6.0	9	6	13	9	*	2	2	0	*	13	0	1008.3
M	68.7	43.4	56.1	88	1974	15	1980	313	37	5.63	15.13	1976	2.05	1966	3.87	1964	5.3	1968	5.3	1968	82	87	57	59	9.2		30	15	1977	58	6.3	9	7	15	11	*	6	2	0	0	4	0	1004.6
A	78.2	53.1	65.7	92	1970	30	1971	74	95	4.65	14.38	1979	1.25	1965	8.42	1979	T	1971	T	1971	85	91	56	59	8.3		28	17	1981	62	5.8	9	7	14	9	0	5	1	*	0	*	0	1005.3
M	85.0	60.4	72.7	99	1964	38	1971	6	245	4.32	10.82	1967	0.74	1977	3.27	1966	0.0		0.0		87	91	56	61	7.0		35	27	1979	61	5.7	9	10	12	10	0	7	1	4	0	0	0	1002.6
J	91.0	67.7	79.4	103	1969	49	1972	0	432	3.40	7.44	1975	0.32	1973	3.24	1979	0.0		0.0		87	91	56	60	6.2		37	18	1981	70	5.2	10	12	8	8	0	8	1	19	0	0	0	1004.4
J	92.7	70.6	81.7	106	1980	51	1967	0	518	4.27	13.25	1979	1.54	1974	5.37	1981	0.0		0.0		90	93	59	66	5.8		40	17	1979	63	5.8	7	14	10	11	0	12	1	24	0	0	0	1004.9
A	92.6	69.8	81.2	102	1981	55	1966	0	502	3.59	7.44	1979	1.45	1980	3.45	1966	0.0		0.0		89	94	59	67	5.6		37	17	1981	64	5.4	8	13	9	10	0	11	2	22	0	0	0	1005.1
S	88.0	64.0	76.0	104	1980	35	1967	0	330	2.99	9.61	1965	0.56	1969	5.86	1965	0.0		0.0		90	94	60	71	6.3		23	21	1981	59	5.5	10	9	11	9	0	5	2	11	0	0	0	1004.5
O	80.1	51.5	65.8	92	1981	30	1980	91	116	2.22	9.13	1970	0.00	1963	6.99	1975	0.0		0.0		89	93	53	72	6.4		25	15	1980	67	4.3	16	6	9	6	0	2	2	1	0	*	0	1007.0
N	68.5	42.0	55.3	88	1971	17	1976	301	10	3.87	9.98	1977	0.93	1967	4.21	1966	0.2	1976	0.2	1976	87	91	58	74	7.3		24	17	1981	55	5.5	11	7	12	8	0	2	3	0	*	6	0	1007.9
D	68.5	37.3	48.9	84	1978	14	1966	504	5	5.04	9.82	1971	0.91	1980	4.61	1971	3.1	1963	1.8	1963	84	88	63	74	8.3		35	35	1976	49	6.2	9	6	16	10	0	3	3	0	0	12	0	1008.6
YR	77.1	52.8	65.0	106	JUL 1980	6	JAN 1977	2380	2321	49.19	15.13	MAR 1976	0.00	OCT 1963	8.42	APR 1979	5.8	JAN 1977	5.3	MAR 1968	86	90	58	66	7.3		40	17	JUL 1979	60	5.7	116	102	147	110	*	64	24	81	1	51	0	1006.0

Means and extremes above are from existing and comparable exposures. Annual extremes have been exceeded at other sites in the locality as follows: Highest temperature 107 in July 1930; lowest temperature -5 in January 1940; maximum monthly precipitation 15.76 in November 1948; maximum monthly snowfall 10.6 in January 1940; maximum snowfall in 24 hours 10.6 in January 1940; fastest mile wind 68 S in March 1952.

(a) Length of record, years, through the current year unless otherwise noted, based on January data.
(b) 70° and above at Alaskan stations.
* Less than one half.
T Trace.

NORMALS - Based on record for the 1941-1970 period.
DATE OF AN EXTREME - The most recent in cases of multiple occurrence.
PREVAILING WIND DIRECTION - Record through 1963.
WIND DIRECTION - Numerals indicate tens of degrees clockwise from true north. 00 indicates calm.
FASTEST MILE WIND - Speed is fastest observed 1-minute value when the direction is in tens of degrees.

October 1976 to date.

Source: NOAA, 1981.

MDNR proposed the following annual average background concentrations for a rural site: TSP, 35 micrograms per cubic meter; NO_2, 20 micrograms per cubic meter; and SO_2, 20 micrograms per cubic meter (Banks, 1983). These values are used in the impact analyses discussed in Sections 4.2.1.3 and 5.2.5.

3.4.3.2 Climate

Meteorological parameters recorded at the Hattiesburg airport and at the Jackson, Mississippi, NWS stations are presented in Tables 3-33 and 3-34, respectively. The stations are located about 29 kilometers (18 miles) and 136 kilometers (85 miles) northwest of the Richton Dome site, respectively, in gently rolling terrain similar to the site area. These data are considered to be reasonably representative of climatic conditions at the site. The data for Jackson are more complete, and are reported below.

The annual mean temperature is 18.3 C (65.0 F). Monthly mean temperatures vary from 8.4 C (47.1 F) in January to 27.6 C (81.7 F) in July. The highest temperature, 42 C (107 F), was recorded in July; the lowest temperature, -21 C (-5 F), was recorded in January (NOAA, 1981).

Precipitation is greatest during the spring and winter months, decreasing during the summer and through the autumn. Most of the precipitation in spring and summer is associated with thunderstorms. Autumn rainfall comes from thunderstorms and tropical storms, while most winter precipitation is caused by subtropical cyclones. At Jackson, annual precipitation averages about 124.9 centimeters (49.2 inches) and has ranged from 80.4 to 235.6 centimeters (31.7 to 92.8 inches). The greatest 24-hour precipitation was about 21.3 centimeters (8.4 inches) and occurred in April 1979 (NOAA, 1981).

Snowfall has occurred from November to April, but is usually light and dissipates rapidly. The annual mean snowfall total is about 2.5 centimeters (1.0 inch). The maximum 24-hour snowfall, 26.9 centimeters (10.6 inches), occurred in January 1940. This total also represents the monthly maximum snowfall for the Jackson area (NOAA, 1981).

Annual average relative humidity at Jackson is 75 percent. The highest monthly average relative humidity, 79 percent, occurs in September; the lowest, 71 percent, occurs in March (NOAA, 1981).

Long-term climatology (paleoclimate) is discussed in Section 3.2.2.3. The possible effects of future climatic changes are discussed in Section 6.3.1.4.

Figure 3-40 represents a wind rose describing surface wind frequency data for Jackson, based on data for 1951-1960. Most frequently wind is from the south-southeast (10.8 percent of the time). The annual average wind speed is 3.3 meters per second (7.3 miles per hour) (Table 3-34).

3.4.3.3 Severe Weather

Weather extremes are important in the structural design of repository surface facilities. The annual fastest mile wind*, and maximum 24-hour rainfall, each associated with a 100-year mean recurrence interval, are approximately 31 meters per second (70 miles per hour) (Simiu et al., 1979) and 26.7 centimeters (10.6 inches) (Hershfield, 1961), respectively.

A total of 49 tornadoes occurred between 1955 and 1967 over a 20,953-square-kilometer (8,090-square-mile) area, which includes the Richton Dome area (Pautz, 1969, p. 64). Assuming a mean path area of 7.3 square kilometers (2.82 square miles) (Thom, 1963, pp. 732-733), the

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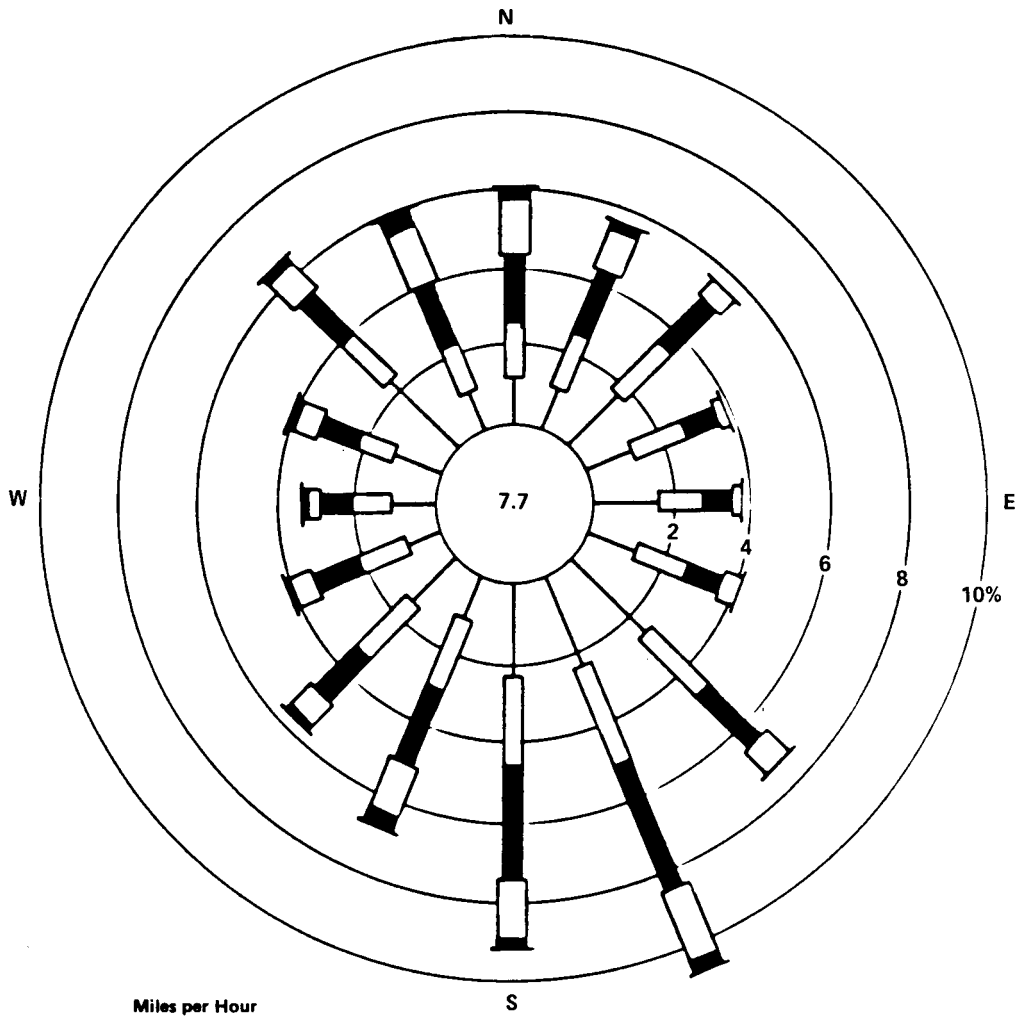
*Defined as the fastest passage of 1.6 kilometers (1.0 mile) of wind at 9.1 meters (30.0 feet) above the ground.



Period of Record: 1951-1960

Source: Mississippi Power and Light Company, n.d.

Annual Wind Rose
Jackson, Mississippi
Richton Dome

Figure 3-40

annual probability of a given point being struck by a tornado is 1.07×10^{-3}. This probability of occurrence for tornadoes at Richton Dome corresponds to a recurrence interval of approximately 932 years.

From 1886 to 1984, 45 tropical storms and hurricanes entered Mississippi, virtually all of which would have affected weather conditions in the dome area (Simpson and Lawrence, 1971, p. 10). Storms are classified as tropical storms if they have winds of 18 to 33 meters per second (40 to 74 miles per hour) or as hurricanes if they have winds of 34 meters per second (75 miles per hour) or greater. Hurricanes occur in the entire Gulf Coast region from June to November. Generally they move into the Richton Dome area from the Mississippi coast. At other times, the hurricane tracks have approached the area from Alabama or Louisiana. Because hurricanes lose strength as they move inland from the coast, the greatest concern for the inland areas like Richton Dome is possible flooding due to excessive rainfall. Of the 45 total storms entering Mississippi, 25 were classified as hurricanes when landfall was reached. None of the storms caused hurricane-force winds at Richton Dome. In recent years several major hurricanes have passed close to the Richton Dome area, specifically hurricanes Camille (August 1969) and Frederic (September 1979). These storms left widespread destruction in their wakes. This damage resulted from the combination of high winds, storm surge, and flooding from intense rainfall. Damages from Camille and Frederic were estimated at 1 billion dollars and 2.3 billion dollars, respectively.

Hurricane Camille, one of the most intense hurricanes ever recorded, with maximum wind gusts to 90 meters per second (201 miles per hour) and sustained winds in excess of 63 meters per second (140 miles per hour), caused extensive flooding over the coastal area of Louisiana, Mississippi, and Alabama. Hattiesburg, the nearest climatological station to Richton Dome, observed 26.67 centimeters (10.50 inches) of rain during the storm and sustained winds estimated near 45 meters per second (100 miles per hour) (U.S. Army Corps of Engineers, 1969).

Hurricane Frederic, among the costliest hurricanes ever to hit the United States, with maximum wind gusts to 71 meters per second (159 miles per hour) and sustained winds estimated at 59 meters per second (132 miles per hour), caused extensive flooding over the coastal area of Mississippi and Alabama. The Hattiesburg station experienced an estimated 18 centimeters (7 inches) of rain during the storm and sustained winds estimated at 36 meters per second (80 miles per hour) (Hebert, 1980).

It is important to note that major damage from both Camille and Frederic was concentrated near the coast. While coastal areas were extensively damaged from Hurricane Camille, the Richton Dome area was described as only lightly damaged (U.S. Army Corps of Engineers, 1969).

Weather extremes are also important in assessing the potential for interruption of normal facility operations. On the average, the area can expect thunderstorms about 70 days per year, hail 2 days per year, freezing rain 1 day per year, and heavy fog (with visibility less than 0.40 kilometer [0.25 mile]) 30 days per year (Baldwin, 1973).

3.4.3.4 Atmospheric Transport and Diffusion

The meteorological factors affecting dispersion, and consequently ambient air quality, in a region are generally related to mixing heights, wind speeds, and the amount of turbulent mixing in the atmosphere. As discussed above and illustrated in Figure 3-40, the wind direction is predominantly from the south-southeast, with annual average wind speed of 3.3 meters per second (7.3 miles per hour).

Turbulent characteristics of the atmosphere can be described in terms of varying stability classes as listed below:

Class A - Extremely Unstable
Class B - Moderately Unstable
Class C - Slightly Unstable
Class D - Neutral
Class E - Slightly Stable
Class F - Moderate to Extremely Stable

The frequency of occurrence of Stability Class F (on an annual basis) provides an indication of the potential for reduced dispersion conditions at night. Table 3-35 presents seasonal and annual distributions of atmospheric stability classes. These parameters are based on data from Jackson, Mississippi, for the 5-year period 1960 to 1964 (NOAA, 1972). The data show that stability class F occurs about 30 percent of the time.

The mixing level (height) represents the potential vertical limit of pollutant dispersion. The mixed layer develops during the day as a result of surface heating by the sun. In general, the higher the mixing level, the greater the dispersion potential. The annual average afternoon mixing level for Jackson is 1,300 meters (4,264 feet). Seasonal average afternoon mixing levels are 970 meters (3,181 feet) for winter; 1,400 meters (4,592 feet) for spring; 1,660 meters (5,444 feet) for summer, and 1,270 meters (4,166 feet) for fall. The annual average morning mixing level for Jackson is 560 meters (1,836 feet). Seasonal average morning mixing levels are 480 meters (1,574 feet) for winter, 490 meters (1,607 feet) for spring, 600 meters (1,960 feet) for summer, and 530 meters (1,738 feet) for fall (Holzworth, 1972).

Poor dispersion conditions (episodes) that persist for several days can result in a buildup of ground-level ambient concentrations. An episode is defined as the occurrence of (1) mixing heights under 1,500 meters (4,920 feet), (2) wind speeds under 4.0 meters per second (8.9 miles per hour), and (3) no significant precipitation (Holzworth, 1972, p. 21). Holzworth's maps (1972, p. 83) show that the Richton Dome site area experienced about 25 episodes (of 48 hours or more) and 65 episode days in 5 years. No episodes lasted 5 days or longer.

The meteorological data from Jackson are considered to be representative of conditions at the site as discussed earlier. One year of sequential, hourly meteorological observations for the year 1975 (NOAA, 1976) and joint frequency tables of wind speed and wind direction by stability (STAR data) for the 1960-to-1964 period (NOAA, 1972) were used in the modeling analyses described in Sections 4.2.1.3 and 5.2.5. The hourly meteorological data were used to estimate short-term (24-hour) impacts. STAR data were used to estimate long-term (annual average) impacts.

3.4.4 Noise

Although site-specific noise measurements have not been made, values for background sound near the Richton Dome area can be estimated based on typical noise data in technical literature and the general character of the existing environment as determined from a March 1984 site reconnaissance. The Richton Dome area has varied environmental settings, with forest predominating (Figure 3-38). Land use becomes more urban near the town of Richton, which is located near the southeast edge of the dome area.

Descriptive measures adopted by the EPA (1974) are used in this EA to describe the time-varying sound and to assess the effects of noise. These measures are L_{eq}, the energy equivalent A-weighted level (dBA), which is the average of the time-varying sound energy; and L_{dn}, the day/night energy equivalent level (dBA), which is the 24-hour A-weighted energy equivalent level with 10 dB added to the nighttime levels (10 p.m. to 7 a.m.).

The nearest residence is approximately 1.0 kilometer (0.6 mile) north of the proposed exploratory shaft facility (ESF) site center (see Figure 3-2). The population density near the dome area is less than 8 persons per square kilometer (20 persons per square mile). For such a sparsely populated area, the expected ambient day/night sound level (L_{dn}) due to human activity is 35 dBA (EPA, 1974, Table B-3). The natural noise sources associated with birds, insects, frogs, and the wind blowing through the forests add to those of the human environment. Summer ambient L_{dn} is approximately 45 dBA when insect activity is greatest (Wyle Laboratories, 1971).

Noise levels are slightly higher along transportation corridors. Traffic along Mississippi State Highway 42, approximately 1.6 kilometers (1 mile) south of the proposed ESF site, and Mississippi State Highway 15, located approximately 3.8 kilometers (2.4 miles) east

Table 3-35. Atmospheric Stability Distribution (Percent) for Jackson, Mississippi (January 1, 1960 through December 31, 1964)

Period	Stability Class					
	Unstable			Neutral	Stable	
	A	B	C	D	E	F
Winter	0.08	4.83	8.90	52.82	9.26	24.10
Spring	3.36	12.14	16.19	29.28	10.32	28.21
Summer	2.88	15.98	15.18	20.91	9.57	35.49
Fall	0.13	5.90	10.50	42.19	9.62	31.67
Annual	1.61	9.73	12.75	36.31	9.69	29.90

Source: NOAA, 1972.

of the area, contribute to the ambient L_{dn} sound levels. Along Mississippi State Highway 42 and within the town of Richton, L_{dn} sound levels are believed to exceed 45 dBA (EPA, 1974). Air traffic in the area is another source of short duration noise increases. There are no schools, hospitals, or other sensitive noise receptors closer to the proposed ESF site than the town of Richton (see Figure 3-38).

The area affected by noise sources is reduced by the natural absorption of acoustic energy as the sound passes over the ground cover of the area. Pine forests may reduce the noise by over 10 dB at the lower frequencies of sound and by as much as 23 decibels at the higher frequencies of sound for each 100 meters (328 feet) that the sound travels through the forest, depending on the height and density of the forest (Beranek, 1971, pp. 182-184).

In this EA, L_{dn} = 45 dBA will be used to represent the ambient noise level for the town of Richton and the transportation corridor. A value of L_{dn} = 35 dBA will be used to represent the ambient noise environment for the isolated rural homes that are distant from Richton and the transportation corridors.

3.4.5 Aesthetic Resources

The terrain in the Richton Dome area is gently rolling. The land is covered by forest interspersed with agricultural areas. Some residences and farms are located near the dome. The site is in a rural setting close to a National Forest and an undeveloped river. The restricted area has recently been cleared of forest vegetation during timber harvesting; this clear-cutting and the resulting barren landscape are common in the region. Visually, the dome is not unique to the surrounding area.

Richton Dome is located about 4.8 kilometers (3.0 miles) south of one portion of De Soto National Forest (Figure 3-39) where timber harvesting also occurs. The Leaf River is located approximately 11.2 kilometers (7 miles) south of the dome area.

3.4.6 Archaeological, Cultural, and Historic Resources

Both prehistoric and historic cultural resources are considered in this section. These resources include archaeological sites, structures, and areas or localities considered important to the cultural history of the region.

The project area lies within the Pine Hills region, perhaps one of the least known portions of Mississippi in terms of cultural resource potential. No cultural resource investigations (historic inventories, archaeological surveys, or oral histories) are known to have been conducted within the dome area or the immediate vicinity. Information on the history and prehistory of the region can be found in the Mississippi State Historic Preservation Plan (Bailey and Lowrey, 1975).

3.4.6.1 Prehistoric Cultural Sequence

The region may have been continuously occupied by a succession of cultural groups for about 17,000 years (Bailey and Lowrey, 1975, p. 11). Prehistorically, three separate eras are recognized: Paleo-Indian, Archaic, and Post-Archaic.

3.4.6.1.1 Paleo-Indian Era (15,000 B.C. - 8,000 B.C.). There is limited evidence of Paleo-Indian occupation in southeastern Mississippi. What little is known of this era is represented by isolated finds of fluted (Clovis-type) projectile points (Tesar, 1974, p. 10; Padgett and Heisler, 1979, p. 9). Most likely, subsistence of Paleo-Indian Groups was based on the procurement of a wide variety of terrestrial and aquatic resources, while settlement was associated with seasonal or seminomadic movement throughout the year.

3.4.6.1.2 Archaic Era (8,000 B.C. - 500 B.C.). The Archaic Era represents a period of adaptation to a post-Pleistocene environment. Archaeological evidence suggests a gradual orientation of the subsistence system around local resource exploitation characterized by increased efficiency in hunting and gathering of plant and animal foods. Technological

advances, including the use of ground stone tools such as adzes, manos, and metates and the introduction of the spear thrower, underscore the increasing efficiency of Archaic subsistence. Through time, the settlement system shifted from the seminomadism of the Paleo-Indians to season-round, semipermanent settlement by the end of the Archaic Era.

The Archaic Era is best described in terms of three periods: Early, Middle, and Late. Evidence of Early Archaic (8,000 B.C. - 5,000 B.C.) habitation has been found along the lower reaches of the Leaf River, where several sites have been excavated. Although no excavations are reported, Middle (5,000 B.C. - 2,500 B.C.) and Late Archaic (2,500 B.C. - 500 B.C.) sites are known in the Leaf River drainage as well (Padgett and Heisler, 1979, p. 10). Sites generally consist of a variety of lithic materials resulting from stone tool manufacture.

3.4.6.1.3 Post-Archaic Era (500 B.C. - A.D. 1700). The Post-Archaic Era is characterized by the appearance of pottery, evidence of horticulture, and the introduction of the bow and arrow. These traits do not appear simultaneously, and individual traits appear at different times in various areas. The Post-Archaic Era has been divided into two cultural periods, the Woodland and the Mississippian, defined largely on the basis of pottery manufacturing techniques, styles, and decoration.

During the Woodland Period (500 B.C. - A.D. 1100), southeastern Mississippi was influenced by cultural developments in the Lower Mississippi Valley and the Gulf Coast (Padgett and Heisler, 1979, p. 10). Early Woodland traits include sand-tempered Alexander and Marksville series ceramics. Middle and Late Woodland ceramics are grog-tempered (crushed pot sherds and fired clay).

The Mississippian Period (A.D. 1100 - A.D. 1700) is marked by the appearance of shell-tempered pottery among the grog-tempered wares, and of small, triangular projectile points. In terms of widespread political influence, ceremonialism, technology, population density, and cultural "richness," the Mississippian is surpassed by no other prehistoric American culture north of Mexico (Jennings, 1974, p. 246).

Although both Woodland and Mississippian Period sites have been recorded in southeastern Mississippi, no stratigraphically excavated or statistically adequate artifact samples have been obtained. Because of this, these occupations are not well understood in the area.

3.4.6.2 Historic Cultural Sequence

The Choctaw Indians are known to have occupied numerous villages in southeastern Mississippi during historic times. Most of these ethnohistoric sites, recorded by Collins (1927), Ford (1936), and Penman (1978), occur along the Chickasawhay River and in the Leaf River drainage.

Although Hernando De Soto reached Mississippi in 1540, and Old Biloxi was established in 1699, it was not until the 1770s that Euro-Americans established settlements in the state (Bailey and Lowrey, 1975, p. 23). Early settlement was restricted to major alluvial valleys, particularly along the Mississippi and Pearl Rivers. It is probable that substantial numbers of Euro-Americans did not reach the Pine Hills region (which encompasses the Richton Dome site) until after the 1830s (Bailey and Lowrey, 1975, p. 24).

3.4.6.3 Recorded Cultural Resources

No cultural resource sites in the dome area are listed in, nominated for, or evaluated as eligible for inclusion in the National Register of Historic Places.

Only one cultural resource site in the project vicinity (Site 22PE552) is on file in the State of Mississippi Department of Archives and History, Division of Historic Preservation. Located about 0.8 kilometer (0.5 mile) southeast of and outside the proposed restricted area, it is a prehistoric site that may have cultural deposits as deep as 1 meter (3.3 feet) (McGahey, 1983).

3.4.6.4 Potential Cultural Resources

There is potential for prehistoric and historic cultural resources in the dome area, although various physical and cultural factors suggest that this potential is low.

Because of previous plowing and logging activities in the area, it is doubtful that undisturbed archaeological resources would be found on the land surface; however, buried remains in colluvial and alluvial deposits are possible. Exposed cultural resources are most likely to be found along stream margins and on undisturbed floodplains.

Archaeological remains from the dome area may date from as early as the Paleo-Indian Era, although the discovery of such early cultural resources is unlikely. If present, these remains would probably be found in eroded upland settings. Surface and subsurface remains of both the Archaic and Post-Archaic eras may be found in eroded uplands, floodplains, and colluvial and alluvial deposits. Because of prior land disturbances, however, surface or near-surface remains in the restricted area are likely to have been damaged or displaced.

Historic remains associated with previous occupation or land use that meet the criteria of eligibility for the National Register are most likely to be structural components of buildings and subsurface features, such as cisterns. These could be found as buried deposits or definable structural components such as building foundations. It is anticipated, however, that if significant historic resources are located in the project area, these will be standing structures reflecting vernacular house, barn, and outbuilding styles. Whether any historic resources exist in the project area is unknown. Recent land disturbance within the restricted area may have damaged or displaced such resources.

3.4.7 Background Radiation

Data presented on the estimated annual dose-equivalent rates from natural and human-introduced background radiation have been reported for the Gulf region (Oakley, 1972; CBEIR, 1980). Definitions of the terms used here are presented in Section 3.2.6.3 (Table 3-11).

Background radiation has four main components: (1) terrestrial radiation (external) resulting from the presence of naturally occurring radionuclides in the earth, (2) cosmic radiation (external) from extraterrestrial sources, (3) natural radiation (internal) from environmental media (air, water, milk), and (4) radiation from global weapons testing. Internal radiation is not included in this analysis, but was estimated to be 27 millirem per year to gonads and 24 millirem per year to bone marrow (CBEIR, 1980, p. 44). The U.S. annual whole body dose equivalent from fallout in 1980 was estimated at 4.4 millirem (CBEIR, 1980, p. 54).

Table 3-36 provides a summary of the dose-equivalent rates for these sources of natural background in the Gulf region, totalling an average of 68 millirem per year*, which is about 10 percent less than the average dose rate of 76 millirem per year for all residents of the United States. This value is comparable with that listed for the State of Mississippi by the EPA (EPA, 1977). The annual population dose to the 337,000 people who lived within 80 kilometers (50 miles) of the center of the site in 1980 was under 23,000 man-rem. This is about 0.13 percent of the 1.7×10^7 man-rem received by the entire population of the United States in 1980.

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*The dose-equivalent rate from background radiation at the site can also be compared with the limit of 25 millirem per year to the whole body from normal repository operations as given in 40 CFR Part 191.

Table 3-36. Dose-Equivalent Rates From Background Radiation, Gulf Region

Source	Dose-Equivalent Rates (millirem per year)
Cosmic Rays[1]	41
External Terrestrial Radiation[2]	23
Weapons-Test Fallout[2]	4
Total	68

Sources:

(1) Oakley, 1972, for Gulf region, p. 54.
(2) CBEIR, 1980, Gulf region, pp. 38-53.

3.5 TRANSPORTATION AND UTILITIES

This section describes the existing transportation network and utilities serving the Richton Dome area. The information is based on information supplied by the State of Mississippi, published reports, and site visits. This information is presented here to provide a general description of transportation and utilities in the area.

3.5.1 Roads

Hattiesburg, Laurel, and Beaumont are the hubs of a network that links the Richton Dome area by highway to large urban areas both within and outside Mississippi. Figure 3-41 shows the more important highways in the general area of the dome.

The nearest Interstate route is I-59, a multilane divided highway with fully controlled access, which passes about 40 kilometers (25 miles) west and northwest of the dome area. This route connects Hattiesburg and Laurel to the southwest with New Orleans, Louisiana, and to the northeast with Meridian, Mississippi; Birmingham, Alabama; and points beyond. The highway has a gross vehicle weight limit of 36,290 kilograms (80,000 pounds). In 1983, average annual daily traffic (AADT) on I-59 between Hattiesburg and Laurel ranged from 9,000 to 20,000 vehicles (see Figure 3-42 for traffic counts on area highways).

Mississippi State Highway 42 connects Hattiesburg and the community of Richton, passing through the dome area. Mississippi State Highway 15 connects Laurel on the north with Beaumont on the south, passing just east of the dome area and through the town of Richton. Both highways are two-lane and considered to be adequate for existing traffic volumes. Traffic volumes in 1984 on Mississippi State Highways 42 and 15 are generally less than 50 percent of capacity, except on State Highway 15 near the towns of Beaumont and Richton where the volume of capacity ratios are 0.88 and 1.35, respectively (Mississippi State Highway Department, 1984). Traffic on State Highway 42 ranges from 2,000 to 7,700 vehicles per day between the towns of Hattiesburg and Richton. State Highway 15 averages approximately 2,000 daily vehicles north of the town of Richton, and from 1,500 to 3,300 vehicles south of the town of Richton.

Traffic counts recorded by a permanent traffic counter located on Mississippi State Highway 15 just north of the town of Richton show the following variations: June and September are the peak months with average daily counts 5 to 6 percent higher than the AADT of 2,605; traffic is heaviest on Friday; and the peak hour occurs around 5 p.m. (Mississippi State Highway Department, 1984).

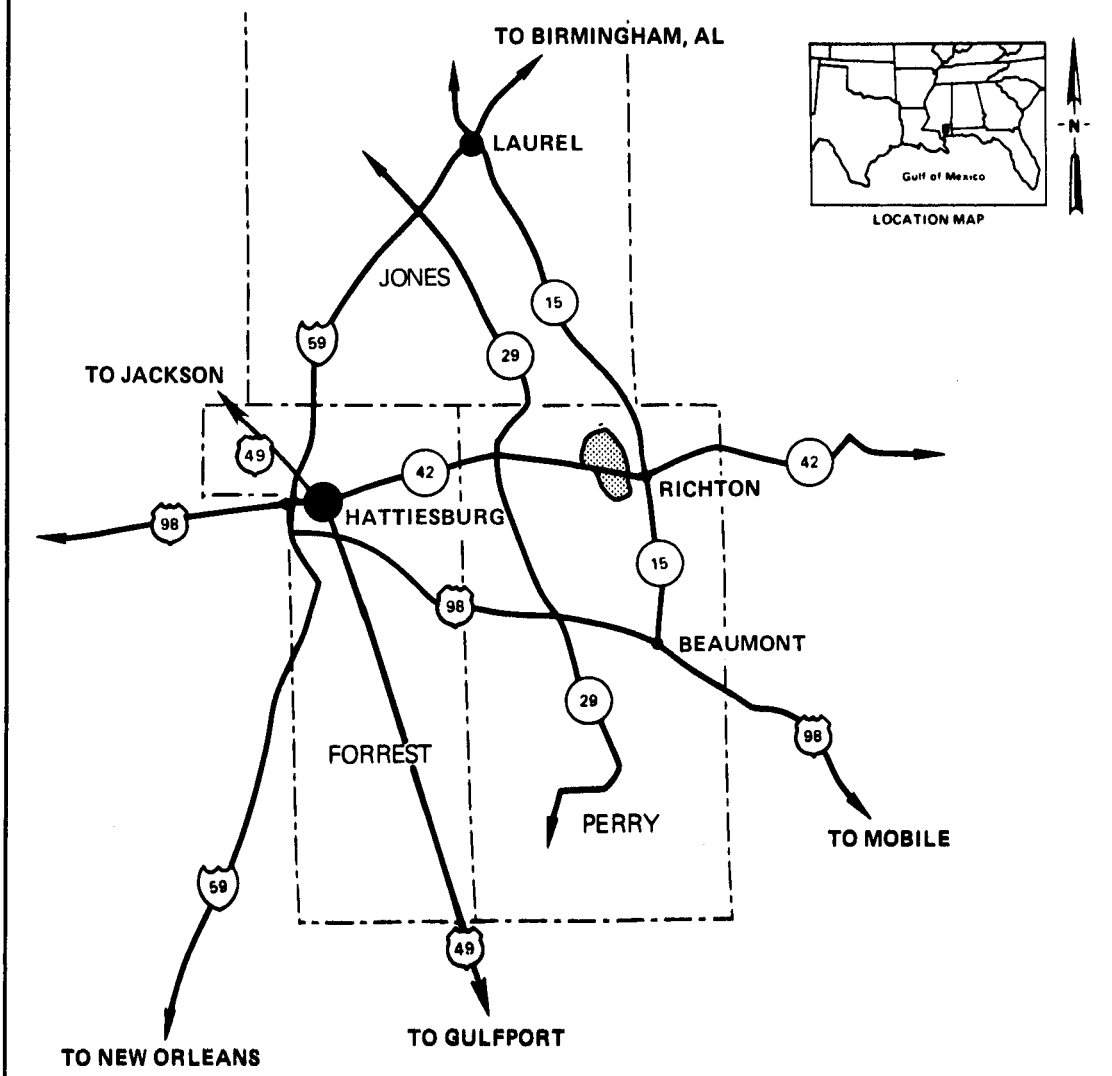
Mississippi State Highways 42 and 15 are rated for 36,000-kilogram (80,000-pound) gross vehicle weight. There are bridges in the area with restricted weight limits.

U.S. Highway 98 (U.S. 98) crosses southern Mississippi, extending from Natchez on the west to Mobile, Alabama, intersecting I-59 southwest of Hattiesburg. This route passes through Hattiesburg and Beaumont, about 24 kilometers (15 miles) south of the dome area. Except where it has recently been improved south of Hattiesburg, U.S. 98 is a two-lane highway. It has a gross vehicle weight limit of 36,290 kilograms (80,000 pounds), except for restricted bridges west of Beaumont. In 1983, AADT counts on U.S. 98 in the area south of the dome ranged from approximately 2,500 to 8,100 vehicles.

Numerous other state and county two-lane roads are within the general area. These roads connect smaller communities and rural areas with the major highways and serve local traffic. Some county roads pass through the proposed restricted area.

3.5.2 Railroads

Rail service in the vicinity of the dome area is provided by two major railroads: the Illinois Central Gulf (ICG) and the Southern Railway (SR) Company, an operating subsidiary of Norfolk Southern Corporation.



Explanation

APPROXIMATE DOME AREA

COUNTY BOUNDARIES

INTERSTATE HIGHWAY

FEDERAL HIGHWAY

STATE HIGHWAY

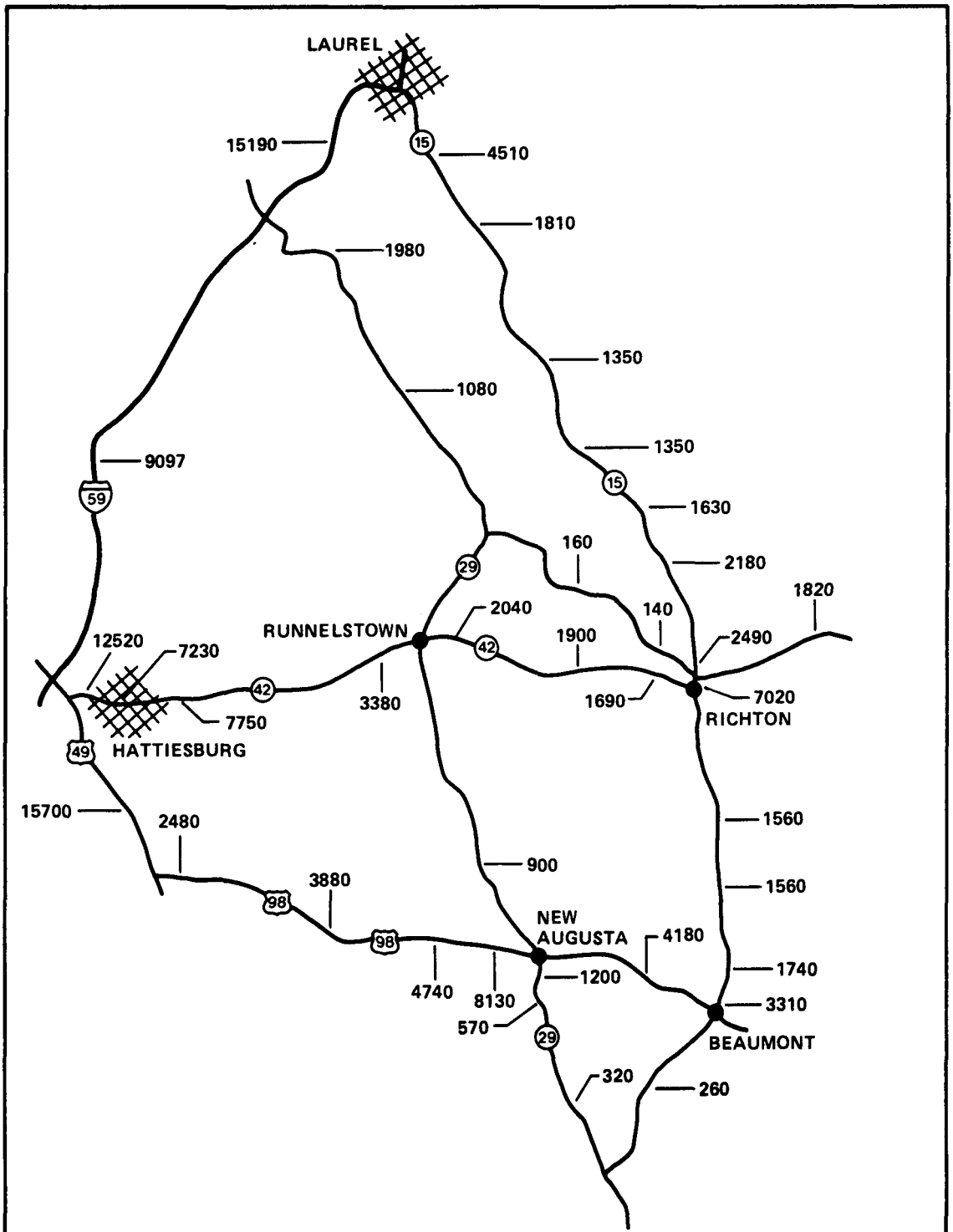
SCALE

KILOMETERS

MILES

Highway Network
Richton Dome Area

Figure 3-41



1983 Annual Average Daily Traffic
Richton Dome Area

Source: Mississippi State Highway Department, 1984, pp. 18, 34, and 56.

Figure 3-42

Hattiesburg is the junction of two ICG main lines. An east-west line connects Natchez in western Mississippi with Mobile, Alabama, and follows approximately the same route as U.S. 98. The other ICG line connects Jackson, Mississippi, and Gulfport, Mississippi (Figure 3-43).

At Beaumont, 43 kilometers (27 miles) east of Hattiesburg on ICG's Hattiesburg-Mobile line, a short branch line in poor condition extends 6 kilometers (4 miles) north to the station of Carmichael. This line formerly extended north to the towns of Richton and Laurel, but was abandoned in 1983. Tracks were removed but, as of March 1984, the right-of-way was still owned by ICG (Martin, 1984). The right-of-way is located approximately 0.8 kilometer (0.5 mile) east of the restricted area.

ICG operates one through freight train daily in each direction between Hattiesburg and Mobile. Intermediate switching is performed by both of these trains and a road switch engine is based in Beaumont. Table 3-37 summarizes frequency of train operations in the area.

In July of 1985, the sale of approximately 1,175 kilometers (730 miles) of ICG's eastern Mississippi lines to the Gulf and Mississippi railway was approved by the Interstate Commerce Commission. The sale includes a line extending north from Laurel to Newton, and points beyond, in northeast Mississippi, as well as an approximate 3.2-kilometer (2-mile) stretch of track extending south of Laurel to a masonite plant (Traffic World, Midwest Bureau, 1985).

SR operates between New Orleans, Louisiana, and Birmingham, Alabama, and points east, passing through Laurel and Hattiesburg. This route largely parallels I-59. Freight operations consist of three to four through trains per day in each direction plus local trains. In addition, SR operates one passenger train per day in each direction for National Railroad Passenger Corporation (Amtrak).

All of the rail lines described above (except the short branch line north from Beaumont) can handle 4-axle cars grossing 119,300 kilograms (263,000 pounds), equivalent to a nominal 90-metric-ton (100-ton) payload.

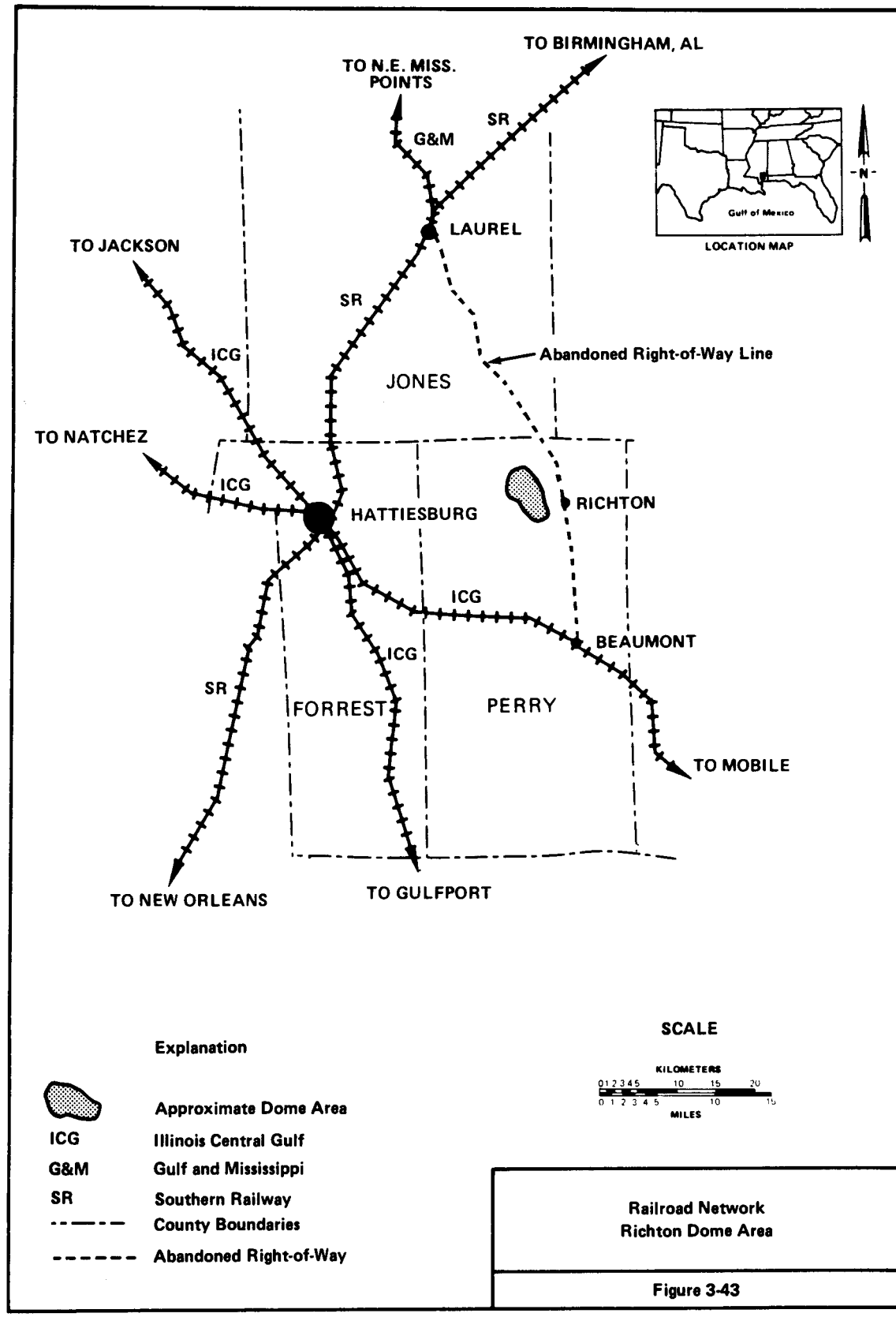
3.5.3 Airports

The only airport in the study area with commercial air service is the Pinebelt Regional Airport in Jones County, immediately west of I-59, 23 kilometers (14 miles) north of Hattiesburg, 27 kilometers (17 miles) southwest of Laurel, and 40 kilometers (25 miles) northwest of Richton Dome. This airport has a 1,980-meter (6,500-foot) runway and is served by commercial airlines, which operate daily flights into Pinebelt from Atlanta and Memphis. Larger airports with more frequent commercial service to more cities (such as at Jackson, Mobile, or New Orleans) are located a minimum of 130 kilometers (80 miles) from Richton Dome.

Other airports in the general vicinity are small, general-aviation airports, owned and operated by local governments, which serve industrial and recreation needs. Public-attended airports (i.e., those with personnel available to offer limited services) are Hattiesburg Municipal, 8 kilometers (5 miles) southeast of Hattiesburg, and Hesler-Noble Field, 5 kilometers (3 miles) southwest of Laurel. The unattended Perry County Airport is located 3.2 kilometers (2 miles) south of the town of Richton immediately west of Mississippi State Highway 15. This airport has a 900-meter (3,000-foot) paved, but unlighted, landing strip (Aircraft Owners and Pilots Association, 1982).

3.5.4 Waterways

No navigable waterways are located in the vicinity of Richton Dome. The nearest navigable waterway is the Tombigbee River, more than 100 kilometers (60 miles) east of the dome area.



Railroad Network
Richton Dome Area

Figure 3-43

Table 3-37. Frequency of Railroad Operations, Richton Dome

Carrier	Section	Train Frequency
ICG	Hattiesburg - Mobile	1 train per day each direction
SR	New Orleans - Birmingham	3-4 through freight trains per day each direction
		1 local freight train per day
SR - for Amtrak	New Orleans - Birmingham	1 passenger train per day each direction

Sources: Martin, 1984
Robinson, 1984.

The ports on the Gulf coast, such as Mobile, Gulfport, and New Orleans, are all accessible by rail and highway. These ports can accommodate all types of vessels and a wide range of cargos. Rail distance from the Richton Dome area to ports along the Gulf coast is from 208 to 280 kilometers (130 to 175 miles).

Rail access is also available to ports along the Mississippi River, such as Memphis, Tennessee, approximately 580 rail-kilometers (360 rail-miles) to the north.

3.5.5 Utilities

Mississippi Power Company, headquartered in Gulfport, Mississippi, is the primary generator and distributor of electricity in a 3,110-square-kilometer (1,200-square-mile) area covering 23 counties in southeast Mississippi (Moody's Investors Service, 1983). Its present generating capacity is 1,966 megawatts. In 1981 its peak load was 1,355 megawatts. The company supplies electricity to several rural electric power cooperatives within its service area. One of these, Dixie Electric Power Association, serves portions of Forrest and Perry Counties (Electrical World, 1984). Most unincorporated areas of Perry County are served by South Mississippi Electric Power Association in Hattiesburg.

United Gas Pipeline Company (UGPC) is the primary supplier of natural gas to communities in the region. Natural gas distributors in the vicinity include Willmut Gas and Oil Company, Entex Gas Company, Union Gas Company, and Chickasawhay Natural Gas Company. Several underground natural gas pipelines pass through or near the dome area as shown in Figure 3-44. The nearest one, owned by UGPC, is 40 centimeters (16 inches) in diameter and passes through the Richton Dome area.

3.6 SOCIOECONOMIC CONDITIONS

Socioeconomic data discussed below include population density and distribution, economic characteristics, community services, social conditions, fiscal conditions, and government structure. The information summarized in this section is taken from the Socioeconomic Data Base Report for Mississippi (BNI, 1984, ONWI-499).

Figure 3-45 shows the location of Richton Dome in relation to urban population centers in Mississippi and the region. Data are presented for an eight-county area surrounding the Richton Dome area, which is considered the socioeconomic study area. These eight counties are within an 80-kilometer (50-mile) commuting distance of the dome and contain major urban centers. Some of these areas will likely experience population increases resulting from project-related immigrants (direct and indirect workers and families).

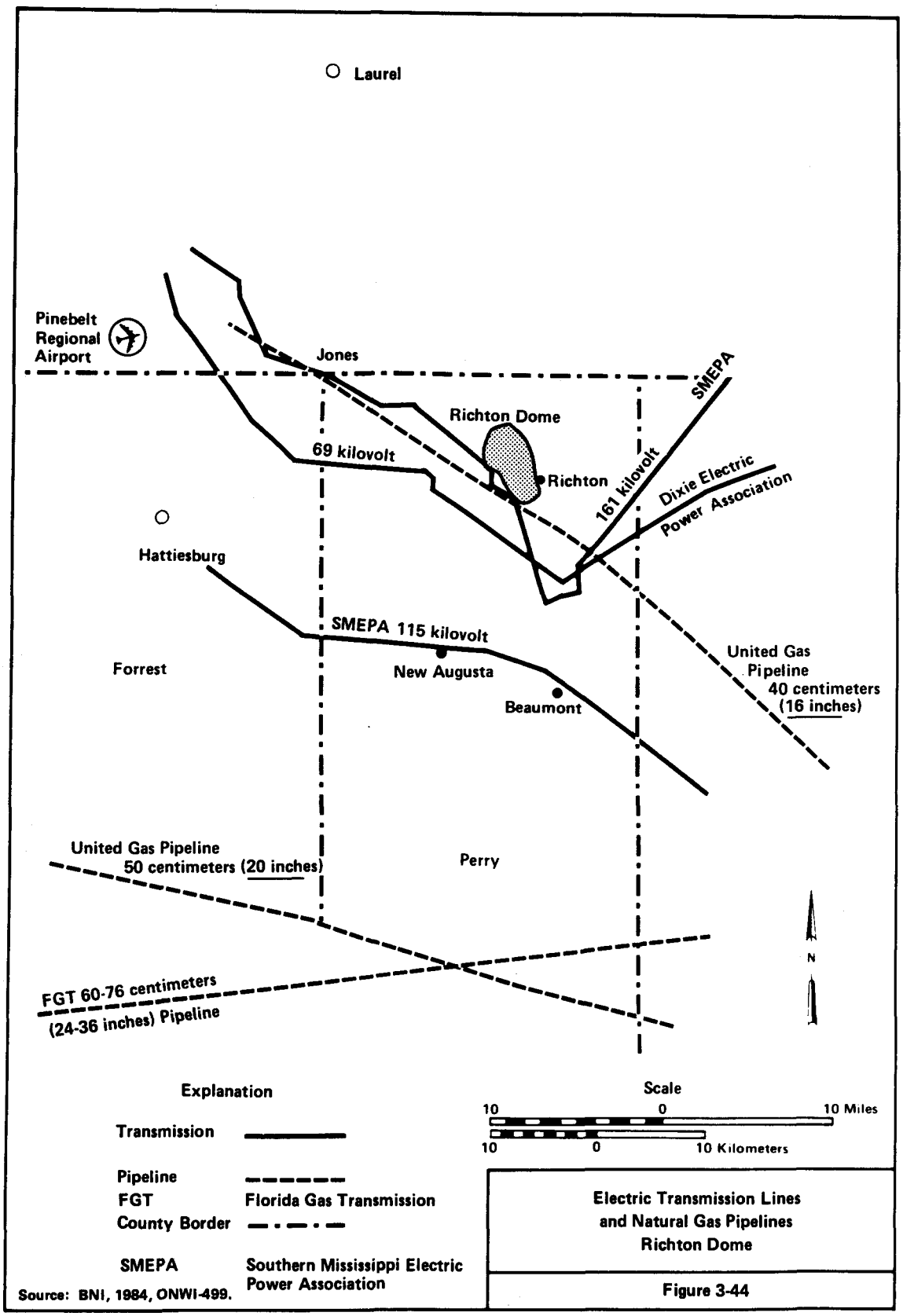
Socioeconomic characteristics described below focus on the city of Hattiesburg, portions of which are in Forrest and Lamar Counties, and the city of Laurel in Jones County. These are the two cities within the study area with a 1980 population of 10,000 or more. Data are also presented for Petal, part of the Hattiesburg urban area; for Richton, the community nearest the site area; and as available for other communities located in the eight-county study area.

3.6.1 Population Density and Distribution

3.6.1.1 Population Density

Figure 3-46 presents the population distribution used for the radiological analysis. This demographic discussion of the site is formatted to conform with meteorological data in order to aid in the radiological assessment. Specifically, the area within an 80-kilometer (50-mile) radius of the site is divided into 16 compass sectors and 0-10, 10-20, 20-30, 30-40, and 40-50 mile annuli. The resulting circular grid is then superimposed on a map of the area to calculate the population in each grid segment.

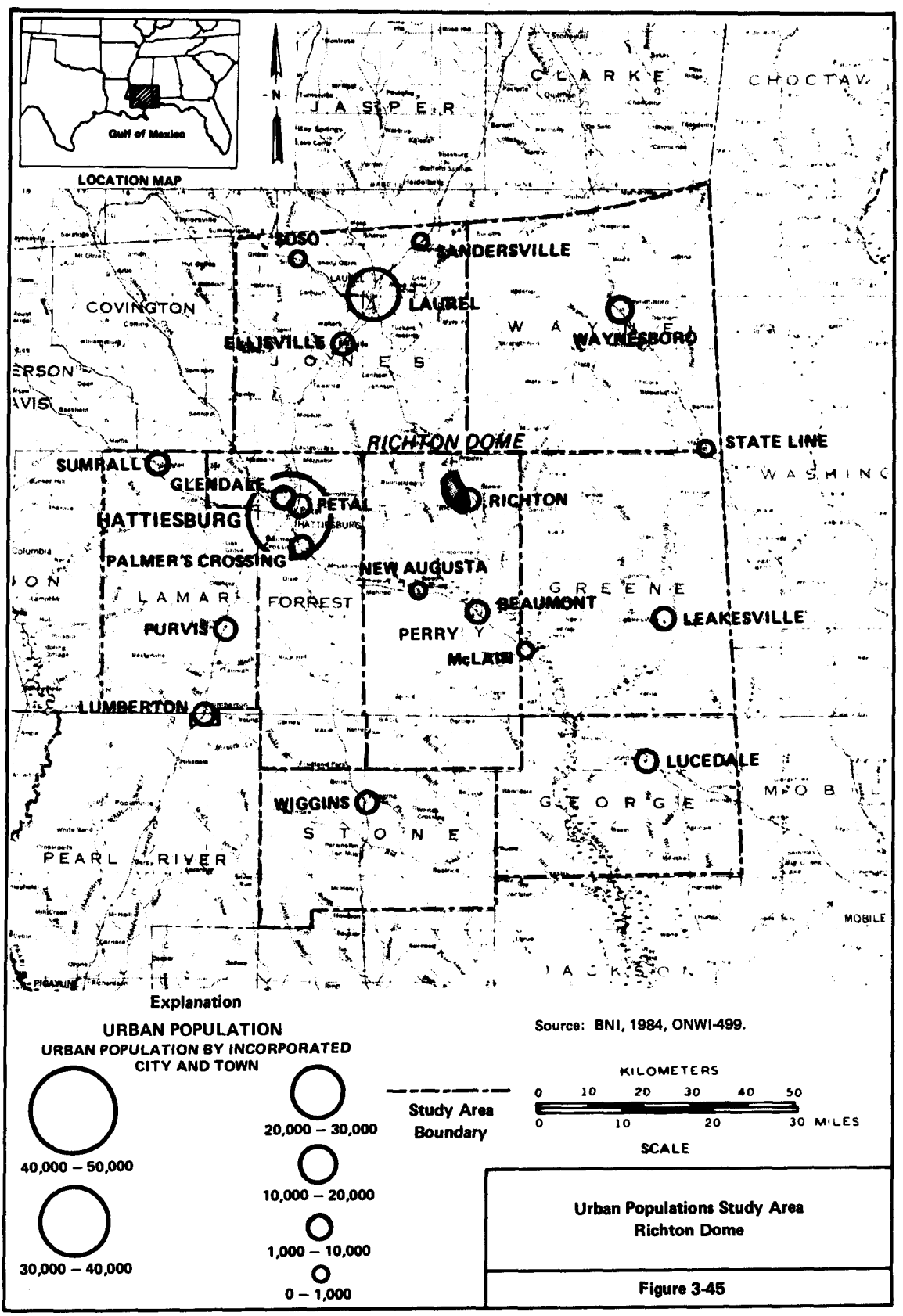
The population values within each segment of the population diagram are calculated by (1) subtracting the contributions of population centers from the total county population to establish a rural population; (2) dividing this rural population value by the county area to



Source: BNI, 1984, ONWI-499.

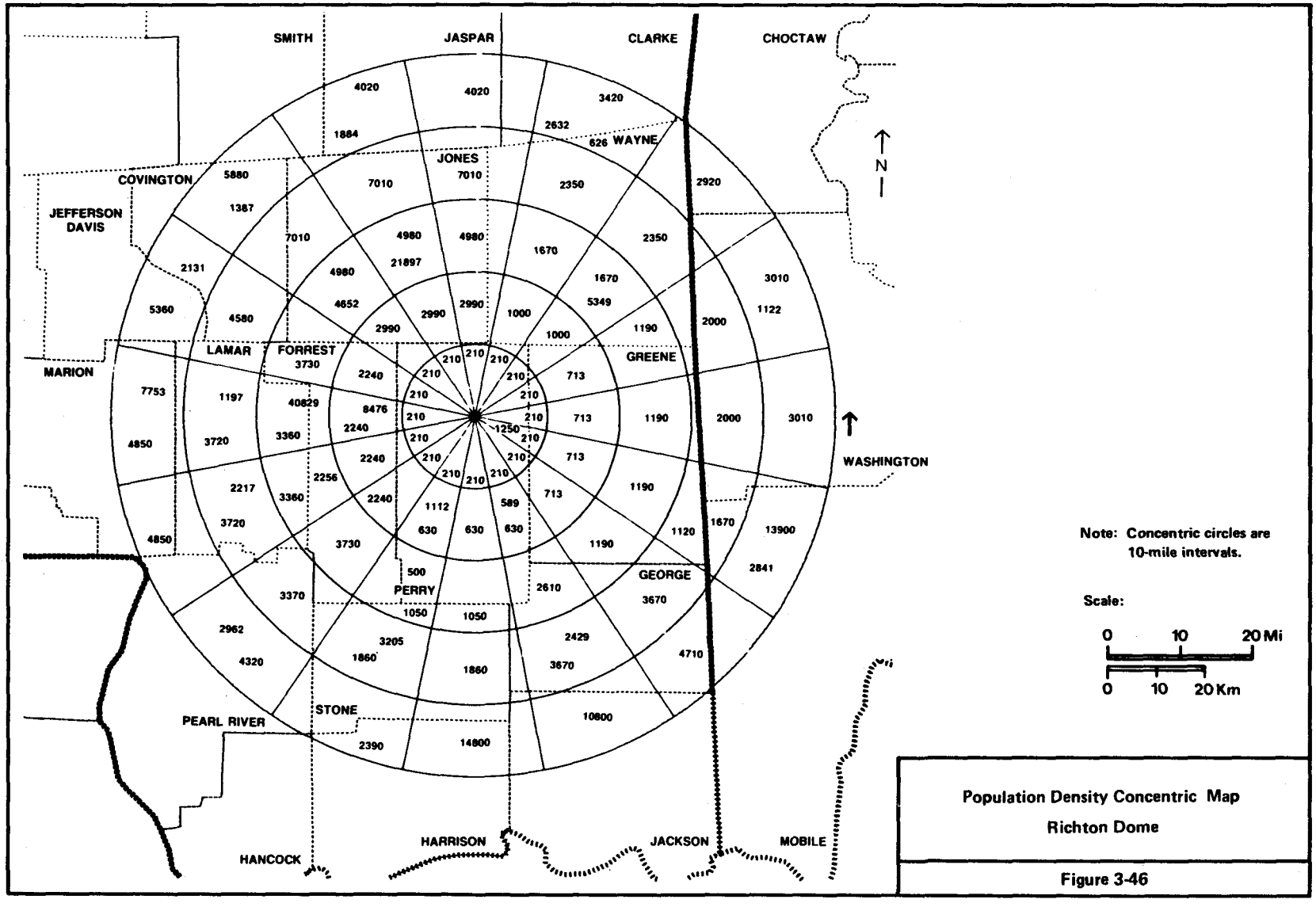
Electric Transmission Lines and Natural Gas Pipelines Richton Dome

Figure 3-44



Urban Populations Study Area
Richton Dome

Figure 3-45



Population Density Concentric Map
Richton Dome

Figure 3-46

get a rural population density; (3) multiplying this rural density by the area represented by the segment; and (4) recording this value, along with the population center values for the centers which occur inside the segment, on the diagram.

Richton Dome is located in Perry County with a population density of 5.8 persons per square kilometer (15.2 persons per square mile). The population densities of two counties in the study area (Forrest, 140.8 and Jones, 81.9) are greater than the national average of 76 for the continental United States. The remaining counties in the study area have densities below 18.5 persons per square kilometer (48 persons per square mile) (Table 3-38).

3.6.1.2 Population Distribution

Table 3-38 presents the 1980 population of the eight counties and the incorporated and unincorporated population centers within the study area. Urban populations are defined here as incorporated areas with 2,500 or more persons. Hattiesburg is the largest population center in the study area and is the only incorporated area with a population exceeding 25,000 (Table 3-38). The other city supporting a population base of 10,000 or more is Laurel. Other urban areas and their populations are: Palmer Crossing, 2,765; Petal, 8,476; Ellisville, 4,652; Wiggins, 3,205; and Waynesboro, 4,368.

Incorporated areas, and their populations, that are closest to Richton Dome are Richton (1,205), Beaumont (1,112), and New Augusta (589) in Perry County.

3.6.1.3 Population Projections

Table 3-39 presents population projections to the year 2005 for all Mississippi study area counties. The 1985 projection was developed based on historic trends and 1977 census estimates (Southern Mississippi Planning and Development District, 1980). The 1990 and 2000 projections were developed by the Mississippi Research and Development Center (1983) based on 1980 U.S. census projections. Projections for the year 2005 were extrapolated based on historical trends.

Between 1980 and 2005, the population in the study area as a whole is projected to increase by 23 percent. The fastest growing study area counties are projected to be Stone County (43 percent) and Lamer County (31 percent). The slowest growing county is expected to be Perry County (7 percent). Remaining counties are expected to grow between 19 and 30 percent. It is assumed that Mississippi study area cities will maintain the same percentage of the county population as in 1980.

Since collection of these data, a new pulp plant (Leaf River) has been sited near New Augusta in Perry County, approximately 14.5 kilometers (9 miles) from the Richton Dome area. Data in this section do not reflect changes resulting from that development. However, an average of 1,500 persons were projected to have been employed in 1983 for construction. About 400 persons were expected to be employed in plant operations. An estimated 600 persons (workers and families) are expected in the area as a result of pulp mill development (Dames and Moore, 1981, pp. 4-1, 4-2).

3.6.1.4 Population Characteristics and Temporary Population

Of the total eight-county population, 23 percent of the 1980 aggregate population was black. The percentage of black population for the study area counties ranged from a high of 34 percent in Wayne County to a low of about 10 percent in George County. In all study area counties the pecentage of black population was less than the 35 percent state average. Other minorities in the eight-county area contributed less than 1 percent to the population. Within the eight-county area in 1980, 52 percent of the population was female. In all study area

Table 3-38. 1980 Population and Density, Richton Dome Study Area

County	1980 Population	1980 Population Density (persons/square mile)
Forrest	66,018	140.8
Glendale	1,329	
Hattiesburg	40,829	2,127.0
Palmer's Crossing	2,765	
Petal	8,476	892.0
George	15,297	31.7
Lucedale	2,429	
Greene	9,827	13.7
Leakesville	1,120	
McLain	688	
Jones	61,912	89.0
Ellisville	4,652	
Laurel	21,897	1,369.0
Sandersville	800	
Soso	434	
Lamar	23,821	47.7
Lumberton	2,217	
Purvis	2,256	
Sumrall	1,197	
Perry	9,864	15.2
Richton[a]	1,205	1,095.5
Beaumont[a]	1,112	278.0
New Augusta	589	
Stone	9,716	21.8
Wiggins	3,205	
Wayne	19,135	23.5
Waynesboro	4,368	
State Line	598	

Source: BNI, 1984, ONWI-499.

(a) Calculation based on approximate land area.

Table 3-39. Population Projections, 1985-2005[a], Richton Dome Study Area

Location	1985	1990	1995	2000	2005	Percentage Change 1985-2005
Forrest County	69,320	72,830	74,820	79,220	82,390	18.9
Hattiesburg	42,840	45,010	46,240	49,010	50,920	18.9
Petal	8,870	9,320	9,580	10,180	10,550	18.9
George County	17,060	17,440	18,460	19,470	20,490	20.1
Greene County	9,570	10,490	10,820	11,150	11,480	20.0
Jones County	61,770	67,350	70,120	72,890	75,660	22.5
Laurel	21,800	23,770	24,750	25,770	26,710	22.5
Lamar County	23,780	27,380	28,610	29,840	31,070	30.7
Perry County	10,910	10,160	10,650	11,130	11,620	6.5
Richton	1,330	1,240	1,310	1,360	1,420	6.8
Stone County	9,120	10,990	11,680	12,360	13,040	43.0
Wayne County	19,270	21,310	22,490	23,690	24,890	29.2
Total Study Area	220,800	237,950	247,650	259,750	270,640	22.6

(a) All numbers rounded to the nearest 10. Baseline population projections for cities were calculated on the assumption that each city maintains its same proportionate percentage of the county population as existed in 1980.

Source: BNI, 1984, ONWI-499.

counties, about 9 to 13 percent of the county population was over age 65. Table 3-40 presents a breakdown of the population by age, sex, and race for the study area.

A large seasonal population is associated with National Guard Training at the Camp Shelby Military Reservation in southern Perry County. Between 28,000 and 32,000 military personnel participate in summer (May-August) training programs involving a maximum of 6,000 people during any 2-week period. This seasonal population is not included in census data for Perry County.

3.6.2 Economic Conditions

3.6.2.1 Employment

The study area had a total employment of nearly 72,000 persons in 1981. Table 3-41 shows employment by category for the eight-county study area. Employment in manufacturing and government predominated within study area counties. In Forrest County and George County, however, the government and the wholesale and retail trade sectors were the largest employers in 1981.

Employment in mining showed significant increases between 1971 and 1981 (ranging from a 150 percent increase in Stone County to a 600 percent increase in Lamar County). Recent government legislation designed to expedite lignite use and oil and gas development within the state may account for these increases (Southern Mississippi Planning and Development District, 1980, p. 73).

3.6.2.2 Unemployment

Unemployment rates in the study area for 1982 are shown in Table 3-42. Perry County demonstrated the second highest unemployment rate (16.1 percent) in the eight-county area.

3.6.2.3 Income Trends

Per capita personal income within the study area increased substantially between 1969 and 1981. In all study area counties except George County, per capita income increased faster than for the State of Mississippi (see Table 3-43).

3.6.2.4 Business Activity

Gross taxable retail sales totaled nearly $1.5 billion within the eight-county study area in 1982. This represents a 240-percent increase from the 1971 taxable retail sales of $438 million (BNI, 1984, ONWI-499, p. 38).

3.6.3 Community Services

3.6.3.1 Housing

Table 3-44 presents housing data for the Richton Dome study area in 1980. The greatest number of housing units are located in the more urban Forrest and Jones Counties and in the more populous cities of Hattiesburg and Laurel.

In 1980, most housing units in the study area were owner-occupied. Forrest County had a relatively more even distribution of owner-occupied (60 percent) and renter-occupied (32 percent) housing units in 1980. Vacancy rates among owner-occupied units were generally less than 2 percent; this compared to a national homeowner vacancy rate of 1.8 percent. Rental vacancy rates were higher in the study area, ranging from 6 percent for Greene County to 17 percent in Wayne County. The City of Beaumont, in Perry County, had a vacancy rate of more than 30 percent. The national rate for rental vacancies is 7.1 percent.

Table 3-40. 1980 Population Characteristics, Richton Dome Study Area

	Total		White		Black		Spanish Origin	
	Female	Male	Female	Male	Female	Male	Female	Male
County: Forrest								
Total Persons	35,055	30,963	25,051	22,668	9,736	7,959	377	370
Under 5 years	2,439	2,501	1,460	1,562	961	932	26	24
5-14 years	4,926	5,101	3,127	3,340	1,776	1,729	49	33
15-19 years	3,662	3,282	2,479	2,288	1,132	9,28	68	88
20-24 years	4,865	4,374	3,623	3,332	1,183	940	81	88
25-64 years	14,619	12,976	10,926	10,103	3,587	2,749	123	119
65 and over	4,544	2,729	3,436	2,043	1,097	681	30	18
County: George								
Total Persons	7,701	7,596	6,922	6,886	762	695	58	40
Under 5 years	662	736	560	641	91	102	3	5
5-14 years	1,476	1,543	1,304	1,379	171	162	3	5
15-19 years	733	768	634	666	100	96	7	5
20-24 years	583	582	521	512	61	68	3	4
25-65 years	3,369	3,247	3,099	3,040	260	203	31	18
65 and older	878	720	804	648	72	71	7	3
County: Greene								
Total Persons	4,985	4,842	3,921	3,915	1,051	921	56	56
Under 5 years	450	483	323	369	102	91	5	7
5-14 years	921	989	677	754	243	234	7	16
15-19 years	470	461	352	349	96	100	9	9
20-24 years	391	315	287	312	102	73	7	5
25-64 years	2,107	2,013	1,750	1,724	354	285	18	13
65 and over	646	511	532	407	109	104	6	6
County: Jones								
Total Persons	32,270	29,642	24,497	22,818	7,627	6,691	237	200
Under 5 years	2,368	2,401	1,591	1,614	760	763	26	29
5-14 years	4,819	5,107	3,409	3,635	1,384	1,448	47	37
15-19 years	2,904	2,994	2,098	2,141	799	837	12	19
20-24 years	2,672	2,610	1,929	1,955	728	644	19	16
25-65 years	14,738	13,322	11,680	10,951	2,988	2,317	104	84
65 and older	4,769	3,208	3,790	2,522	968	682	29	15

Table 3-40. 1980 Population Characteristics, Richton Dome Study Area
(Page 2 of 2)

	Total		White		Black		Spanish Origin	
	Female	Male	Female	Male	Female	Male	Female	Male
County: Lamar								
Total Persons	12,044	11,777	10,616	10,509	1,355	1,207	113	129
Under 5 years	970	1,069	824	919	140	147	10	12
5-14 years	2,129	2,236	1,814	1,958	301	266	24	23
15-19 years	1,163	1,264	1,000	1,097	148	155	18	23
20-24 years	1,086	1,165	945	1,024	134	132	11	22
25-64 years	5,474	5,215	4,966	4,783	481	410	46	45
65 and over	1,222	828	1,067	728	151	97	4	4
County: Perry								
Total Persons	5,078	4,786	3,929	3,783	1,141	1,000	57	30
Under 5 years	431	450	323	336	108	134	6	1
5-14 years	912	949	639	316	273	233	20	12
15-19 years	511	514	388	393	123	120	7	2
20-24 years	418	379	322	287	96	92	5	1
25-65 years	2,188	2,021	1,768	1,698	413	321	20	12
65 and older	618	453	489	353	128	100	5	6
County: Stone								
Total Persons	4,887	4,829	3,747	3,716	1,111	1,084	30	57
Under 5 years	359	374	255	269	103	104	1	--
5-14 years	818	829	564	549	279	249	4	13
15-19 years	627	651	460	479	160	161	8	17
20-24 years	404	491	295	369	105	113	3	21
25-65 years	2,072	2,038	1,672	1,685	391	346	13	12
65 and older	607	446	501	365	103	81	1	4
County: Wayne								
Total Persons	9,827	9,308	6,447	6,248	3,358	3,047	81	68
Under 5 years	884	911	499	528	383	380	9	10
5-14 years	1,767	1,848	1,026	1,068	739	778	18	18
15-19 years	923	968	546	605	376	361	8	7
20-24 years	884	838	558	560	324	277	10	4
25-65 years	4,159	3,867	2,958	2,901	1,187	961	31	22
65 and older	1,210	876	860	586	349	290	5	7

Source: Bureau of the Census, 1982.

Table 3-41. Employment by Category in 1981, Richton Dome Study Area

	Agriculture[a]	Manufacturing	Mining[b]	Construction	Transportation, Communication, and Public Utilities	Government	Wholesale and Retail Trade	Finance and Real Estate	Miscellaneous Services
Forrest County	190	4,380	210	1,460	1,630	8,260	7,640	1,390	4,560
George County	100	320	20	40	200	750	820	120	290
Greene County	100	360	NA	20	30	580	150	30	210
Jones County	630	5,570	1,960	1,220	1,190	5,150	5,060	660	2,400
Lamar County	140	1,240	140	140	330	950	380	100	700
Perry County	100	700	30	40	30	640	230	50	160
Stone County	80	1,080	50	60	190	850	540	80	400
Wayne County	230	1,320	670	140	120	1,050	940	120	400

(a) Agricultural employment is tabulated by place of residence (i.e., no commuters into or out of a county are indicated); all other caregories include data by place of work (i.e., a count of all jobs within each county).

(b) Includes oil and gas.

Source: BNI, 1984, ONWI-499.

Table 3-42. Unemployment Rates, Richton Dome Study Area

Area	Percent Unemployment
Forrest County	8.8
George County	13.3
Greene County	17.2
Jones County	8.7
Lamar County	8.6
Perry County	16.1
Stone County	15.1
Wayne County	14.3
State of Mississippi	11.0

Source: BNI, 1984, ONWI-499.

Table 3-43. Per Capita Income for the Period 1969-1981, Richton Dome Study Area

Jurisdiction	Dollars		Percent Increase 1969-1981
	1969	1981	
Forrest County	2,212	8,262	274
George County	1,934	5,788	199
Greene County	1,389	4,668	236
Jones County	2,074	8,361	303
Lamar County	1,852	6,046	226
Perry County	1,504	6,296	319
Stone County	1,887	7,459	295
Wayne County	1,617	6,036	273
State of Mississippi	2,339	7,409	217

Source: BNI, 1984, ONWI-499.

Table 3-44. Housing Characteristics in Area Counties and Cities for 1980, Richton Dome Study Area

Jurisdiction	Total Year-Round Housing	Mobile Home/ Trailer	Total Owner Occupied Units	Owner Vacancy Rate	Renter Occupied Units	Rental Vacancy Rate, Percent	Total Vacant Units	Motels, 1982
Forrest County	24,981	1,300	14,917	1.6	8,061	9.3	2,003	
Glendale	472	N/A[a]	409	1.0	42	14.3	21	
Hattiesburg	16,003	495	8,008	1.9	6,509	8.9	1,486	18
Palmer's Crossing	1,014	105	622	1.3	311	11.1	81	
Petal	3,267	46	2,167	1.5	857	14.5	243	
George County	5,717	657	4,235	1.0	593	13.0	889	
Lucedale	933	N/A	586	1.8	236	14.5	111	2
Greene County	3,391	443	2,693	0.3	372	6.3	326	
Leakesville	400		292	NA	0.3	10.2	79	74
Jones County	23,791	2,138	16,416	1.8	5,133	11.5	2,242	
Ellisville	1,418	126	941	2.3	352	11.6	125	
Laurel	8,963	147	5,185	2.8	2,993	10.4	785	5
Lamar County	8,573	1,071	6,430	1.9	1,421	13.2	722	
Lumberton	812		532	0.7	0.7	7.1	209	209
Sumrall	458		344	0.6	0.6	8.8	83	83
Purvis	788		631	0.9	0.9	15.7	107	107
Perry County	3,492	408	2,685	0.4	475	10.4	332	
Richton	467	N/A	297	0.3	129	7.2	41	
Beaumont	377		287	0.3	0.3	30.3	46	46
Stone County	3,374	325	2,480	1.7	516	15.7	378	
Wiggins	1,126	27	789	1.5	240	12.1	97	2
Wayne County	6,819	1,032	5,105	1.0	1,082	16.6	632	
Waynesboro	2,019	205	1,301	1.8	511	21.5	207	5

(a) N/A = Not available through census data.

Source: BNI, 1984, ONWI-499.

Within the eight-county area, there are a total of 2,115 hotel/motel rooms available. The greatest number are located in the cities of Hattiesburg (1,336 units) and Laurel (435 units).

Estimates of future housing needs, prepared by the Southern Mississippi Planning and Development District, indicate that a total of 10,416 additional units will be needed within the study area by 1995; a total of 14,389 additional units will be needed by the year 2000 (BNI, 1984, ONWI-499).

3.6.3.2 Education

Within the study area, nine public school districts operate at the county level and five districts are administered at the municipal level. In addition, one consolidated district, Lumberton-Line, is located in Lamar County and serves students in southern Lamar County and northern Pearl River County.

Table 3-45 shows the 1980-1981 enrollments, number of teachers, and the student-to-teacher ratios in elementary and secondary public schools in the study area.

Enrollments in study area schools generally showed decreases between 1981 and 1983, reflecting the declining enrollment trend nationwide resulting from the decreasing birth rate (Southern Mississippi Planning and Development District, 1980, p. 115).

Within the study area, four-year secondary institutions are located in Laurel and Hattiesburg; branch junior colleges are also located in Jones and Stone Counties. Secondary vocational schools are located in Lamar, Stone, Forrest, Jones, and George Counties; post-secondary vocational/technical centers are located in Lamar, Forrest, Stone, and George Counties.

3.6.3.3 Health Services

Health care facilities and services are concentrated in the more urban Jones and Forrest Counties. Two hospitals in Forrest County are located in the Hattiesburg/Petal urban area. In Jones County, three hospitals are located in Laurel and one in Ellisville. The Perry County Hospital in Richton is a small hospital that primarily serves residents in Perry County. The licensed number of beds in the Perry County Hospital totaled 44 in 1982 with an average occupancy rate of 47.4 percent. This means that on the average only 21 of the hospital beds were being used (BNI, 1984, ONWI-499). There are a total of 1,296 licensed hospital beds in the eight-county area. The projected 1986 need is for a total of 1,153 beds within the eight-county area. The projected 1986 need compared to the 1982 licensed beds was greater only in Ellisville Municipal Hospital and Lumberton Citizens Hospital. The average 1982 occupancy within the study area was 57 percent. With the exception of Perry County, all study area counties have extended care facilities (e.g., nursing homes) that provide a total of 1,834 beds. The majority of these facilities are also located in the more urban Jones and Forrest Counties. Table 3-46 summarizes health care facilities and personnel in the eight counties; the number of physicians per 1,000 population is also shown. All study area counties were below the national average of 1.74 physicians per 1,000 population.

3.6.3.4 Recreation

Figure 3-39 shows recreational sites located within the study area. Portions of the De Soto National Forest (administered by the U.S. Forest Service) are located in Forrest, Greene, Stone, Jones, Perry, and Wayne Counties. Kurtz Game Reserve is located in Greene County. Paul B. Johnson State Park is located 15 miles south of Hattiesburg. In addition, four water parks are located within the study area near Laurel, Lumberton, Waynesboro, and Wiggins. These water parks offer recreational activities such as camping, hiking, and water sports. Tennis courts and ball fields are available in nearly all study area cities. A listing of public recreation facilities in the study area is shown in Table 3-47.

Table 3-45. School Enrollments and Student-to-Teacher Ratio in Area Public Schools, 1980-1981, Richton Dome Study Area

Jurisdiction	Elementary			Secondary		
	Enrollment[1]	Number of Teachers[2]	Student-to-Teacher Ratio	Enrollment[1]	Number of[2] Teachers	Student-to-Teacher Ratio
Forrest County[a]	1,820	111	16:1	922	56	16:1
Hattiesburg	3,063	193	16:1	2,759	148	19:1
Petal	1,434	69	21:1	1,394	70	20:1
George County	2,511	116	22:1	1,018	45	23:1
Greene County	1,175	64	18:1	1,015	64	16:1
Jones County	4,558	249	18:1	3,091	172	18:1
Laurel	1,557	91	17:1	1,780	120	15:1
Lamar County	2,253	106	21:1	2,033	110	19:1
Lumberton	533	30	18:1	431	24	18:1
Perry County	801	44	18:1	748	47	16:1
Richton	376	22	17:1	396	27	15:1
Stone County	1,053	60	18:1	956	50	19:1
Wayne County	2,270	118	19:1	1,484	93	16:1

(a) Includes Forrest County Agricultural High School.

Sources: (1) Mississippi Research and Development Center, 1983, pp. 45-48
(2) Mississippi Research and Development Center, 1982, p. 3.

Table 3-46. Health Care Facilities and Personnel in Area Counties, Richton Dome Study Area

County	Total Hospitals	Total Licensed Beds	1986 Needs (Beds)	Total Physicians[a]	Physicians per 1,000 Population
Forrest	2	600	595	108	1.64
George	1	60	47	5	0.33
Greene	1	18	7	0	--
Jones	4	419	333	47	0.76
Lamar	1	26	29	3	0.13
Perry	1	44	30	2	0.20
Stone	1	49	37	5	0.50
Wayne	1	80	75	6	0.31
Total	12	1,296	1,153	176	0.82

(a) Data by place of practice.

Source: BNI, 1984, ONWI-499.

Table 3-47. Recreational Facilities, Richton Dome Study Area

Jurisdiction	Parks	Tennis Courts	Swimming Pools	Ball Fields	Golf Courses
Forrest County					
Hattiesburg	14[a]	18	2	14	1
Petal	-	1	-	2	-
Jones County					
Laurel	13	14	3	13	-
Perry County					
Beaumont	1	1	-	1	-
New Augusta	-	1	-	1	-
Richton	-	2	-	2	-

(a) Includes State and Federal parks.

Source: BNI, 1984, ONWI-499.

3.6.3.5 Protective Services

Law enforcement services are provided by county sheriff departments and municipal police departments. Table 3-48 summarizes law enforcement personnel available within the study area cities in 1982. In 1979, there were 73 officers in the eight county sheriff departments. Of these, 36 were full-time officers and 37 were part-time or auxiliary personnel. In municipal police departments, there were a total of 304 officers, 252 of whom were full-time personnel. Hattiesburg and Laurel had the greatest number of officers, reflecting the greater population in these urban areas. Table 3-48 also presents the number of officers per 1,000 population. When both the part-time and full-time officers are considered, the national average (2.1 officers per 1,000 population) is met in all study area cities except Leakesville in Greene County, Ellisville in Jones County, Sumrall in Lamar County, and Beaumont in Perry County.

Table 3-48 also summarizes fire protection services in the study area counties and cities. The services are currently staffed by 927 firefighters of which 169 (18 percent) are full-time salaried personnel and 758 (82 percent) are volunteers. All (543) of the fire fighters in the rural departments are volunteers, while 169 (44 percent) in the municipal fire departments are volunteers.

3.6.3.6 Water Supply

Water systems in study area counties and cities supply water for commercial, industrial, and residential use. The study area includes 18 municipal systems and 50 county/rural systems. Table 3-49 presents information on water use and system capacities in study area cities. All municipal systems obtain their water supplies from wells.

3.6.3.7 Sewage and Solid Waste Disposal

With the exception of Sumrall in Lamar County, all study area cities have sanitary sewage systems that service between 50 and 100 percent of the municipalities' residents. In addition, storm sewer systems provide partial service to communities in 8 of the 15 study area cities.

All study area cities use a lagoon system for treatment of sewage, except Waynesboro in Wayne County, which has an activated sludge treatment system. Laurel has the only treatment facilities which are over 100 percent load capacity; however, facilities at Lucedale in George County and at Waynesboro in Wayne County are at loads of 95 percent and 90 percent, respectively. In New Augusta (Perry County) and McLain (Greene County), treatment facilities are at loads of 20 and 19 percent, respectively (Table 3-50).

Sanitary landfills are the primary method of solid waste disposal in the study area. Greene County is the only county without a licensed sanitary landfill; Forrest County has two licensed landfills (BNI, 1984, ONWI-499).

3.6.4 Social Conditions

3.6.4.1 History

The historic period began in Mississippi in 1540 when Spanish explorers under Hernando de Soto first entered the area. In 1669, the first permanant European settlement in the lower Mississippi Valley, Soeur d'Iberville, was established by the French. French dominion over the area ended in 1763 by the Treaty of Paris when the area briefly became an English province until succeeded by the Spanish in 1774. In April 1798, the Mississippi Territory was created by the United States and Natchez became the territorial capital. Many of the early pioneers were Scottish settlers from Virginia and the Carolinas. Particularly in Greene and Wayne Counties, Gaelic was extensively spoken until the 1820s when the large influx of English-speaking settlers caused its disuse (BNI, 1984, ONWI-499). Mississippi was admitted to the union in December 1817.

Table 3-48. Protective Services in Area Cities, Richton Dome Study Area

Jurisdiction	Total Officers		Officers per 1,000 population	Firefighters	
	County	City		Salaried	Volunteer
Forrest County	9				70
Hattiesburg		127	3.1	87	0
Petal		18	2.1	6	27
George County	10				180
Lucedale		15	6.2	1	24
Greene County	4				83
Leakesville		2	1.8	0	13
McLain		2	2.9	0	15
Jones County	26				110
Ellisville		8	1.7	3	18
Laurel		83	3.8	67	0
Lamar County	13				35
Sumrall		2	1.7	0	5
Purvis		7	3.1	3	15
Lumberton		5	2.3	0	12
Perry County	4				10
New Augusta		2	3.4	0	15
Beaumont		1	0.9	0	15
Richton		9	7.5	0	24
Stone County	3				0
Wiggins		12	3.7	0	20
Wayne County	4				55
Waynesboro		11	2.1	2	12

Source: BNI, 1984, ONWI-499.

Table 3-49. Water Use and Plant Capacity, Richton Dome Study Area

Jurisdiction	Volume, million gallons per day		
	Average Daily Consumption	Peak Consumption	Plant Capacity
Forrest County			
Hattiesburg	7.5	10.1	12.0
Petal	1.0	1.1	1.8
George County			
Lucedale	0.44	0.51	1.44
Greene County			
McLain	0.1	0.14	0.504
Leakesville	N/A[a]	N/A	0.936
Jones County			
Laurel	5.9	9.40	10.80
Ellisville	0.6	0.75	2.16
Lamar County			
Lumberton	0.239	0.350	2.952
Purvis	0.211	0.225	1.080
Sumrall	N/A	N/A	0.432
Perry County			
Beaumont	0.090	0.200	1.224
New Augusta	0.125	0.150	1.728
Richton	0.225	0.225	1.008
Stone County			
Wiggins	4.0	6.0	12.0
Wayne County			
Waynesboro	0.8	0.95	2.88

(a) N/A = not available.

Source: BNI, 1984, ONWI-499.

Table 3-50. Sewage Treatment Facilities, Richton Dome Study Area

Jurisdiction	Capacity, million gallons/day	Present Load, Percent of Capacity
Forrest County		
Hattiesburg	13.0	57
Petal	0.755	60
George County		
Lucedale	0.279	95
Greene County		
McLain	0.135	19
Leakesville	0.225	72
Jones County		
Laurel	6.0	134(b)
Ellisville	0.95	50
Lamar County		
Lumberton	0.376	76
Purvis	0.283	80
Sumrall	None	None
Perry County		
Beaumont	0.15	70
New Augusta	0.15	20
Richton	N/A(a)	N/A
Stone County		
Wiggins	1.26	60
Wayne County		
Waynesboro	1.2	90

(a) N/A = not available.
(b) City of Laurel, 1984.

Source: BNI, 1984, ONWI-499.

The Choctaw Indians, the largest of the Mississippi tribes, occupied the area at the time of arrival of the first Europeans. In 1805, they ceded their land in southeastern Mississippi to the U.S. Government. By the 1840s, the remainder of their land had been transferred to the U.S. Government and the bulk of the Choctaw Indians joined the Creek, Chickasaw, Cherokee, and Seminole as the "Five Civilized Tribes" of the Indian Territory, and relocated in Oklahoma.

About 1,000 Choctaw Indians refused to leave Mississippi and moved to the east-central part of the state. Their descendants, the Mississippi Band of Choctaw Indians, presently live on about 17,000 acres of land in the Plains area of the state, north of the socioeconomic study area (BNI, 1984, ONWI-499).

With secession of Indian lands, vast tracts of fertile delta farmland were claimed by farmers and the plantation-based cotton economy flourished (Kelley and Spillman, 1976, pp. 27-29). Associated with plantation development was the widespread use of black African slaves. The migration of the Africans and Afro-Americans in the 18th and 19th centuries has influenced the history and culture of the state (Gutman, 1976, pp. 327-360).

However, the Piney Woods Region, which includes all of the study area counties, produced low cotton yields. Consequently, settlers in the Piney Woods Region turned mainly to cattle grazing and small farms (Kelley and Spillman, 1976 pp. 27-29). Although smaller farms established in these marginal lands to the east were not dependent upon slave labor, the owners were drawn into the Civil War (Pierce, 1974, p. 170; Skates, 1979, p. 20). In 1860, at the outbreak of the Civil War, 55 percent of the population of Mississippi was black and slave (Pierce, 1974, p. 166).

With the decline of lumbering in the northern states, the forest industry turned its interest to the southern timber (Kelley and Spillman, 1976, p. 30). Lumber production in Mississippi expanded rapidly until, by the 1904-1915 period, Mississippi was ranked third among lumber-producing states in the United States (Hickman, 1973, p. 213-214).

A number of the major towns in the region were founded during the period of the timber boom. For example, in 1902, the village of Rich's Mill moved a mile and a half to be on a rail route out of Laurel and changed its name to Richton. Hattiesburg and Laurel were also founded during this period (Wacaster, 1975, p. 448).

By 1925, timber production in the area declined precipitously and was virtually nonexistent during the 1930's. This was due to the depletion of the forests of southeastern Mississippi and the decline of demand during the depression (Kelley and Spillman, 1976, pp. 34, 35). After World War II, the lumber industry recovered, with more emphasis placed on diversified wood products such as particle board, plywood, and paper (Wacaster, 1975, pp. 435-436; Hickman, 1973, pp. 227-231). Timber production remains the leading industrial sector in the area. The newly constructed Leaf River Pulp Mill in Perry County is indicative of how the forest industry is attracted to the region's natural and human resources.

The Federal Government has played an important role in the history of southeastern Mississippi during the last fifty years. During World War II, several bases in the region, including Camp Shelby near Hattiesburg, served as training facilities for thousands of troops and military personnel. Camp Shelby continues to be a major regional employer (Kelley and Spillman, 1976, p. 36).

3.6.4.2 Lifestyle

The study area counties are included in the heart of the South (Reed, 1982, pp. 61-77). Among the cultural similarities it shares with such other parts of the south as central Alabama or northern Louisiana is a strong sense of place. As Reed (1982, p. 136) wrote,

> "Another persisting aspect of Southern culture that may have some bearing on how the region adjusts to development is what has been called localism-roughly, a tendency to see communities as different from each other and to prefer one's own. There is more to this, I think, than mere parochialism. The trait seems to be related to the sense of place remarked by so many observers of Southern life and culture, a sensitivity to the things that make one's community unique and, in particular, the existence of a web of friendship and, often kinship that would be impossible to reproduce elsewhere."

Religion is an important element of culture in the south and the study area. Protestant denominations dominate the study area with 270 churches (96 percent of the total number of churches). In addition, there are nine Catholic churches and, in Hattiesburg, one Jewish synagogue (BNI, 1984, ONWI-499). In Perry County in particular, local churches often sponsor religious and social activities and religious beliefs and practices are seen as influential to the everyday activities of individuals and groups (Wacaster, 1975, p. 481).

3.6.4.3 Attitudes Toward Growth, Development, and the Repository

Residents of the study area counties appear to be favorably disposed toward commercial and industrial development in their counties. In a 1982 study, all mayors and board of supervisors' presidents were asked to identify major capital improvement needs for their jurisdictions. The results of that survey indicated that officials in all of the study area counties perceived needs for commercial redevelopment, industrial site development, and venture capital investment (Southern Mississippi Planning and Development District, 1982, pp. 36, 43-45, 51-53, 56-58).

Attitudes of area residents toward repository development are mixed. Technical reports documenting these attitudes have not been prepared but testimony from public hearings indicates that many residents oppose the repository.

3.6.4.4 Social Problems

One indicator of social conditions in an area is the crime rate. The number of index crimes* and the crime rate per 1,000 population for study area counties and for the state of Mississippi are shown in Table 3-51. Statistics reflect only those crimes reported by county and municipal law enforcement agencies to the Uniform Crime Reporting Division. Counties with higher crime rates are the more urban Forrest and Jones Counties; the crime rates in these two counties were also higher than the state crime rate in 1982. This could indicate either more crime in these two counties or more sophisticated reporting systems. The relatively low crime rate for the rural counties is considered by many as an indication of a higher quality of life in the area.

The Mississippi Department of Mental Health operates regional comprehensive community health centers; three such centers serve residents within the study area. The center in Hattiesburg serves residents of Forrest, Greene, Jones, Lamar, Perry, and Wayne Counties; the center in Gulfport serves residents of Stone County; and, the center in Pascagoula serves residents of George County. Alcohol and drug abuse, and social maladjustment cases are the two categories representing the highest number of cases of treatment at the centers (BNI, 1984, ONWI-499).

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*Index crime offenses include murder, rape, robbery, assault, burglary, larceny, motor vehicle theft, and arson.

Table 3-51. Number of Crimes and Crime Rate per 1,000 Population in 1982, Richton Dome Study Area[a]

Jurisdiction	Offenses	Crime per 1,000 Population[b]
Forrest County	2,505	37.9
George County	34	2.2
Greene County	21	2.1
Jones County	1,943	31.4
Lamar County	45	1.9
Perry County	40	4.1
Stone County[c]	-	-
Wayne County	182	9.5
State of Mississippi	71,241	28.3

(a) Numbers based on those reported to the Uniform Crime Reporting Division.
(b) Rate calculated based on 1980 population.
(c) Did not report.

Source: BNI, 1984, ONWI-499.

3.6.5 Fiscal Conditions and Government Structure

3.6.5.1 Fiscal Conditions

Local revenue is gathered primarily from nonrevenue receipts (may include loans, proceeds from investments, and sale of property or investments), state and other outside aid, and county revenue, including property taxes. Forrest, George, Lamar, and Perry Counties experienced a net fiscal surplus in 1979, while Greene and Stone Counties experienced fiscal deficits in 1979; Jones and Wayne Counties also had fiscal deficits in 1980 (Table 3-52).

At the local level, revenue-generating taxes include property, sales, and use taxes. Property taxes are levied by school districts, municipalities, counties, and special districts. The rate of assessment is usually expressed as a percentage of current market value of property (including land, buildings, personal property, and inventories). The property tax is then levied on that assessed valuation. Table 3-52 shows the assessed valuation of property in the study area; 1979 figures were used for all counties except Jones and Wayne, where 1980 figures were used. Expenditures by county are also shown in Table 3-52.

3.6.5.2 Government Structure

The eight Mississippi study area counties are organized under the "beat," or district governmental structure. Counties are governed by a five-member board of supervisors. The county is divided into five beats (districts), and one supervisor is elected from each beat to represent that beat's interests on the board. Each supervisor also administers the legal and financial management of that beat.

Most cities and towns in the study area are organized under the mayor-alderman structure. Under this system, a mayor and five aldermen administer the local government. The two larger study area cities, Hattiesburg and Laurel, are incorporated under the commission form of government, which uses a mayor and two commissioners to administer the local government (Southern Mississippi Planning and Development District, 1980, pp. 81-82).

A comprehensive planning process has been initiated through planning commissions in Lamar and Forrest Counties and in 11 municipalities. Local comprehensive plans developed through the HUD 701 planning assistance program have been adopted as general guidelines for future growth in Lamar County and in 12 municipalities. In addition to comprehensive planning efforts, local land-use controls have been adopted. Lamar County and 11 municipalities have adopted zoning ordinances; subdivision regulations exist in three counties and nine municipalities (BNI, 1984, ONWI-499, Table 5-1).

Within the study area, only Perry County and nine municipalities are currently using capital improvement programs to plan and develop public facilities and services within their governmental jurisdiction.

Table 3-52. Revenues and Disbursements for the Counties of the Richton Dome Study Area

Category	Forrest (1979)	Greene (1979)	George (1979)	Jones (1980)	Lamar (1979)	Perry (1979)	Stone (1979)	Wayne (1980)
Revenues								
Property Tax	$ 2,269,574	$ 425,088	$ 700,070	$ 3,301,683	$ 729,968	$ 388,432	$ 433,767	$ 730,246
Other County Revenues	1,423,886	169,926	233,133	2,598,100	2,921,419	721,639	248,856	331,373
State/Other Aid	2,645,726	1,062,785	846,970	3,083,373	1,346,326	1,162,815	720,507	1,795,729
Non-Revenue Receipts	9,218,743	327,174	2,824,588	--	10,777,861	93,216	1,015,062	--
Total Receipts	15,557,929	1,984,973	4,604,761	8,983,156	15,775,575	2,366,102	2,418,191	2,857,348
Disbursements								
General Government	$ 1,454,469	$ 285,334	$ 418,604	$ 1,615,026	$ 625,585	$ 287,472	$ 388,350	$ 489,057
Public Safety	600,230	78,587	103,142	358,107	231,789	84,742	113,480	194,291
Public Works	1,548,720	1,068,921	844,132	3,168,512	1,068,013	769,820	489,133	1,648,437
Health and Welfare	382,902	56,034	112,210	500,987	138,155	45,653	54,738	178,863
Education/Recreation	165,024	23,644	30,119	1,152,119	46,762	21,796	26,749	448,469
Conservation/Economic Development	91,447	32,355	18,312	269,584	40,544	38,882	18,993	43,752
Debt Service	314,093	30,410	73,383	521,083	2,516,338	129,831	36,492	68,070
Non-Operating and Capital Outlay	10,460,452	662,611	2,908,503	5,333,009	10,744,831	744,529	1,388,941	23,768
Total Disbursements	15,173,526	2,256,102	4,508,654	12,923,997	15,687,052	2,146,660	2,556,746	3,097,137
Excess Receipts Over (Under Disbursements)	384,403	(271,129)	96,107	(3,940,841)	88,523	219,442	(138,555)	(237,788)

Note: Numbers may not total due to rounding.

Source: BNI, 1984, GNWI-499.

3.7 CHAPTER 3 REFERENCES

3.7.1 References Listed by Author

Airborne Systems, Inc., 1983. Index to Photography of Richton Dome, Mississippi, aerial photograph, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Aircraft Owners and Pilots Association, 1982. AOPA's Airports USA 1982, Section on Mississippi, Bethesda, MD, pp. 294-300.

Alexander, C. W., C. L. Morgan, and M. E. Norman, 1945. "Developments in Southeastern States in 1944," American Association of Petroleum Geologists Bulletin, Vol. 29, No. 6, pp. 815-831.

Anderson, D. G., and K. H. Stokoe II, 1978. "Shear Modulus: A Time-Dependent Soil Property," Dynamic Geotechnical Testing, Special Technical Publication 654, American Society for Testing and Materials, Philadelphia, PA, pp. 66-90.

Anderson, R. Ernest, D. Hoye Eargle, and Beth O. Davis, 1973. Geologic and Hydrologic Summary of Salt Domes in Gulf Coast Region of Texas, Louisiana, Mississippi, and Alabama, U.S. Geological Survey Open-File Report 4339-2, U.S. Department of the Interior, Denver, CO.

Aron, Fred W., 1985. Memorandum from Aron, National Guard Bureau, to Headquarters, Department of the Army, Washington, DC, about Draft Environmental Assessments, Cypress Creek and Richton Dome sites, May 23.

Atwater, Gordon I., and McLain J. Forman, 1959. "Nature of Growth of Southern Louisiana Salt Domes and its Effect on Petroleum Accumulations," Bulletin of the American Association of Petroleum Geologists, Vol. 43, No. 11, p. 2594.

Aycock, Ray, 1985. Two verification forms from Aycock, U.S. Fish and Wildlife Service, Jackson, MS, to R. Apanius, Battelle Columbus Division, Columbus, OH, about National Wildlife Refuges, April 11.

Bailey, Robert J., and Priscilla Lowery, eds., 1975. Historic Preservation in Mississippi: A Comprehensive Plan, Mississippi Department of Archives and History, Jackson, MS.

Baldwin, J. L., 1973. Climates of the United States, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Washington, DC, pp. 80-82, 85.

Banks, Jerry B., 1983. Letter, including chart, from Banks, North
Air Emission Section, Mississippi Department of Natural Resources, to Michael Merry, Bechtel Group, Inc., about Mississippi air quality data, August 17.

Bateman, R. L., 1985. Fluids in Salt, draft technical memorandum, prepared by the Earth Technology Corporation for the Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, August 30.

Bechtel Group, Inc., and Law Engineering Testing Company, 1983. Site Characterization Plan: Gulf Coast Salt Domes, ONWI-293, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Bechtel National, Inc., 1982. Environmental Characterization Report for the Gulf Interior Region, Mississippi Study Area, ONWI-193, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Bechtel National, Inc., 1984. Socioeconomic Data Base Report for Mississippi, ONWI-499, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Bentley, C. B., 1983. Preliminary Report of the Geohydrology Near Cypress Creek and Richton Salt Domes, Perry County, Mississippi, U.S. Geological Survey Water-Resources Investigations Report 83-4169, U.S. Department of the Interior, prepared with the U.S. Department of Energy, Jackson, MS.

Beranek, Leo L., ed., 1971. Noise and Vibration Control, McGraw-Hill Book Company, New York, NY.

Berger, Z., and J. Aghassy, 1982. "Geomorphic Manifestations of Salt Dome Stability," Ch. 5 in R. G. Craig and J. L. Craft, eds., Applied Geomorphology, George Allen and Unwin, Boston, MA.

BGI, see Bechtel Group, Inc.

Bicker, Alvin R., Jr., 1970. Economic Minerals of Mississippi, Bulletin 112, Mississippi Geological, Economic and Topographical Survey, Jackson, MS.

BNI, see Bechtel National, Inc.

Bodle, Ralph R., 1941. "United States Earthquakes, 1939," Serial No. 637 in Frank Neumann et al., eds., United States Earthquakes: 1936-1940, Coast and Geodetic Survey, U.S. Department of Commerce, Washington, DC.

Bograd, Michael B.E., 1981. "Earthquakes in Mississippi," Mississippi Geology, Vol. 1, No. 4, pp. 4-6.

Bollinger, G. A., 1975. A Catalogue of Southeastern United States Earthquakes 1754 through 1974, Research Division Bulletin 101, Department of Geological Science, Virginia Polytechnic Institute and State University, Blacksburg, VA.

Bondietti, E. A., and C. W. Francis, 1979. "Geologic Migration Potentials of Technetium-99 and Neptunium-237," Science, Vol. 203, pp. 1337-1340.

Bornhauser, Mat, 1958. "Gulf Coast Tectonics," American Association of Petroleum Geologists Bulletin, Vol. 42, No. 2, pp. 339-370.

Boswell, Ernest H., 1976a. The Lower Wilcox Aquifer in Mississippi, U.S. Geological Survey Water-Resources Investigations 60-75, U.S. Department of the Interior, prepared with the Mississippi Board of Water Commissioners, Jackson, MS.

Boswell, Ernest H., 1976b. The Meridian-Upper Wilcox Aquifer in Mississippi, U.S. Geological Survey Water-Resources Investigations 76-79, U.S. Department of the Interior, prepared with the Mississippi Board of Water Commissioners, Jackson, MS.

Boswell, Ernest H., 1979. The Citronelle Aquifer in Mississippi, U.S. Geological Survey Water-Resources Investigations 78-131, U.S. Department of the Interior, prepared with the Mississippi Board of Water Commissioners, Jackson, MS.

Boswell, Ernest H., F. H. Thomson, and D. E. Shattles, 1970. Water for Industrial Development in Clarke, Jasper, Lauderdale, Newton, Scott, and Smith Counties, Mississippi, sponsored jointly by the Water Resources Division, U.S. Geological Survey, and Mississippi Research and Development Center, Jackson, MS.

Braddock, L. W., 1985. Letter from Braddock, Forest Service, Jackson, MS, to S. E. Pomeroy, Battelle Columbus Laboratories, Columbus, OH, about location of wilderness areas, July 22.

Brahana, J. V., and G. J. Dalsin, 1977. Water for Industrial Development in George, Hancock, Pearl River, and Stone Counties, Mississippi, sponsored jointly by Water Resources Division, U.S. Geological Survey, and Mississippi Research and Development Center, Jackson, MS.

Brandwein, Sidney S., and Robert M. White, 1983. Surface Geologic Reconnaissance of Richton Dome, Perry County, Mississippi, ONWI-298, prepared by Law Engineering Testing Company for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Brazee, Rutlage J., and William K. Cloud, 1960. United States Earthquakes, 1958, Coast and Geodetic Survey, U.S. Department of Commerce, Washington, DC.

Brooks, Kanand, Jr., 1985a. Letter from Brooks, Soil Conservation Service, to B. White, Salt Repository Project Office, U.S. Department of Energy, with Farmland Conservation Impact Rating form, March 14.

Brooks, Kanand, Jr., 1985b. Telephone conversation between Brooks, Soil Conservation Service, and P. Prendergast, Battelle Columbus Division, about Farm Protection Act, April 29.

Brown, Glen Francis, Velora Meek Foster, Robert Wynn Adams, Edwin W. Reed, and Harold Dement Padgett, Jr., 1944. Geology and Ground-Water Resources of the Coastal Area in Mississippi, Mississippi State Geological Survey Bulletin 60, in cooperation with the U.S. Geological Survey, University, MS.

Brunner, Charlotte A., 1982. "Paleoceanography of Surface Waters in the Gulf of Mexico During the Late Quaternary," Quaternary Research, Vol. 17, pp. 105-119.

Bryson, R. A., and W. M. Wendland, 1967. "Tentative Climatic Patterns for Some Late Glacial and Post-Glacial Episodes in Central North America," in W. J. Mayer-Oakes, ed., Life, Land and Water, Proceedings of the 1966 Conference on Environmental Studies of the Glacial Lake Agassiz Region, University of Manitoba Press, Winnipeg, Manitoba, pp. 271-299.

Bureau of the Census, 1982. 1980 Census of Population, General Propulation Characteristics, Mississippi, PC80-1-B26, U.S. Department of Commerce, Washington, DC, pp. 106-126.

Bureau of the Census, 1983. 1980 Census of Housing, General Housing Characteristics, Mississippi, HC80-1-A26, U.S. Department of Commerce, Washington, DC.

Burnett, A. W., and S. A. Schumm, 1983. "Alluvial-River Response to Neotectonic Deformation in Louisiana and Mississippi," Science, Vol. 222, pp. 49-50.

Buschbach, T. C., 1980. New Madrid Seismotectonic Study, Activities During Fiscal Year 1979, NUREG/CR-0977, U.S. Nuclear Regulatory Commission, Washington, DC.

Callahan, J. A., 1975. Public and Industrial Water Supplies in Southern Mississippi, 1974, Bulletin 75-2, prepared by U.S. Geological Survey in cooperation with the Mississippi Board of Water Commissioners.

Callahan, J. A., 1983. Water Use in Mississippi for 1980, U.S. Geological Survey Open-File Report 83-224, U.S. Department of the Interior, prepared in cooperation with the Mississippi Department of Natural Resources, Bureau of Land and Water Resources, Jackson, MS.

Callahan, J. A., 1984. Written communication from Callahan, U.S. Geological Survey, to R. Kelleher, Bechtel National, Inc., San Francisco, CA, containing computer printout of wells in Mississippi, January 5.

CBEIR, see Committee on Biological Effects.

City of Laurel, 1984. Report on Operation and Maintenance of Wastewater Treatment Plant, Donald Thrash (NE) Lagoon, Masonite Lagoon, Northwest Lagoon, Smiley Lagoon, and South Lagoon, prepared for U.S. Environmental Protection Agency, Washington, DC, March 21.

Cleveland, Jess M., 1979a. "Critical Review of Plutonium Equilibria of Environmental Concern," Ch. 19 in E. A. Jenne, ed., Chemical Modeling in Aqueous Systems, American Chemical Society, Washington, DC.

Cleveland, J. M., 1979b. The Chemistry of Plutonium, American Nuclear Society, LaGrange Park, IL, pp. 105-127.

Cleveland, J. M., T. P. Rees, and K. L. Nash, 1983. "Neptunium and Americium Speciation in Selected Basalt, Granite, Shale, and Tuff Ground Waters," Science, Vol. 221, pp. 271-273.

Cliburn, J. W., and C. G. Jackson, Jr., 1975. Rare and Endangered Amphibians and Reptiles in Mississippi, A Preliminary List of Rare and Threatened Vertebrates in Mississippi, Mississippi Game and Fish Commission, Jackson, MS.

Coffman, Jerry L., and Carl A. von Hake, 1975. United States Earthquakes, 1973, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, and U.S. Geological Survey, U.S. Department of the Interior, Boulder, CO.

Coffman, Jerry L., Carl A. von Hake, and Carl W. Stover, 1982. Earthquake History of the United States (revised edn. through 1970), Publication 41-4 (Reprinted 1982 with Supplement, 1971-80), National Oceanic and Atmospheric Administration, U.S. Department of Commerce, and U.S. Geological Survey, U.S. Department of the Interior, Boulder, CO.

Coffman, Jerry L., and Carl W. Stover, eds., 1977. United States Earthquakes, 1975, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, and U.S. Geological Survey, U.S. Department of the Interior, Boulder, CO.

Coffman, Jerry L., and Carl W. Stover, eds., 1979. United States Earthquakes, 1977, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, and U.S. Geological Survey, U.S. Department of the Interior, Boulder, CO.

Coleman, Elvin W., 1969. Statewide Lake and Stream Survey, Complete Report, Fisheries Division, Project F-8-R, Mississippi Game and Fish Commission, Jackson, MS.

Collins, H. B., 1927. "Potsherds from Choctaw Village Sites in Mississippi," Journal of the Washington Academy of Sciences, Vol. 17, No. 10, pp. 259-263.

Committee on Biological Effects of Ionizing Radiation, 1980. The Effects on Population of Exposures to Low Levels of Ionizing Radiation, National Academy Press, Washington, DC.

Cook, F. A., 1959. Freshwater Fishes in Mississippi, Mississippi Game and Fish Commission, Jackson, MS.

Cronin, Thomas M., Barney J. Szabo, Thomas A. Ager, Joseph E. Hazel, and James P. Owens, 1981. "Quaternary Climates and Sea Levels of the U.S. Atlantic Coastal Plain," Science, Vol. 211, No. 4479, pp. 233-240.

Dames & Moore, 1981. Draft Environmental Assessment, Proposed Railroad Spur Line, Leaf River Bridge, and Kraft Pulp Mill, Perry County, Mississippi, Atlanta, GA.

Davis, R. E., and K. H. Byers, 1979. Soil Survey of Forrest County, Mississippi, Soil Conservation Service and Forest Service, U.S. Department of Agriculture, with Mississippi Agricultural and Forestry Experiment Station.

de Beer, E., 1965. "Influence of the Mean Normal Stress on the Shearing Strength of Sand," Proceedings of the Sixth International Conference on Soil Mechanics and Foundation Engineering, Vol. I, University of Toronto Press, Toronto, Ontario, Canada, pp. 165-169.

Delcourt, P. A., 1980. "Goshen Springs: Late Quaternary Vegetation Record for Southern Alabama," Ecology, No. 61, pp. 371-386.

DeVries, David A., William H. Moore, Marshall K. Kern, Hugh McD. Morse, and Grover E. Murray, 1963. Jasper County Mineral Resources, Bulletin 95, Mississippi Geological, Economic and Topographical Survey, Jackson, MS.

Dinkins, T. H., Jr., 1967. "Subsurface Stratigraphy of George County," in Charles H. Williams, Jr., ed., George County Geology and Mineral Resources, Bulletin 108, Mississippi Geological, Economic and Topographical Survey, Jackson, MS, pp. 191-228.

Docekal, J., 1970. "Earthquakes of the Stable Interior, with Emphasis on the Midcontinent," Ph.D. dissertation, University of Nebraska, Lincoln, NE.

Dockery, David T., 1981. Stratigraphic Column of Mississippi, Mississippi Bureau of Geology, Jackson, MS.

DOE, see U.S. Department of Energy.

Doering, John A., 1956. "Review of Quaternary Surface Formations of the Gulf Coast Region," American Association of Petroleum Geologists Bulletin, Vol. 40, No. 8, pp. 1816-1862.

Drumheller, J. C., S. I. Fuerst, B. P. Cavan, and J. A. Saunders, 1982. Petrographic and Geochemical Characteristics of the Richton Salt Core, ONWI-277, prepared by Law Engineering Testing Company for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Eargle, D. Hoye, 1968. Stratigraphy and Structure of the Tatum Salt Dome Area, Southeastern Mississippi and Northeastern Washington Parish, Louisiana, Special Paper 88, Geological Society of America, Inc., Boulder, CO.

Eco-Inventory Studies, Inc., 1983. Threatened and Endangered Species Survey for the Richton Salt Dome Area: Terrestrial and Aquatic Animals, Project 12354, prepared for Bechtel Group, Inc., San Francisco, CA, for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Edwards, Jimmy P., P. George Martin, J. Wayne Magoon, Wayne W. Kilpatrick, and Charley Henry, Jr., 1980. Soil Survey of Caddo Parish, Louisiana, Soil Conservation Service, U.S. Department of Agriculture, Washington, DC, in cooperation with the Louisiana Agricultural Experiment Station.

EG&G Geometrics, 1980. Aerial Gamma Ray and Magnetic Survey, Hattiesburg Quadrangle of Mississippi, Alabama, and Louisiana, prepared for U.S. Department of Energy, Grand Junction, CO.

Electrical World, 1984. Directory of Electric Utilities, 1983-1984, 92nd ed., McGraw-Hill Book Company, New York, NY.

EPA, see U.S. Environmental Protection Agency.

Eppley, Robert A., and William K. Cloud, 1961. United States Earthquakes, 1959, Coast and Geodetic Survey, U.S. Department of Commerce, Washington, DC.

Ertec, Inc., 1983. Midyear FY 83 Richton Dome Screening and Suitability Review, ONWI-484, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Ertec, Inc., 1983. Potentiometric-Level Monitoring Program - Mississippi and Louisiana: Annual Status Report for Fiscal Year 1982, ONWI-478, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Ertec, Inb., 1983. Preliminary Overburden Characterization at Richton Dome, ONWI-481, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Ertec, Inc., 1983. Regional Ground-Water Flow Near Richton Dome, Mississippi: Annual Status Report for Fiscal Year 1982, ONWI-456, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Ertec, Inc., 1984. Potentiometric-Level Monitoring Program-Mississippi and Louisiana: Annual Status Report for Fiscal Year 1983, BMI/ONWI-525, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

ETC, see The Earth Technology Corporation.

Fenneman, Nevin M., 1946. Physical Divisions of the United States, U.S. Geological Survey Map, reprinted 1957, U.S. Department of the Interior, Washington, DC.

Fisk, H. N., 1940. Geology of Avoyelles and Rapides Parishes, 2 vols., Department of Conservation, Louisiana Geological Survey, New Orleans, LA.

Fisk, H. N., 1944. Geological Investigation of the Alluvial Valley of the Lower Mississippi, War Department, U.S. Army Corps of Engineers, Vicksburg, MS.

Ford, James A., 1936. Analysis of Indian Village Site Collections from Louisiana and Mississippi, Anthropological Study No. 2, Department of Conservation, Louisiana Geological Survey, New Orleans, LA.

Forest Service, 1975. Map of De Soto National Forest, Mississippi, U.S. Department of Agriculture, Washington, DC.

Forest Service, 1978. Forest Statistics for Mississippi Counties, Resource Bulletin SO-69, U.S. Department of Agriculture, Southern Forest Experiment Station, New Orleans, LA.

Frye, J. C., 1962. "Comparison Between Pleistocene Deep-Sea Temperatures and Glacial and Interglacial Episodes," Geological Society of America Bulletin, Vol. 73, pp. 263-266.

Gandl, Lynette A., 1979. The Oligocene Aquifer System in Mississippi, U.S. Geological Survey Water-Resources Investigations Report 79-28, U.S. Department of the Interior, prepared with the Mississippi Board of Water Commissioners, Jackson, MS.

Gandl, L. A., and C. A. Spiers, 1980. Results of Water Quality Sampling Near Richton, Cypress Creek, and Lampton Salt Domes, Mississippi, U.S. Geological Survey Open-File Report 80-443, U.S. Department of the Interior, prepared with U.S. Department of Energy, Washington, DC.

Garrels, Robert M., and Charles L. Christ, 1965. Solutions, Minerals, and Equilibria, Freeman, Cooper & Company, San Francisco, CA, pp. 209-225, and 255.

Gevantman, L. H., ed., 1981. Physical Properties Data for Rock Salt, National Bureau of Standards Monograph 167, U.S. Department of Commerce, Washington, DC.

Golder Associates, 1977. Report to Gulf Interstate Engineering Co. on Geotechnical Study of Cote Blanche Island Salt Mine, Volume I - Text and Figures, Vancouver, British Columbia, Canada, pp. 24, 43-45, and abstract.

Gulf Coast Association of Geological Societies, 1972. Tectonic Map of Gulf Coast Region, U.S.A., Scale 1:2,500,000, American Association of Petroleum Geologists, Tulsa, OK.

Gulf States Utilities Company, 1973. River Bend Station, Units 1 and 2, Preliminary Safety Analysis Report, Vol. II, Beaumont, TX.

Gupta, Sumant K., Amy M. Monti, and Terry L. Steinborn, 1985. Salt Dissolution Assessment at Seven Potential Nuclear Waste Repository Locations in Salt, BMI/ONWI-567, Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Gutman, Herbert G., 1976. The Black Family in Slavery and Freedom: 1750-1925, Vintage Books, New York, NY, pp. 327-360.

Halbouty, Michel T., 1979. Salt Domes - Gulf Region, United States and Mexico, 2nd edn., Gulf Publishing Company, Houston, TX.

Hansen, Francis D., 1978. Case History Rock Mechanics Examination of the Jefferson Island Salt Mine: II. Laboratory Evaluation of Strength and Creep Deformation Characteristics of Dome Salt Under Confining Pressure, Y/OWI/SUB-77/22303/5, prepared by RE/SPEC Inc. for Office of Waste Isolation, Union Carbide Corporation, Nuclear Division, Oak Ridge, TN, pp. 15 and 18-21.

Hansen, J., D. Johnson, A. Lacis, S. Lebedeff, P. Lee, D. Rind, and G. Russell, 1981. "Climate Impact of Increasing Atmospheric Carbon Dioxide," Science, Vol. 213, No. 4511, pp. 957-966.

Hardin, Frank R., and George C. Hardin, Jr., 1961. "Contemporaneous Normal Faults of Gulf Coast and Their Relation to Flexures," Bulletin of the American Association of Petroleum Geologists, Vol. 45, No. 2, pp. 238-248.

Hawkins, M. E., and C. J. Jirik, 1966. Salt Domes in Texas, Louisiana, Mississippi, Alabama, and Offshore Tidelands: A Survey, U.S. Bureau of Mines Information Circular 8313, U.S. Department of the Interior, Washington, DC.

Hays, J. D., John Imbrie, and N. J. Shackleton, 1976. "Variations in the Earth's Orbit: Pacemaker of the Ice Ages," Science, Vol. 194, No. 4270, pp. 1121-1132.

Heck, N. H., and R. R. Bodle, 1931. "United States Earthquakes, 1929," Serial No. 511, in N. H. Heck et al., 1968, United States Earthquakes: 1928-1935, Coast and Geodetic Survey, U.S. Department of Commerce, Washington, DC.

Hem, John D., 1970. Study and Interpretation of the Chemical Characteristics of Natural Water, 2nd edn., U.S. Geological Survey Water Supply Paper 1473, U.S. Department of the Interior, Washington, DC.

Hebert, Paul J., 1980. "Atlantic Hurricane Season of 1979," Monthly Weather Review, National Hurricane Center, Vol. 108, pp. 973-990.

Hershfield, David M., 1961. Rainfall Frequency Atlas of the United States, Technical Paper No. 40, U.S. Weather Bureau, U.S. Department of Commerce, Washington, DC.

Hess, William L., 1985. Verifications from Hess, Forest Service, Atlanta, GA, to J. D. Rench, Battelle Columbus Division, Columbus, OH, about National Wild and Scenic Rivers and National Trials, June 13.

Hickman, Nollie W., 1973. "Mississippi Forests," Ch. 30 in R. A. McLemore, ed., A History of Mississippi, Vol. II, University and College Press of Mississippi, Hattiesburg, MS.

Hoek, E., and E. T. Brown, 1980. Underground Excavation in Rock, The Institution of Mining and Metallurgy, London, England.

Hofrichter, Erich, 1968. "Stratigraphy and Structure of the Palangana Salt Dome, Duval County, Texas," Saline Deposits, The Geological Society of America Special Paper 88, New York, NY, pp. 365-379.

Holdahl, Sanford R., and Nancy L. Morrison, 1974. "Regional Investigations of Vertical Crustal Movements in the U.S., Using Precise Relevelings and Mareograph Data," Tectonophysics, Vol. 23, No. 4, pp. 373-390.

Holzworth, George C., 1972. Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States, AP-101, U.S. Environmental Protection Agency, Office of Air Programs, Research Triangle Park, NC.

Hosman, R. L., A. T. Long, T. W. Lambert, and others, 1968. Tertiary Aquifers in the Mississippi Embayment, U.S. Geological Survey Professional Paper 448-D, U.S. Department of the Interior, Washington, DC.

Howard, James, C., 1971. "Computer Simulation Models of Salt Domes," The American Association of Petroleum Geologists Bulletin, Vol. 55, No. 3, pp. 495-513.

Hoy, Robert B., Richard M. Foose, and B. J. O'Neil, Jr., 1962. "Structure of Winnfield Salt Dome, Winn Parish, Louisiana," Bulletin of the American Association of Petroleum Geologists, Vol. 46, No. 8, pp. 1444-1459.

Imai, Tsueno, and Kevi Tonouchi, 1982. "Correlation of N Value S-Wave Velocity and Shear Modulus," Proceedings of the Second European Symposium on Penetration Testing (May 24-27, Amsterdam), A. A. Balkema, Rotterdam, The Netherlands, pp. 67-72.

Imbrie, John, and Katherine Palmes Imbrie, 1979. Ice Ages - Solving the Mystery, Enslow Publishers, Hillside, NJ.

INTERA Environmental Consultants, Inc., 1984. First Status Report on Regional and Local Ground-Water Flow Modeling for Richton Dome, Mississippi, ONWI-502, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Isphording, Wayne C., and George C. Flowers, 1985. "Subsidence Problems Related to the Development of Siliciclastic Karst on the Citronelle Formation of Southwestern Alabama," abstract in The Geological Society of America Abstracts With Programs 1985, Vol. 17, Boulder, CO, p. 617.

Jackson, Jerome A., 1977. "Red-Cockaded Woodpeckers and Pine Red Heart Disease," AUK, Vol. 94, pp. 160-163.

Jackson, M. P. A., 1981. "Tectonic Environment During Early Infilling of the East Texas Basin," Geology and Geohydrology of the East Texas Basin, Geological Circular 81-7, prepared for U.S. Department of Energy by Bureau of Economic Geology, The University of Texas at Austin, Austin, TX, pp. 7-11.

Jackson, M. P. A., and Christopher J. Talbot, 1985. The Internal Structure of Model and Natural Salt Domes, Experimental Modeling of Salt Diapirs: Final Report, prepared by Bureau of Economic Geology for Office of Nuclear Waste Isolation, Battelle Memorial Institute, in preparation.

Jacobs, J., 1979. Memo from Jacobs, Mississippi Natural Heritage Program, Mississippi Museum of Natural Science, to G. Haskins, Bechtel National, Inc., about protected species, October.

Jennings, Jesse D., 1974. Prehistory of North America, 2nd edn., 2 vols., McGraw-Hill Book Company, New York, NY.

Jordan, Dennis B., 1982. Letter from Jordan, Field Supervisor, Fish and Wildlife Service, Jackson, MS, to J. O. Neff, Salt Repository Project Office, U.S. Department of Energy, Columbus, OH, about endangered species in Perry County, MS, and Bienville Parish, LA, November 29.

Jordan, Dennis B., 1983. Letter, including pamphlet, from Jordan, Field Supervisor, Fish and Wildlife Service, Jackson, MS, to D. Cornman, Bechtel Group, Inc., about the American alligator and red-cockaded woodpecker in Mississippi, April 4.

Jurkowski, G., and R. Reilinger, 1981. Recent Vertical Crustal Movements: The Eastern United States, NUREG/CR-2290, prepared for U.S. Nuclear Regulatory Commission, Washington, DC.

Karably, Louis S., Jr., Bruce L. Jernigan, Ion C. Petre, and Joseph M. Sullivan, 1983. Salt, Caprock, and Sheath Study, ONWI-355, prepared by Law Engineering Testing Company for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Karges, H. E., 1975. "Petroleum Potential of Mississippi Shallow Salt Domes," Transactions of the Gulf Coast Association of Geological Societies, Vol. 25, pp. 168-181.

Kelley, Arthell, and Robert C. Spillman, 1976. "Sequent Occupancy of the Piney Woods and Southeastern Mississippi, 1805 to 1976," The Mississippi Geographer, Vol. 4, No. 1, pp. 25-40.

Knauth, L. Paul, and Madhurendu B. Kumar, 1981. "Trace Water Content of Salt in Louisiana Salt Domes," Science, Vol. 213, pp. 1005-1007.

Kolb, Charles R., Joseph C. Holmes, and John J. Alford, 1983. The Quaternary Geology of Vacherie Salt Dome, North Louisiana Salt Dome Basin, Vols. I and II, ONWI-467, prepared by Institute for Environmental Studies, Louisiana State University, for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Kreitler, Charles W., E. W. Collins, E. D. Davidson, Jr., O. R. Dix, G. A. Donaldson, S. P. Dutton, G. E. Fogg, A. B. Giles, D. W. Harris, M. P. A. Jackson, C. M. Lopez, M. K. McGowen, W. R. Muehlberger, W. D. Pennington, S. J. Seni, D. H. Wood, and H. V. Wuerch, 1981. Geology and Geohydrology of the East Texas Basin, II: A Report on the Progress of Nuclear Waste Isolation Feasibility Studies (1980), Geological Circular 81-7, prepared for U.S. Department of Energy by Bureau of Economic Geology, The University of Texas at Austin, Austin, TX.

Kreitler, Charles W., and Shirley P. Dutton, 1983. Origin and Diagenesis of Cap Rock, Gyp Hill and Oakwood Salt Domes, Texas, Report of Investigations No. 131, prepared for the U.S. Department of Energy by Bureau of Economic Geology, The University of Texas at Austin, Austin, TX.

Kuchler, A. W., 1975. Potential Natural Vegetation of the Conterminous United States, map, American Geographical Society Special Publication No. 36, New York, NY.

Kumar, Madhurendu B., 1981. Report of Studies of Hydrologic Isolation of Mined Openings in Salt Domes of the Gulf Coast, prepared for the U.S. Department of Energy by Institute for Environmental Studies, Louisiana State University, Baton Rouge, LA.

Kupfer, Donald H., 1962. "Structure of Morton Salt Company Mine, Weeks Island Salt Dome, Louisiana," Bulletin of the American Association of Petroleum Geologists, Vol. 46, No. 8, pp. 1460-1467.

Kupfer, D. H., 1963. "Structure of Salt in Gulf Coast Domes," First Symposium on Salt, Northern Ohio Geological Society, Cleveland, OH, pp. 104, 115.

Kupfer, Donald H., 1974. "Shear Zones in the Gulf Coast Salt Delineate Spines of Movement," Transactions of the Gulf Coast Association of Geological Societies, Vol. 24, pp. 204-205.

Kupfer, Donald H., 1976. "Shear Zones Inside Gulf Salt Stocks Help to Delineate Spines of Movement," The American Association of Petroleum Geologists Bulletin, Vol. 60, No. 9, pp. 1434-1447.

Kupfer, Donald H., 1980. "Problems Associated with Anomalous Zones in Louisiana Salt Stocks, U.S.A.," in A. H. Coogan and L. Hauber, eds., Fifth Symposium on Salt, Vol. 1, Northern Ohio Geological Society, Cleveland, OH, pp. 112-134.

Lade, Paul V., and Kenneth L. Lee, 1976. Engineering Properties of Soils, UCLA-ENG-7652, Soil Mechanics Laboratory, School of Engineering and Applied Science, University of California at Los Angeles, Los Angeles, CA.

Lagedrost, John F., and Webster Capps, 1983. Thermal Property and Density Measurements of Samples Taken From Drilling Cores From Potential Geologic Media, BMI/ONWI-522, prepared by Fiber Materials, Inc., for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Lambe, T. William, and Robert V. Whitman, 1969. "Stress-Strain Relations for Drained Conditions," Ch. 22 in Soil Mechanics, John Wiley & Sons, Inc., New York, NY, p. 318.

Langmuir, D., 1978. "Uranium Solution-Mineral Equilibria at Low Temperatures with Applications to Sedimentary Ore Deposits," Geochimica et Cosmochimica Acta, Vol. 42, pp. 547-569.

Langmuir, Donald, and Arthur C. Riese, 1985. "The Thermodynamic Propertes of Radium," Geochimica et Cosmochimica Acta, Vol. 49, pp. 1593-1601.

Law Engineering Testing Company, 1981. Geologic Evaluation of Gulf Coast Salt Domes: Overall Assessment of the Gulf Interior Region, ONWI-106, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Law Engineering Testing Company, 1982. Gulf Coast Salt Domes Geologic Area Characterization Report, Vol. I, Introduction, ONWI-117, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Law Engineering Testing Company, 1982. Gulf Coast Salt Domes Geologic Area Characterization Report, Mississippi Study Area, Vol. VI, ONWI-120, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Law Engineering Testing Company, 1982. Gulf Coast Salt DomesGeologic Area Characterization Report, Mississippi Study Area, Vol. VII, Appendix, ONWI-120, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Law Engineering Testing Company, 1982. Gulf Coast Salt Domes Shallow Borings Report: Richton Dome, ONWI-167, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Law Engineering Testing Company, 1983. Geothermal Studies of Seven Interior Salt Domes, ONWI-289, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Lehner, Peter, 1969. "Salt Tectonics and Pleistocene Stratigraphy on Continental Slope of Northern Gulf of Mexico," The American Association of Petroleum Geologists Bulletin, Vol. 53, No. 12, pp. 2431-2479.

LETCo, see Law Engineering Testing Company.

Lindberg, Ralph D., and Donald D. Runnells, 1984. "Ground Water Redox Reactions: An Analysis of Equilibrium State Applied to Eh Measurements and Geochemical Modeling," Science, Vol. 225, pp. 925-927.

Lindner, E. N., and J. A. Halpern, 1977. "In Situ Stress: An Analysis," Proceedings, 18th U.S. Symposium on Rock Mechanics, Energy Resources and Excavation Technology June 22-24, Keystone, CO), Vol. 2, Colorado School of Mines Press, Golden, CO, pp. 4C1-1 to 4C1-7.

Luper, Edwin E., Runa Angurarohita, and Wilbur T. Baughman, 1972. Smith County Geology and Mineral Resources, Bulletin 116, Mississippi Geological, Economic and Topographical Survey, Jackson, MS.

Martin, Ray G., 1978. "Northern and Eastern Gulf of Mexico Continental Margin: Stratigraphic and Structural Framework," in A. H. Bouma et al., eds., Framework, Facies, and Oil-Trapping Characteristics of the Upper Continental Margin, Studies in Geology No. 7, American Association of Petroleum Geologists, Tulsa, OK, pp. 21-42.

Martin, B., 1984. Telephone conversation between Martin, Illinois Center Gulf Railway Trainmaster, Hattiesburg, MS, and Peter Van Gorp, Bechtel National, Inc., about railway service in the Mississippi Study Area, August 31.

Martinez, J. D., R. L. Thoms, C. G. Smith, Jr., C. R. Kolb, E. J. Newchurch, and R. E. Wilcox, 1977. An Investigation of the Utility of Gulf Coast Salt Domes for the Storage or Disposal of Radioactive Wastes, Y/OWI/SUB-4112/37, prepared for Office of Waste Isolation, Union Carbide Corporation, Nuclear Division, and U.S. Department of Energy, by Institute for Environmental Studies, Louisiana State University, Baton Rouge, LA.

Maxwell, R. W., Jr., 1971. "Origin and Chronology of Alabama River Terraces," Transactions of the Gulf Coast Association of Geological Societies, Vol. 21, pp. 83-95.

May, James H., Wilbur T. Baughman, John E. McCarty, Rollin C. Glenn, and William B. Hall, 1974. Wayne County Geology and Mineral Resources, Bulletin 117, Mississippi Geological, Economic and Topographical Survey, Jackson, MS.

McGahey, Sax O., 1983. Letter, including maps, from McGahey, Chief Archaeologist, Mississippi Department of Archives and History, to J. O. Neff, Salt Repository Project Office, U.S. Department of Energy, Battelle Memorial Institute, Columbus, OH, about archaeological sites and surveys, April 14.

Mellegard, Kirby D., Paul E. Senseny, and Francis D. Hansen, 1983. Quasi-Static Strength and Creep Characteristics of 100-mm-Diameter Specimens of Salt From Avery Island, Louisiana, ONWI-250, prepared by RE/SPEC Inc. for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Metcalfe, Douglas E., and Robert E. Andrews, 1984. Second Status Report on Regional and Local Ground-Water Flow Modeling for Richton and Cypress Creek Domes, Mississippi, prepared by INTERA Technologies, Inc., for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, in preparation.

Metzger, Ann G., 1983. "The Northeast Mississippi Earthquakes of 29 January and 5 February, 1983," Mississippi Geology, Vol. 3, No. 4, pp. 8-9.

Michalski, A., 1985. Draft technical memorandum for Michlaski, Ertec, Inc., prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, about anomalous features, September 18.

Milliken, Larry D., 1985. Selected Energy and Mineral Resources Assessment, Richton Salt Dome, Perry County, Mississippi, prepared by The Earth Technology Corporation for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, in preparation.

Minch, J., 1984. Telephone conversation between Minch, National Earthquake Information Service, and S. Gibson, regarding the January 5, 1984, earthquake in Southwestern Alabama, January 17.

Mine Safety and Health Administration Storage Task Force, 1978. Fact Finding Investigation of Southern Louisiana Salt Domes: Weeks Island, Cote Blanche Island, Jefferson Island, Belle Isle, Avery Island.

Mississippi Department of Agriculture and Commerce and U.S. Department of Agriculture Statistical Reporting Service, 1983. Mississippi Agricultural Statistics 1981-1982, Mississippi Crop and Livestock Reporting Service Supplement Number 17, Jackson, MS.

Mississippi Department of Natural Resources, 1982. State of Mississippi, 1982 Water Quality Report to Congress, Section 305(b), Bureau of Pollution Control, Jackson, MS.

Mississippi Department of Natural Resources, 1984. Mississippi Dams Inventory, Complete Listing, Bureau of Land and Water, Jackson, MS.

Mississippi Forestry Commission, 1976. 1976 Mississippi Forest Products Directory, Jackson, MS.

Mississippi Museum of Natural Science, 1978. Mississippi Natural Heritage Program, Computer Printout of Rare and Endangered Species of Marion and Perry Counties, Jackson, MS.

Mississippi Power and Light Company, n.d. Fig. 2.3-1 in Grand Gulf Nuclear Station Units 1 and 2, Final Safety Analysis Report, Vol. 1, Docket Numbers 50416 and 50417, Jackson, MS.

Mississippi Research and Development Center, 1983. County Data Bank Information, Jackson, MS.

Mississippi Research and Development Center, 1982. Mississippi Community Data, Jackson, MS.

Mississippi State Highway Department, 1984. Capacity of State Highways 15 and 42, traffic volume variation printouts and figures.

Mississippi State Oil and Gas Board, 1983. Annual Production Report, Mississippi Oil and Gas Reservoirs, Year Ending December 31, 1983, Jackson, MS.

Mississippi State Oil and Gas Board, 1985. Annual Production Report of the Oil and Gas Reservoirs of Mississippi, Year Ending December 31, 1984, Jackson, MS, pp. 7, 15, 17, 19, 20, 22, 37, 38, 40, 47, 52, 57, 74, and 76.

Mongan, Tom R., 1985. Letter from Mongan, Bechtel National, Inc., to M. R. Thomas, Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, with attachments, October 9.

Monti, Amy M., and Sumant K. Gupta, 1984. Salt Dissolution Analysis in Existing Boreholes at Cypress Creek Dome, memorandum, Office of Nuclear Waste Isolation, Battelle Project Management Division, Columbus, OH.

Moody's Investors Service, 1983. Moody's Public Utility Manual, Dun and Bradstreet Corporation.

Moore, D. B., 1971. Subsurface Geology of Southwest Alabama, Bulletin 99, Geological Survey of Alabama.

MSHA, see Mine Safety and Health Administration.

Muehlberger, William R., 1960. "Internal Structures and Mode of Uplift of the Grand Saline Salt Dome, Van Zandt County, Texas, United States of America," in Structure of the Earth's Crust and Deformation of Rocks, pp. 28-33.

Muehlberger, William R., and Patricia S. Clabaugh, 1968. "Internal Structure and Petrofabrics of Gulf Coast Domes," in L. F. Brown, Jr., ed., Proceedings, Fourth Forum on Geology of Industrial Minerals (March 14-15, 1968, Austin, Texas), Bureau of Economic Geology, The University of Texas at Austin, Austin, TX, pp. 81-89.

Mullin, Clayton W., 1982. Draft Geology of the Caprock and Salt Stock of the Richton Salt Dome, prepared by Georgia Institute of Technology for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Murphy, Peter J., 1985. Potential for Dissolution at Richton Dome, Mississippi, draft technical memorandum, prepared by The Earth Technology Corporation for the Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, September 18.

Murray, Grover E., 1952. "Sedimentary Volumes in Gulf Coastal Plain of the United States and Mexico, Part III: Volume of Mesozoic and Cenozoic Sediments in Central Gulf Coastal Plain of the United States," Bulletin of the Geological Society of America, Vol. 63, pp. 1177-1192.

Murray, Grover E., 1961. Geology of the Atlantic and Gulf Coastal Province of North America, Harper and Brothers, New York, NY.

Murray, Grover E., 1983. Evaluation of Potential Mineral Resources in the Vicinity of Seven Selected Domes in Texas, Louisiana, and Mississippi, ONWI-169, prepared by Law Engineering Testing Company for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Myrick, T. E., B. A. Berven, and F. F. Haywood, 1981. State Background Radiation Levels: Results of Measurements Taken During 1975-1979, ORNL/TM-7343, prepared for U.S. Department of Energy by Health and Safety Research Division, Oak Ridge National Laboratory, Union Carbide Corporation, Oak Ridge, TN.

National Geophysical and Solar-Terrestrial Data Center, 1982. Earthquake Data File for Area 28-30° North, 80-100° West as of October 14, 1982, Environmental Data Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Boulder, CO.

National Oceanic and Atmospheric Administration, 1972. Monthly and Annual Wind Distribution by Pasquill Stability Classes (6) Star Program, Data prepared for Woodward-Envicon, Inc., Atlanta, GA, 2 tables and key.

National Oceanic and Atmospheric Administration, 1976. Local Climatological Data, Annual Summaries for 1976, Part I, Ala-Mont, Part II, Neb-Wyo, National Climatic Center, Environmental Data Service, U.S. Department of Commerce, Asheville, NC.

National Oceanic and Atmospheric Administration, 1981. Local Climatological Data, Annual Summary with Comparative Data, Jackson, Mississippi, National Climatic Center, Environmental Data and Information Service, U.S. Department of Commerce, Asheville, NC.

Nava, S., and S. Everett, eds., 1984a. TEIC Quarterly Seismological Bulletin, January -March, 1984, Vol. V, No. 1, prepared for U.S. Nuclear Regulatory Commission by Tennessee Earthquake Information Center, Memphis State University, Memphis, TN.

Nava, S., and S. Everett, eds., 1984b. TEIC Quarterly Seismological Bulletin, April - June, 1984, Vol. V, No. 2, prepared for U.S. Nuclear Regulatory Commission by Tennessee Earthquake Information Center, Memphis State University, Memphis, TN.

Nava, S., and S. Everett, eds., 1984c. TEIC Quarterly Seismological Bulletin, July - September, 1984, Vol. V, No. 3, prepared for U.S. Nuclear Regulatory Commission by Tennessee Earthquake Information Center, Memphis State University, Memphis, TN.

Nava, S., and S. Everett, eds., 1984d. TEIC Quarterly Seismological Bulletin, October - December, 1984, Vol. V, No. 4, prepared for U.S. Nuclear Regulatory Commission by Tennessee Earthquake Information Center, Memphis State University, Memphis, TN.

Necioglu, Alton, and Otto W. Nuttli, 1974. "Some Ground Motion and Intensity Relations for the Central United States," Earthquake Engineering and Structural Dynamics, Vol. 3, pp. 111-119.

Neff, J. Q., 1985. Letter from Neff, Salt Repository Project Office, U.S. Department of Energy, to A. E. Sullivan, U.S. Soil Conservation Service, Jackson, MS, about compliance with Farmlands Protection Policy Act, February 28.

Neumann, A. Conrad, and Willard S. Moore, 1975. "Sea Level Events and Pleistocene Coral Ages in the Northern Bahamas," Quaternary Research, Vol. 5, pp. 215-224.

Neumann, Frank, 1932. United States Earthquakes, 1931, Serial No. 553, Coast and Geodetic Survey, U.S. Department of Commerce, Washington, DC.

Neumann, Frank, and R. R. Bodle, 1932. United States Earthquakes, 1930, Serial No. 539, Coast and Geodetic Survey, U.S. Department of Commerce, Washington, DC.

Newchurch, E. J., 1976. "Selection of Salt-Dome Study Areas," Ch. III in J. D. Martinez et al., An Investigation of the Utility of Gulf Coast Salt Domes for the Storage or Disposal of Radioactive Wastes, prepared for Office of Waste Isolation by Institute for Environmental Studies, Louisiana State University, Baton Rouge, LA, pp. 31-46.

Newcome, Roy, Jr., compiler, 1971. Results of Aquifer Tests in Mississippi, U.S. Geological Survey Bulletin 71-2, prepared by the Water Resources Division with the Mississippi Board of Water Commissioners, Jackson, MS.

Newcome, Roy, Jr., 1975. The Miocene Aquifer System in Mississippi, U.S. Geological Survey Water-Resources Investigations 46-75, U.S. Department of the Interior, prepared with the Mississippi Board of Water Commissioners, Jackson, MS.

Newcome, Roy, Jr., 1976. The Sparta Aquifer System in Mississippi, U.S. Geological Survey Water-Resources Investigations 76-7, U.S. Department of the Interior, prepared with the Mississippi Board of Water Commissioners, Jackson, MS.

NGSDC, see National Geophysical and Solar-Terrestrial Data Center.

NOAA, see National Oceanic and Atmospheric Administration.

Norquist, Cary, 1985. Telephone conversation between Norquist, Fish and Wildlife Service, and David Cobb, Bechtel National, Inc., about candidate and proposed threatened and endangered plant species at the Richton Dome site, December 17.

Norquist, Cary, and Mike Dawson, 1985. Telephone conversation between Norquist and Dawson, Fish and Wildlife Service, and Dave Cornman, Bechtel National, Inc., about candidate threatened and endangered plant and animal species for Mississippi based on September 27, 1985 Federal Register Notice of Review, December 16.

Nuttli, Otto W., 1973. "The Mississippi Valley Earthquakes of 1811 and 1812: Intensities, Ground Motion and Magnitudes," Bulletin of the Seismological Society of America, Vol. 63, pp. 227-248.

Nuttli, Otto W., 1974. "Magnitude-Recurrence Relation for Central Mississippi Valley Earthquakes," Seismological Society of America Bulletin, Vol. 64, pp. 1189-1207.

Nuttli, Otto W., 1979. "The Seismicity of the Central United States, Geology in the Siting of Nuclear Power Plants," Reviews in Engineering Geology, Vol. 4, pp. 67-93.

Nuttli, Otto W., and Robert B. Herrmann, 1978. State-of-the-Art for Assessing Earthquake Hazards in the United States: Report 12, Credible Earthquakes for the Central United States, Miscellaneous Paper S-73-1, prepared by the Department of Earth and Atmospheric Sciences, St. Louis University, for Chief of Engineers, U.S. Army, Washington, DC.

Nuttli, Otto W., and Robert B. Herrmann, 1981. Consequences of Earthquakes in the Mississippi Valley, American Society of Civil Engineers Preprint 81-519, Department of Earth and Atmospheric Sciences, St. Louis University, St. Louis, MO.

Oakley, Donald T., 1972. Natural Radiation Exposure in the United States, ORP/SID 72-1, U.S. Environmental Protection Agency, Washington, DC.

Obert, Leonard, 1962. "In Situ Determination of Stress in Rock," Mining Engineering, August, p. 55.

Ohsaki, Yorihiko, and Ryoji Iwasaki, 1973. "On Dynamic Shear Moduli and Poisson's Ratios of Soil Deposits," Soils and Foundations, Vol. 13, No. 4, Japanese Society of Soil Mechanics and Foundation Engineering, Hongo, Bunkyo-Ku, Tokyo, Japan, pp. 61-73.

Oxley, Marvin L., Edward Minihan, and Julius M. Ridgway, 1968. "A Study of the Jurassic Sediments in Portions of Mississippi and Alabama," in T. H. Dinkins, Jr., ed., Jurassic Stratigraphy of Mississippi, Bulletin 109, Mississippi Geological, Economic and Topographical Survey, Jackson, MS, pp. 39-77.

Padgett, T. J., and D. M. Heisler, 1979. Predictive Model of Archaeological Site Location in the Central Leaf River Basin, Mississippi, University of Southern Mississippi, Hattiesburg, MS.

Palmer, Allison R., compiler, 1983. "The Decade of North American Geology, 1983 Geologic Time Scale," Geology, Vol. 11, pp. 503-504.

Paulson, Oscar L., Jr., and Frank T. Pescatore, Jr., 1979. The Effects of the Phillips Fault Zone on Subsurface Jurassic Sediments and Petroleum Production of Jasper County, Mississippi, unpublished manuscript, University of Southern Mississippi, Hattiesburg, MS.

Pautz, Maurice E., ed., 1969. Severe Local Storm Occurrences, 1955-1967, Technical Memorandum SBTM FCST 12, Weather Bureau, Environmental Sciences Services Administration, U.S. Department of Commerce, Silver Springs, MD.

Peabody, A. W., 1969. "Principles of Cathodic Protection," Ch. 5, in NACE Basic Corrosion Course, National Academy of Corrosion Engineers, Houston, TX.

Peirce, L. B., 1966. Surface Water in Southwestern Alabama, Bulletin 84, Geological Survey of Alabama, University of Alabama, University, AL.

Penman, John T., 1978. "Historic Choctaw Towns of the Southern Division," Journal of Mississippi History, Vol. 40, No. 2, pp. 132-141.

Peppard-Souders and Associates, Inc., 1982. Executive Reference Map No. 305, Mississippi-Alabama-Florida Panhandle, Scale 1:380,160, Geomap Company, Dallas, TX.

Pfeifle, Tom W., Kirby D. Mellegard, and Paul E. Senseny, 1983. Preliminary Constitutive Properties for Salt and Nonsalt Rocks From Four Potential Repository Sites, ONWI-450, prepared by RE/SPEC Inc. for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Pierce, Neal R., 1974. The Deep South States of America: People, Politics, and Power in the Seven Deep South States, W. W. Norton & Company, Inc., New York, NY, pp. 166, 168-170, 208, 211-215, 218, and 224.

Pindell, James, and John F. Dewey, 1982. "Permo-Triassic Reconstruction of Western Pangea and the Evolution of the Gulf of Mexico/Caribbean Region," Tectonics, Vol. 1, No. 2, pp. 179-211.

Plimpton, H. G., Ralph K. Foster, John S. Risbeck, Roy P. Rutherford, Richard F. King, Gary L. Buffington, and Warren C. Traweek, 1979. Final Report of Mine Explosion Disaster, Belle Isle Mine, Cargill, Inc., Franklin, St. Mary Parish, Louisiana, prepared for Mine Safety and Health Administration.

Poag, C. Wylie, 1973. "Late Quaternary Sea Levels in the Gulf of Mexico," Transactions of the Gulf Coast Association of Geological Societies, Vol. 23, pp. 394-400.

Portland Cement Association, 1971. Recommended Practice for Construction of Residential Concrete Floors on Expansive Soils, Vol. II, Los Angeles, CA.

Rainey, D. L., 1981. Letter from Rainey, Texasgulf Chemicals Company, Newgulf, TX, to Mark Smith, Mississippi Bureau of Geology, summarizing information about sulfur wells drilled at Richton Dome.

Rainwater, E. H., 1963. "Geological History and Oil and Gas Possibilities of Mississippi," Mississippi Geological Survey Geological Research Papers - 1962, Jackson, MS, pp. 77-106.

Reed, John Shelton, 1982. One South, An Ethnic Approach to Regional Culture, Louisiana State University Press, Baton Rouge, LA, pp. 61-77, 129-138, and 154-161.

Ritter, Dale F., 1978. Process Geomorphology, William C. Brown Company, Dubuque, IA.

Robinson, R. E., 1984. Telephone conversation between Robinson, Southern Railway Chief Dispatcher, Hattiesburg, MS, and P. Van Gorp, Bechtel National, Inc., about railway service in the Richton Dome area, August 29.

Roedder, E., and I-Ming Chou, 1982. A Critique of "Brine Migration in Salt and Its Implications in the Geologic Disposal of Nuclear Waste," Oak Ridge National Laboratory Report 5818, by G. H. Jenks and H. C. Claiborne, U.S. Geological Survey Open-File Report 82-1131, U.S. Department of the Interior, Reston, VA.

Rogers, Ken E., 1983. Tasks 1 and 2 Reports (revised), 12354-TSA-7, prepared for Bechtel Group, Inc., San Francisco, CA.

Russell, C. Winston, 1984. Hydrological/Geochemical Search for Sandstone-Type Uranium Deposits in Forrest, Jones, Perry and Eastern Lamar Counties, Southeastern Mississippi, Report on Research Project MMRI #83-11S, Department of Geology, University of Southern Mississippi, University, MS.

Saucier, Roger T., and Arthur R. Fleetwood, 1970. "Origin and Chronologic Significance of Late Quaternary Terraces, Ouachita River, Arkansas and Louisiana," Geological Society of America Bulletin, Vol. 81, pp. 869-890.

Seni, Steven J., and M.P.A. Jackson, 1983. "Evolution of Salt Structures, East Texas Diapir Province, Part 1: Patterns and Rates of Halokinesis," American Association of Petroleum Geologists Bulletin, Vol. 67, No. 8, pp. 1245-1274.

Seni, Steven J., and M.P.A. Jackson, 1984. Sedimentary Record of Cretaceous and Tertiary Salt Movement, East Texas Basin: Times, Rates, and Volumes of Salt Flow, Implications to Nuclear Waste Isolation and Petroleum Exploration, Report of Investigations No. 139, prepared for U.S. Department of Energy by Bureau of Economic Geology, The University of Texas at Austin, Austin, TX.

Senseny, Paul E., 1982. "Task 2: Laboratory Studies," in "Repository Design Analysis," Technical Progress Report for the Quarter 1 July - 30 September, 1982, ONWI-9(82-4), Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, pp. 155-160.

Senseny, Paul E., 1985. "Determination of a Constitutive Law for Salt at Elevated Temperature and Pressure," in H. J. Pincus and E. R. Hoskins, eds., Measurement of Rock Properties at Elevated Pressures and Temperatures, ASTM STP 869, American Society for Testing and Materials, Philadelphia, PA, pp. 55-71.

Shows, T. N., W. L. Broussard, and C. P. Humphreys, Jr., 1966. Water for Industrial Development in Forrest, Greene, Jones, Perry, and Wayne Counties, Mississippi, Mississippi Research and Development Center, prepared by Water Resources Division, U.S. Geological Survey, U.S. Department of the Interior, Jackson, MS.

Sibol, M. S., and G. A. Bollinger, compilers, 1985. "Hypocenter Listing From Southeastern U.S. Seismic Network Bulletins No. 1-14 (July, 1977 to July, 1984)," Southeastern U.S. Seismic Network Bulletin 14A, Seismological Observatory, Virginia Polytechnic Institute and State University, Blacksburg, VA, pp. 30 and 46.

Simiu, Emil, Michael Changery, and James Filliben, 1979. Extreme Wind Speeds at 129 Stations in the Contiguous United States, NBS Building Science Series 118, National Bureau of Standards, U.S. Department of Commerce, Washington, DC, pp. 45-48, 135-136.

Simpson, R. H., and Miles B. Lawrence, 1971. Atlantic Hurricane Frequencies Along the U.S. Coastline, NOAA Technical Memorandum NWS SR-58, National Oceanic and Atmospheric Administration, National Weather Service, U.S. Department of Commerce, Fort Worth, TX.

Skates, John Ray, 1979. Mississippi, A Bicentennial History, W. W. Norton & Company, Inc., New York, NY, pp. 20-21.

Slaughter, George M., Robert M. White, and Robert P. Alger, 1983. Permeability of Selected Sediments in the Vicinity of Five Salt Domes in the Gulf Interior Region, ONWI-356, prepared by Law Engineering Testing Company for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Smith, Jeffry A., 1976. "Developments in West Texas and Eastern New Mexico in 1975," The American Association of Petroleum Geologists Bulletin, Vol. 60, No. 8, pp. 1243-1250.

Society of American Foresters, 1980. Forest Cover Types of the United States and Canada, F. H. Eyre, ed., Bethesda, MD.

Soil Conservation Service, 1971. General Soil Map, Perry County, Mississippi, Mississippi Agricultural and Forestry Experiment Station, U.S. Department of Agriculture, Washington, DC.

Sokolnikoff, I. S., 1956. Mathematical Theory of Elasticity, 2nd edn., McGraw-Hill Book Company, New York, NY, pp. 358-359.

Southern Mississippi Planning & Development District, 1980. District Development Process, Gulfport, MS.

Southern Mississippi Planning & Development District, 1982. District Development Program, Regional Strategy Update/December, '82, Gulfport, MS.

Spiers, C. A., 1977. The Cockfield Aquifer in Mississippi, U.S. Geological Survey Water-Resources Investigations 77-17, Open-File Report, U.S. Department of the Interior, prepared with the Mississippi Board of Water Commissioners, Jackson, MS.

Spiers, C. A., and L. A. Gandl, 1980. A Preliminary Report of the Geohydrology of the Mississippi Salt-Dome Basin, U.S. Geological Survey Water-Resources Investigations 80-595, Open-File Report, U.S. Department of the Interior, prepared in cooperation with the U.S. Department of Energy, Jackson, MS.

Stone & Webster Engineering Corporation, 1983. Preliminary Assessment of the Healing of Fractures in Salt, ONWI-363, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Stover, C. W., B. G. Reagor, and S. T. Algermissen, 1979a. Seismicity Map of Alabama, Miscellaneous Field Studies Map MF-1059, Scale 1:1,000,000, U.S. Geological Survey, U.S. Department of the Interior, Reston, VA.

Stover, C. W., B. G. Reagor, and S. T. Algermissen, 1979b. Seismicity Map of Mississippi, Miscellaneous Field Studies Map MF-1058, Scale 1:1,000,000, U.S. Geological Survey, U.S. Department of the Interior, Washington, DC.

Stover, C. W., and C. A. Von Hake, eds., 1980. United States Earthquakes, 1978, published jointly by U.S. Geological Survey and National Oceanic and Atmospheric Administration, Golden, CO.

Stumm, Werner, and James J. Morgan, 1970. Aquatic Chemistry: An Introduction Emphasizing Chemical Equilibria in Natural Waters, John Wiley & Sons, Inc., New York, NY, pp. 172-194 and 500-507.

SWEC, see Stone and Webster Engineering Corporation.

Talley, H. Carroll, Jr., and William K. Cloud, 1962. United States Earthquakes, 1960, Coast and Geodetic Survey, U.S. Department of Commerce, Washington, DC.

Tammemagi, Hans Y., Marc C. Loken, John D. Osnes, and Ralph A. Wagner, 1985. A Compilation of Data for Thermomechanical Analyses of Four Potential Salt Repositories, ONWI-364, prepared by RE/SPEC Inc. for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Taylor, R. E., C. P. Humphreys, Jr., and D. E. Shattles, 1968. Water for Industrial Development in Covington, Jefferson Davis, Lamar, Lawrence, Marion, and Walthall Counties, Mississippi, Water Resources Division, U.S. Geological Survey, U.S. Department of the Interior, Jackson, MS.

Terzaghi, Karl, and Ralph B. Peck, 1967. Soil Mechanics in Engineering Practice, 2nd edn., John Wiley & Sons, Inc., New York, NY.

Tesar, Louis Daniel, 1974. Archaeological Assessment Survey of the Tallahala Reservoir Area, Jasper County, Mississippi, prepared for the National Park Service by Mississippi State University, Mississippi State, MS.

Tharpe, E. J., 1975. Low-Flow Characteristics of Mississippi Streams, U.S. Geological Survey Bulletin 75-1, with the Mississippi Board of Water Commissioners, Jackson, MS.

The Earth Technology Corporation, 1984. Comments on a Letter by George D. DeBuchananne (U.S. Geological Survey) Regarding the Use of Salt Domes for High-Level Waste Disposal, BMI/ONWI-511, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

The Earth Technology Corporation, 1984a. Stratigraphy and Structure over Richton Dome - Data and Findings Relevant to the Issue of Salt Dissolution, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, October 3.

The Earth Technology Corporation, 1985a. Geodetic and Geomorphic Analysis of Uplift in the Gulf Coast Region, in preparation.

The Earth Technology Corporation, 1985b. Gravity Modeling Study, Richton Dome, Mississippi, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, September, in preparation.

The Earth Technology Corporation, 1985c. Probable Maximum Flood Analysis, Richton Dome, Mississippi - Phase I, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH (draft).

The Earth Technology Corporation, 1985d. Regional Ground-Water Flow Near Richton and Cypress Creek Domes, Mississippi, Annual Status Report for Fiscal Year 1984, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, in preparation.

Thom, H.C.S., 1963. "Tornado Probabilities," Monthly Weather Review, Vol. 91, October-December, pp. 730-736.

Thoms, R. L., and R. M. Gehle, 1982. "Experimental Study of Rocksalt for Compressed Air Energy Storage," Rock Mechanics: Caverns and Pressure Shafts, International Society for Rock Mechanics Symposium (May 25-28, 1982, Aachen, West Germany), pp. 991-1002.

Thomasovsky, Major, and Brigadier General Brackeen, 1985. Report of teleconference of Thomasovsky and Brackeen, both of State of Mississipi Military Department, and Salt Repository Project Office staff members clarifying questions on Mississippi Military Department comments, July 1.

Thornbury, William D., 1965. Regional Geomorphology of the United States, Parts I and II, John Wiley & Sons, Inc., New York, NY.

Tien, Pei-lin, F. B. Nimick, A. B. Muller, P. A. Davis, R. V. Guzowski, L. E. Duda, and R. L. Hunter, 1983. Repository Site Data and Information in Bedded Salt: Palo Duro Basin, Texas, NUREG/CR-3129, SAND82-2223, prepared for Office of Nuclear Materials Safety and Safeguards, U.S. Nuclear Regulatory Commission, by Sandia National Laboratories, Albuquerque, NM.

Todd, David K., 1959. Groundwater Hydrology, reprinted 1967, John Wiley & Sons Inc., New York, NY.

Traffic World, Midwest Bureau 1985. "713 Miles of ICC Line in Eastern Mississippi Sold for $22.5 Million," Traffic World, July 15, p. 30.

Trusheim, F., 1960. "Mechanism of Salt Migration in Northern Germany," American Association of Petroleum Geologists Bulletin, Vol. 44, No. 9, pp. 1519-1540.

U.S. Army Corps of Engineers, 1968. Pascagoula River Comprehensive Basin Study, Vol. III, Mobile District, Mobile, AL.

U.S. Army Corps of Engineers, 1981. HEC-1 Flood Hydrograph Package: Users' Manual, Hydrologic Engineering Center, Davis, CA.

U.S. Army Corps of Engineers, 1969. Report on Hurricane Camille, 14-22 August 1969, Mobile, AL.

U.S. Department of Agriculture, 1979. Land Use by County, Data Base Classifications, Mississippi Statewide Cooperative River Basin Study, Mississippi Cooperative Extension Service, Mississippi State, MS.

U.S. Department of Agriculture, 1982. Agricultural Statistics, Statistical Reporting Services, Washington, DC.

U.S. Department of Housing and Urban Development, 1978. Flood Hazard Boundary Map, Perry County, Mississippi, Unincorporated Areas, Federal Insurance Administration, Washington, DC.

U.S. Department of the Navy, 1982. Soil Mechanics, Design Manual 7.1, Naval Facilities Engineering Command, Alexandria, VA.

U.S. Environmental Protection Agency, 1974. Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, EPA/ONAC 550/9-74, Washington, DC.

U.S. Environmental Protection Agency, 1977. Radiological Quality of the Environment in the United States, EPA-520/1-77-009, Washington, DC.

U.S. Environmental Protection Agency, 1984. Retrieval from the STORET Data File.

U.S. Geological Survey, 1962. Tectonic Map of the United States, Scale 1:2,500,000, U.S. Department of the Interior, Washington, DC.

U.S. Geological Survey, 1970. Hattiesburg, Mississippi; Alabama; Louisiana Map, 1953, revised, Scale 1:250,000, U.S. Department of the Interior, Reston, VA.

U.S. Geological Survey, 1972. State of Mississippi Map, Scale 1:500,000, U.S. Department of the Interior, Washington, DC.

U.S. Geological Survey, 1973. Rhodes, Mississippi Quandrangle Map, Scale 1:24,000, U.S. Department of the Interior, Reston, VA.

U.S. Geological Survey, 1974. United States Geologic Map, East Half, Scale 1:2,500,000, U.S. Department of the Interior, Reston, VA.

U.S. Geological Survey, 1977. Hydrologic Unit Map, 1974, State of Mississippi, prepared in cooperation with the U.S. Water Resources Council, U.S. Department of the Interior, Reston, VA.

U.S. Geological Survey, 1982a. Ovett, Miss., Quadrangle Map, N3122.5-W8900/7.5, Scale 1:24,000, U.S. Department of the Interior, Reston, VA.

U.S. Geological Survey, 1982b. Ovett SE, Mississippi, Quadrangle Map, Scale 1:24,000, U.S. Department of the Interior, Reston, VA.

U.S. Geological Survey, 1982c. Richton, Miss., Quadrangle Map, N3115-W8852.5/7.5, Scale 1:24,000, U.S. Department of the Interior, Reston, VA.

U.S. Geological Survey, 1982d. Water Resources Data for Mississippi - Water Year 1981, Water-Data Report MS-81-1, in cooperation with the Mississippi Department of Natural Resources and other agencies, U.S. Department of the Interior, Jackson, MS.

U.S. Geological Survey, 1984a. WATSTORE Data Retrieval, Reston, VA.

U.S. Geological Survey, 1984b. Surface-Water and Related-Land Resources Development in the United States and Puerto Rico, map, scale 1:3,168,000, U.S. Department of the Interior, Washington, D. C.

U.S. Geological Survey and U.S. Bureau of Mines, 1980. Principles of a Resource/Reserve Classification for Minerals, U.S. Geological Survey Circular 831, U.S. Department of the Interior, Washington, DC.

USGS, see U.S. Geological Survey.

U.S. Water Resources Council, 1978. Water Supply and Use Data, The Nation's Water Resources 1975-2000, 3 vols., Second National Water Assessment, Washington, DC.

U.S. Weather Bureau, 1965. Climatography of the United States No. 86-18, Decennial Census of United States Climate, Climatic Summary of the United States, Supplement for 1951 through 1960, Mississippi, U.S. Department of Commerce, Washington, DC.

Van Eysinga, F. W. B., 1975. Geological Time Table, Elsevier Scientific Publishing Company, Amsterdam, The Netherlands.

Ver, Istvan L., and Douglas W. Anderson, 1977. Characterization of Transformer Noise Emissions - Volume 2: Transformer Environmental Noise Siting Guide, Report No. 3305, Vol. 2 prepared by Bolt Beranek and Newman Inc. for Empire State Electric Energy Research Corporation, New York, NY.

Vesic, Aleksandar S., and G. Wayne Clough, 1968. "Behavior of Granular Materials Under High Stresses," Journal of the Soil Mechanics and Foundations Division, Vol. 94, SM 3, pp. 661-688.

von Hake, Carl A., and William K. Cloud, 1969. United States Earthquakes, 1967, Jerry L. Coffman, ed., Environmental Sciences Service Administration, U.S. Department of Commerce, Washington, DC.

Wacaster, C. Thompson, 1975. "Social and Educational History of Perry County, Mississippi," Ch. VI in P. C. Wolff, ed., Rural America: A Social and Educational History of Ten Communities, Vol. I, ABT Associates Inc., Cambridge, MA, pp. 431-436, 447-449, and 481.

Walcott, R. I., 1972. "Gravity, Flexure, and the Growth of Sedimentary Basins at a Continental Edge," Geological Society of America Bulletin, Vol. 83, pp. 1845-1848.

Walker, Charles W., 1974. "Nature and Origin of Caprock Overlying Gulf Coast Salt Domes," Fourth Symposium on Salt, Northern Ohio Geological Society, pp. 169-195.

Walters, Robert F., 1975. "Salt Beds in the Subsurface in Russell, Lincoln, Ellsworth, Barton and Rice Counties, Central Kansas," Part I of Salt Dissolution in Oil and Gas Test Holes in Central Kansas, prepared for U.S. Energy Research and Development Administration by Oak Ridge National Laboratory, Union Carbide Corporation, Oak Ridge, TN.

Wasson, B. E., 1980a. Potentiometric Map of the Lower Wilcox Aquifer in Mississippi, Fall 1979, U.S. Geological Survey Water-Resources Investigations Open-File Report 80-597, U.S. Department of the Interior, prepared in cooperation with the Mississippi Department of Natural Resources, Bureau of Land and Water Resources, Jackson, MS.

Wasson, B. E., 1980b. Potentiometric Map of the Meridian-Upper Wilcox Aquifer in Mississippi, Fall 1979, U.S. Geological Survey Water-Resources Investigations Open-File Report 80-590, U.S. Department of the Interior, prepared in cooperation with the Mississippi Department of Natural Resources, Bureau of Land and Water Resources, Jackson, MS.

Wasson, B. E., 1980c. Potentiometric Map of the Sparta Aquifer System in Mississippi, Fall 1980, U.S. Geological Survey Water-Resources Investigations Open-File Report 81-1051, U.S. Department of the Interior, prepared in cooperation with the Mississippi Department of Natural Resources, Bureau of Land and Water Resources, Jackson, MS.

Wasson, B. E., 1980d. Sources for Water Supplies in Mississippi, U.S. Geological Survey and Mississippi Research and Development Center, Jackson, MS.

Wasson, B. E., 1981. Potentiometric Map of the Cockfield Aquifer, Mississippi, Fall 1980, U.S. Geological Survey Water-Resources Investigations Open-File Report 81-1053, U.S. Department of the Interior, Washington, DC.

Werner, M. L., 1985a. Assessments Pursuant to EA Comments on Overdome Faulting and Lineaments in the Neardome Area, draft technical memorandum, prepared by The Earth Technology Corporation for the Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, August 30.

Werner, M. L., 1985b. Structure and Mineralization of Richton Dome Caprock, Boring MRIG-9, prepared by The Earth Technology Corporation for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, draft.

Werner, M. L., 1985c. Evaluation of the Structure and Stratigraphy Over Richton Dome, prepared by The Earth Technology Corporation for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, in preparation.

Williams, Charles H., Jr., 1969. Cross Section from Mississippi-Tennessee State Line to Horn Island in Gulf of Mexico, Mississippi Geological Survey, Jackson, MS.

Williams, Charles H., Jr., Theo H. Dinkins, Jr., and Thomas E. McCutcheon, 1966. George County Geology and Mineral Resources, Bulletin 108, Mississippi Geological, Economic and Topographical Survey, Jackson, MS.

Wilson, H. H., 1975. "Sub Salt Origin of Exotic Blocks in Piercement Domes Reveals the Probability of Oligo-Miocene Salt in the Gulf of Mexico Region," Transactions - Gulf Coast Association of Geological Societies, Vol. 25, pp. 1-19.

Wood, Harry O., and Frank Neumann, 1931. "Modified Mercalli Intensity Scale of 1931," Seismological Society of America Bulletin, Vol. 53, No. 5, pp. 979-987.

Wyle Laboratories, 1971. Community Noise, prepared for Office of Noise Abatement and Control, U.S. Environmental Protection Agency, Washington, DC, pp. 4, 6, 8, 12, 17-18, 20-24, 28, 33, 37, A-69, A-72, B-12, and B-13.

Yang, J. M., 1981. "Thermophysical Properties," Ch. 4 in L. H. Gevantman, ed., Physical Properties Data for Rock Salt, National Bureau of Standards, U.S. Department of Commerce, Washington, DC.

Zoback, M. D., and M. L. Zoback, 1980. "State of Stress inthe Conterminous United States," Journal of Geophysical Research, Vol. 85, No. B11, pp. 6113-6156.

3.7.2 Federal Regulations and Statutes

7 CFR Part 658, regulations under the Farmland Protection Policy Act (7 USC Secs. 4201-4209).

10 CFR Part 960, Nuclear Waste Policy Act of 1982; General Guidelines for the Recommendation of Sites for the Nuclear Waste Repositories; Final Siting Guidelines.

36 CFR Part 261, regulations under the National Forest Management Act (16 USC Secs. 475, 1600-1676).

40 CFR Part 50, National Primary and Secondary Ambient Air Quality Standards.

40 CFR Part 81, Identification of Mandatory Class I Areas Where Visibility Is an Important Value.

40 CFR Part 191, Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes (Draft).

Bald and Golden Eagle Protection Act, 16 USC Secs. 668-668d.

Clean Air Act, as amended, 42 USC Secs. 7401-7642.

Farmland Protection Policy Act, 7 USC Secs. 4201-4209.

Forest and Rangeland Renewable Resources Planning and Research Act, 16 USC Secs. 1600-1676.

Migratory Bird Treaty Act, as amended, 16 USC Secs. 703-711.

Multiple-Use Sustained-Yield Act, 16 USC Secs. 528-531.

National Forest Organic Legislation, 16 USC Sec. 475.

National Wildlife Refuge System Administration Act of 1966, 16 USC Secs. 668dd-668ee.

Nuclear Waste Policy Act of 1982, 42 USC Secs. 10101-10226.

Wild and Scenic Rivers Act, 16 USC Secs. 1271-1287.

Wilderness Act, 16 USC Secs. 1131-1136.

3.7.3 State of Mississippi Laws

Air and Water Pollution Control Law for Mississippi, Miss. Code Ann. Sec. 49-17-1 to 49-17-43, 17-17-27 (3), and 17-17-47 (1972 & Supp. 1984).

Chapter 4

EXPECTED EFFECTS OF SITE CHARACTERIZATION ACTIVITIES

This chapter describes both the proposed site characterization activities including construction of two exploratory shafts that would be carried out if the Richton Dome Site is recommended for characterization and the expected effects of these activities on the public health and safety and the physical environment and socioeconomic conditions. The proposed site characterization activities will be undertaken to establish the geologic conditions and the ranges of parameters of a candidate site needed to evaluate its suitability for the location of a repository. These activities are intended to expand the existing data base on the Richton Dome site to do the following:

- Determine the suitability of the site for a repository based on the "General Guidelines for Recommendation of Sites for Nuclear Repositories" (10 CFR Part 960)
- Compare the sites that are characterized
- Provide site-specific information necessary for final repository design
- Obtain information required for an Environmental Impact Statement
- Comply with the U.S. Nuclear Regulatory Commission's (NRC) requirements for licensing the repository.

Section 4.1 contains descriptions of the site characterization activities, including field studies, construction of an exploratory shaft, land acquisition, and environmental and socioeconomic studies. The activities described in this section are representative of those comprising site characterization. In general, field studies and other activities will begin before construction of the exploratory shaft. Section 4.2 discusses expected effects of site characterization activities on the physical environment and socioeconomic conditions and includes a summary of measures which will monitor the effects of the activities. Section 4.3 discusses alternatives to the baseline activities and impacts described in Sections 4.1 and 4.2. These alternatives include a single shaft option, a different location for the shafts, and different water supply and waste disposal approaches.

4.1 SITE CHARACTERIZATION ACTIVITIES

This section describes the site characterization activities and site-specific engineering studies that would be undertaken to determine site suitability. Prior to the sinking of an exploratory shaft, a Site Characterization Plan (SCP) will be prepared, which will present more detail on the rationale and extent of the proposed studies. In addition to the SCP, a number of more detailed study plans will be prepared prior to each activity (or group of activities).

The description of the proposed activities is divided into three subsections:

- Field Studies - Geologic research activities.
- Exploratory Shaft Facility - Land acquisition, construction, and subsurface testing activities.
- Other Activities - Environmental, socioeconomic, and transportation activities.

4.1.1 Geotechnical Field Studies

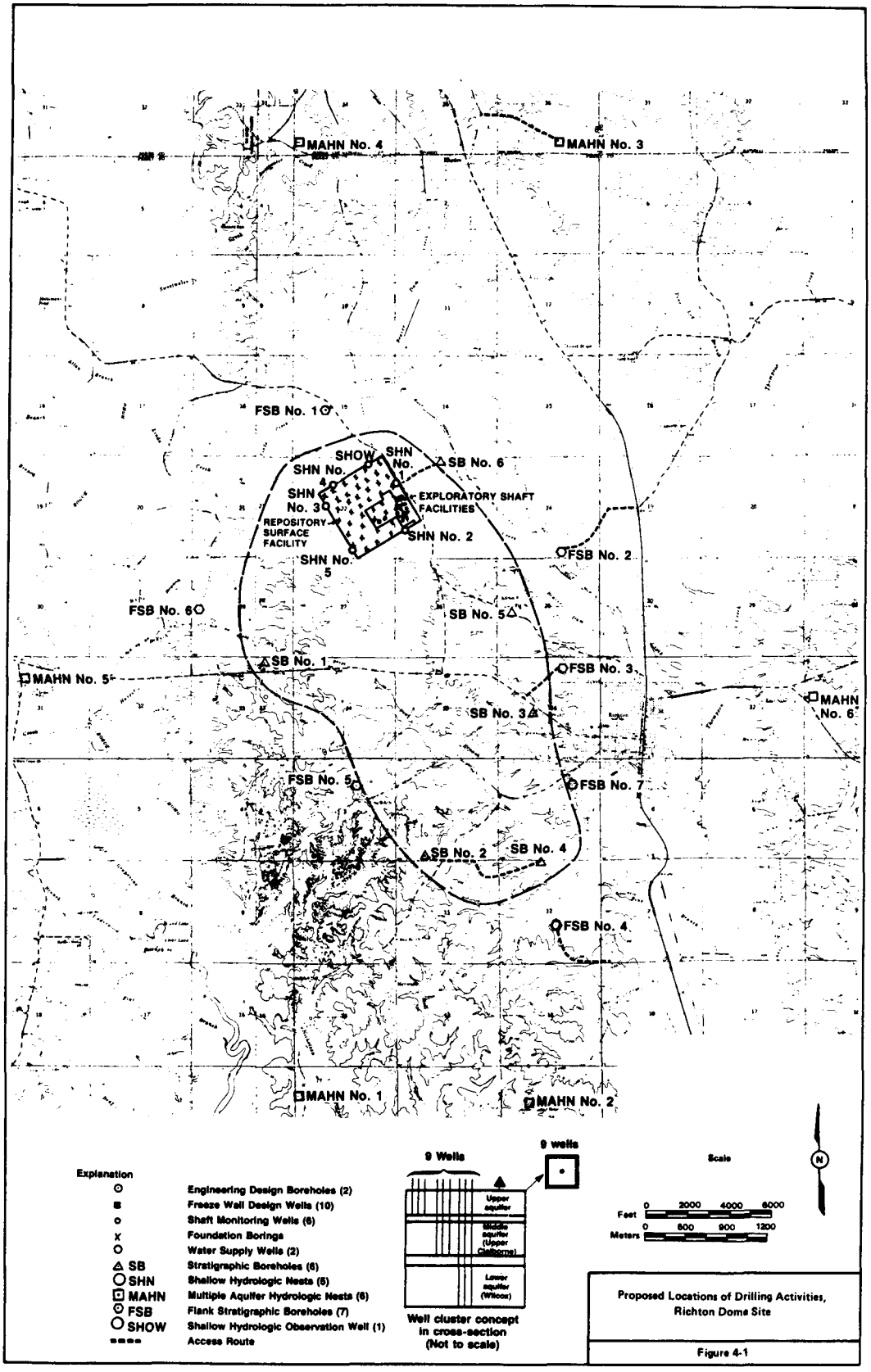
Table 4-1 lists the geotechnical field activities that are likely to be performed during site characterization in the order that they relate to the siting guidelines (10 CFR Part 960). The locations of the proposed drilling field activities (Figure 4-1) presented in

Table 4-1. Geotechnical Field Activities to be Performed During Site Characterization, Richton Dome

Activity Name	Activity Discussion
10 CFR 960.4 - Postclosure Guidelines[a]	
Geohydrology (960.4-2-1)	
Surface Hydrologic Characterization	4.1.1.1.1
Multiple Aquifer Hydronests	4.1.1.1.2
Shallow Upper Aquifer Hydronests	4.1.1.1.3
Monitoring and Sampling of Wells	4.1.1.1.4
Geochemistry (960.4-2-2)	
Monitoring and Sampling Wells	4.1.1.1.4
Rock Characteristics (960.4-2-3)	
Surface Geologic Mapping	4.1.1.1.5
Flank Stratigraphic Boreholes	4.1.1.1.6
Overdome Stratigraphic Boreholes	4.1.1.1.7
Tectonics (960.4-2-7)	
Microseismic Network	4.1.1.1.8
Seismic Reflection and Refraction Surveys	4.1.1.1.9
Potential Field Survey	4.1.1.1.10
Human Interference (960.4-2-8)	
Sulfur Exploration Wells	4.1.1.1.11
Borehole Search and Characterization	4.1.1.1.12
10 CFR 960.5 - Preclosure Guidelines	
Surface Characteristics (960.5-2-8)	
Topographic Mapping	4.1.1.2.3
Rock Characteristics (960.5-2-9)	
Engineering Design Borehole	4.1.1.2.1
Early Foundation Design, Surface Facilities, Access Routes, and Utility Foundation Boreholes	4.1.1.2.2
Hydrology (960.5-2-10)	
Monitoring and Sampling Wells	4.1.1.1.4
Repository Surface Facilities Monitoring Wells	4.1.1.1.4
Freeze Wall Design Wells	4.1.1.2.4
Water Supply Wells	4.1.1.2.5
Shaft Monitoring Wells, Exploratory Shaft Facility Monitoring Wells, and Repository Surface Facility Monitoring Wells	4.1.1.2.6
Surface Hydrologic Characterization	4.1.1.1.1

[a]Dissolution (10 CFR 960.4-2-6) is not linked as a separate topic, but the required activities will be performed under the geohydrology and geochemistry topics.

A larger reproduction of this figure appears at the back of this volume.



this section are tentative. Final locations and the extent to which activities may be coupled will be influenced by technical, environmental, and land access considerations. By using these tentative locations, however, representative environmental impacts are assessed. Table 4-2 summarizes the estimated requirements of the field activities identified in Table 4-1. Table 4-2 shows the work force and land use estimates for field activities. The proposed schedule for field activities is presented in Figure 4-2.

Field activities described in this section will modify the existing surface or subsurface conditions. In some cases, a specific activity, such as borehole drilling, will occur over several weeks or months. In the case of the exploratory shaft facility, the construction and testing will occur over several years.

The various techniques (e.g., shallow and deep drilling) that will be implemented during the course of the field activities are described in the following paragraphs. These generic descriptions will alleviate the need to repeat these descriptions in subsections, except where variations to the basic activity are proposed. Prior to initiation of field work, land access agreements and applicable construction and drilling permits will be obtained.

Drill Site Preparation. Construction of access roads will be kept to a minimum by using existing roads and trails wherever possible. Road and site preparation may require the clearing of brush and trees by hand or by bulldozer, blading and stockpiling of the upper 15 centimeters (6 inches) of topsoil, and leveling of the site. Surface stabilization may require the use of a gravel or wood plank surface to prevent deterioration of surface conditions. Access road design will be based on surface conditions, equipment size, and the amount of traffic to and from the site. Drill-pad size will be based on surface conditions and rig size, required support equipment, and the extent of the drilling and testing to be performed. In general, the site must have adequate space for a water-supply well or storage tanks, mud pits or tanks, the drill rig, drill pipe and well-casing racks, pumps, generators, support trailers, well-service and borehole logging equipment, and other light vehicles. The drill pad will be surveyed for location and elevation control. A typical drill site for deep or multiple borings is shown in Figure 4-3. Where possible, offsite transport of sediment will be minimized with sediment ponds and fabric traps.

For deep or multiple well sites, drilling water may be provided by water-supply wells drilled on the site. For the drilling of shallow holes, water will be trucked in.

Borehole Drilling and Coring. A variety of drilling methods suited to various rock types, hole depths, and sampling procedures is available for geologic and geotechnical exploration. Two commonly used methods are rotary and auger drilling. Rotary drilling advances the borehole by breaking up the rock through a downward force applied to a rotating drill bit. Drilling fluid, usually consisting of water mixed with bentonite or chemical additives to form a mud, is circulated through the drill rod to cool the drill bit, flush cuttings out of the hole, and prevent the borehole walls from collapsing. Drilling fluid will be contained on site in either above-ground tanks or lined excavated pits. Reserve pits may be excavated to hold excess drill fluids. Rotary drilling will be used when an activity requires borings to be drilled deeper than 45 meters (150 feet) or rock core is desired for laboratory testing. Auger drilling involves the use of hollow, exteriorly spirally bladed pipe or rods (flights) to drill through relatively soft sands and clays. Augered holes, also 10 centimeters (4 inches) or 15 centimeters (6 inches) in diameter, are typically drilled without added water. Auger drilling will be used when an activity requires borings to be drilled 45 meters (150 feet) or until the water table is encountered. The auger rigs will use hollow auger flights, through which hammer-driven splitspoon and Shelby-tube samples will be taken at 1.5-meter (5-foot) intervals.

At various stages of rotary drilling, casing may be installed in the borehole and grouted in place to stabilize the borehole or isolate it from adjacent rock units. Grouting of the

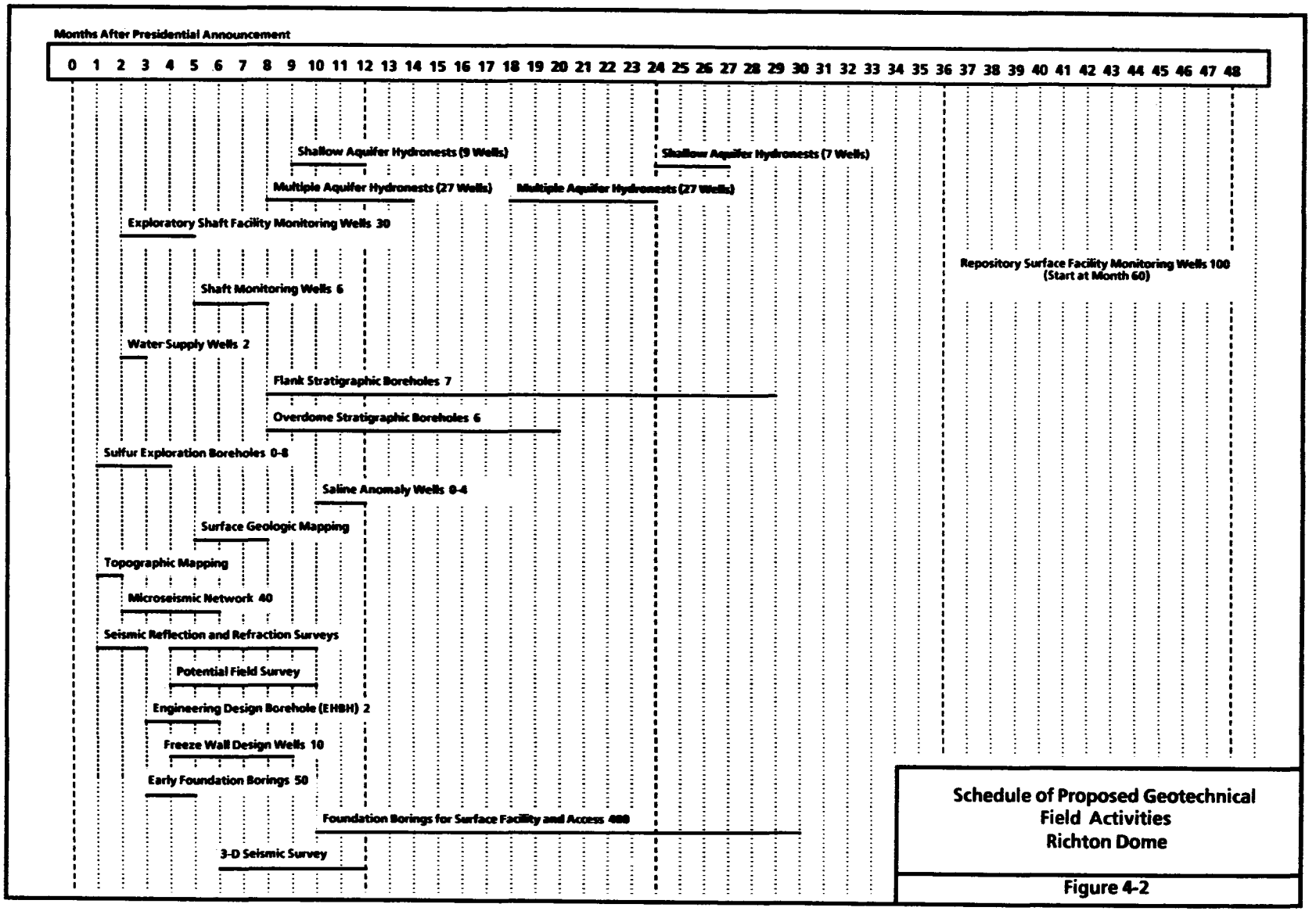
Table 4-2. Summary of Geotechnical Field Activity Requirements, Richton Dome Site

Activity	Scope	Quantity per Site	Total Number of Boreholes	Land Use		Work Force per Site	Major Equipment per Site	Duration of Activity	Duration at Each Site
				Number of Sites	Requirements per Site[a]				
Shallow Aquifer Hydroneats	Drilling, coring, logging, testing, and monitoring	3 hydroneats and 1 well	16	6	4-10 acres	27	1 large truck-mounted drill rig, auxiliary equipment, 8-10 light vehicles	6 months	1 month
Multiple Aquifer Hydroneats	Drilling, some coring, logging, testing, and monitoring	9 wells	54	6	12-15 acres	54	1 platform drill rig and 1 large truck-mounted drill rig, auxiliary equipment, 8-10 light vehicles	12 months	6 months
Saline Anomaly Wells	Sample existing wells (possible drilling)	1 well	(0-4)	60 (0-4)	Access (0.1 acre)	2 (6)	1 light truck (+ light truck-mounted drill rig)	2 months	1 day
Exploratory Shaft Facility Monitoring Wells	Drilling, logging, casing, testing, monitoring for baseline and periodic aquifer condition	1 well	30	30	None, on land cleared for shaft facilities	6	1 small truck-mounted drill rig and auxiliary equipment, 2 light vehicles	3 months	3 days
Repository Surface Facility Monitoring Wells	Drilling, sampling, casing, and development	1 well	100-225	100-225	0.1 acre	6	1 small truck-mounted drill rig, auxiliary equipment, 2 light vehicles	9-20 months	2 days
Shaft Monitoring Wells	Drilling, selective coring, logging, testing, and monitoring	3 wells	6	2	None, on land cleared for EDBHs	27	1 large truck-mounted drill rig, auxiliary equipment, 8-10 light vehicles	3 months	3 months
Water Supply Wells	Drilling, casing, well development, and testing	1 well	2	2	0.1 acre	6	1 small truck-mounted drill rig and auxiliary equipment, 2 light vehicles	1 month	1 month
Overdome Stratigraphic Boreholes	Coring and logging	1 borehole	6	6	4 acres	27	1 large truck-mounted drill rig, auxiliary equipment, 8-10 light vehicles	12 months	4 months
Flank Stratigraphic Boreholes	Drilling, coring, and logging	1 borehole	7	7	4 acres	27	1 large truck-mounted drill rig, auxiliary equipment, 8-10 light vehicles	21 months	3 months
Sulfur Exploration Boreholes	Locate old bore holes; wash out and plug, if necessary	1 borehole	0-8	34	Access only or 0.30 acre	2-4	1 heavy vehicle, 2 light vehicles	3 months	2-7 days
Surface Geologic Mapping	Detailed geologic and geomorphic mapping, and minor trenching	--	--	Site and access	Access, possible shallow pit exposures	4-6	2 light vehicles	3 months	3 months
Topographic Mapping	Establish ground control reference points, brush cutting	1 control point	--	40	Access	6	3-4 light vehicles	1 month	1/2 day
Borehole Search and Characterization	Possible reentry and plugging of found holes	1	0+	0+	Access only or 0.10+ acre	15	1 light vehicle, drilling equipment as required	1-6 months	1-6 months
Microseismic Monitoring Network	Installation of seismographs and shallow drill holes	1 station	40	25	0.1 acre	2-3	1 small truck-mounted drill rig, 1 light vehicle	4 months	2-5 days
Seismic Reflection Lines	Establish temporary instrument points, initiate source energy discharge	155 total miles[b]	--	--	380 acres of primitive roads, and hand cut lines	25	5 heavy vehicles, seismic equipment, 5 light vehicles	6 months	--

Table 4-2. Summary of Geotechnical Field Activity Requirements, Richton Dome Site
(Page 2 of 2)

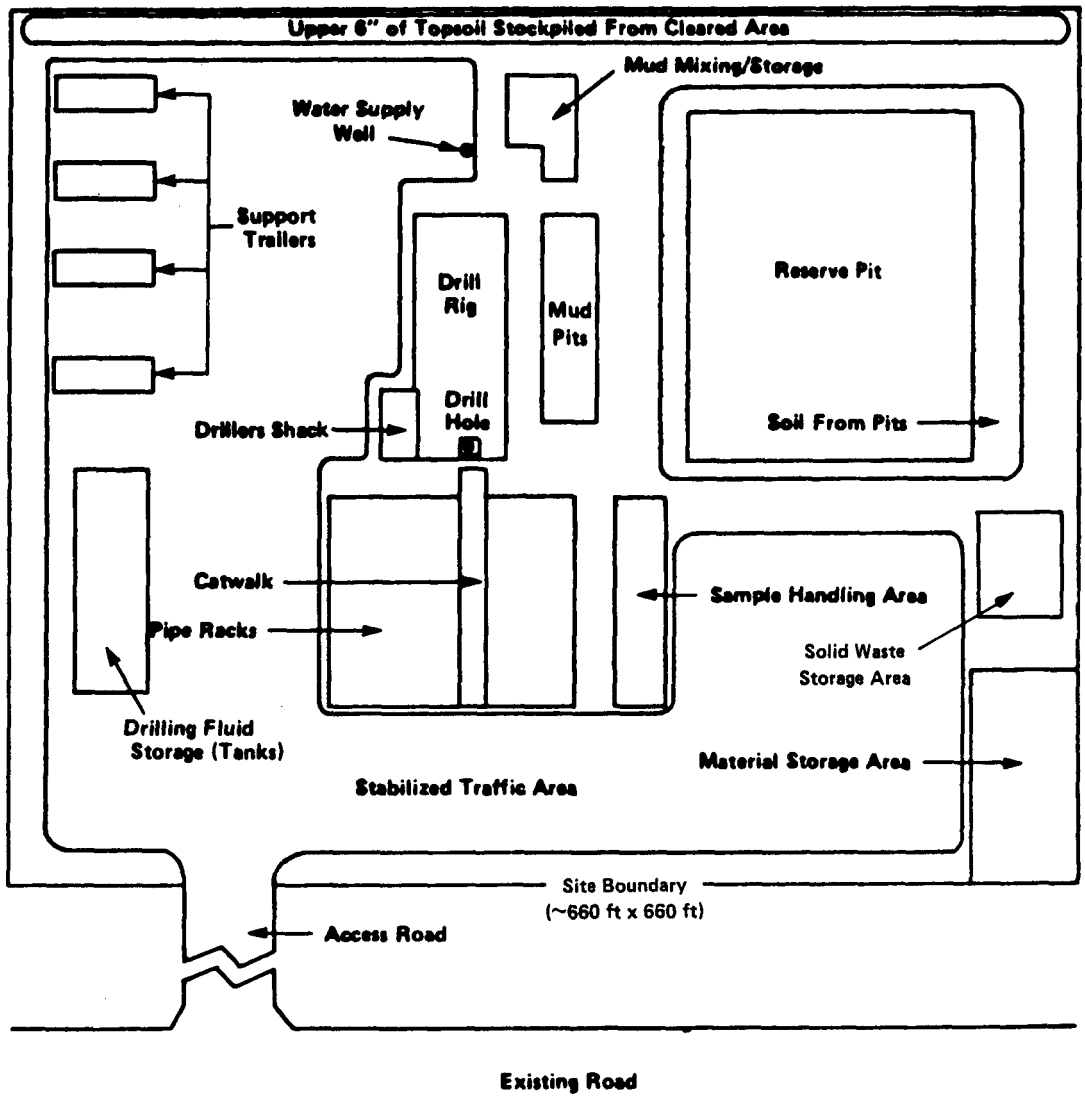
Activity	Scope	Quantity per Site	Total Number of Boreholes	Land Use		Work Force per Site	Major Equipment per Site	Duration of Activity	Duration at Each Site
				Number of Sites	Requirements per Site[a]				
Seismic Refraction Lines	Detailed near-shaft and shallow subsurface profiling	2 line-miles[b]	—	—	Access only by truck	4	2 light trucks	2 months	—
Potential Field Survey	Over site gravity, magnetics, electric potential field surveys, and hole to hole surveys	10 square miles[c]	—	—	Access only	3	2 light vehicles	6 months	—
Engineering Design Borehole (EDBH)	Drilling, coring, and logging	1 borehole	2	2	10 acres	27	1 platform drill rig and auxiliary equipment, 8-10 light vehicles	3 months	3 months
Freeze-Wall Design Wells	Drilling, some coring, logging, testing, and monitoring	5 boreholes	10	2	None, on land cleared for EDBHs	27	1 large truck-mounted rig and auxiliary equipment, 8-10 light vehicles	5 months	5 months
Early Foundation Design Borings	Sampling, coring, and logging	1 borehole	50	50	0.1 acre	6	1 small truck-mounted drill rig, auxiliary equipment, 2 light vehicles	2 months	1 day
Foundation Borings for Surface Facilities and Access	Drilling, sampling, coring, logging, and test pits	1 borehole	400	400	0.1 acre	6	1 small truck-mounted drill rig, auxiliary equipment, 2 light vehicles	20 months (part time)	1 day

(a) One acre = 0.405 hectare.
(b) One mile = 1.609 kilometers.
(c) One square mile = 2.590 square kilometers.



Schedule of Proposed Geotechnical Field Activities Richton Dome

Figure 4-2



Note: Drawing Not to Scale

Generalized Drill Site Schematic for Geologic and Hydrologic Borings Richton Dome

Figure 4-3

Source: Ertec, 1982, p. 2-3

casing will be accomplished either by using equipment commonly available on the drill rig, or by additional equipment which will be brought to the site.

Geophysical Logging. Downhole geophysical logging will be done after wells are drilled, and sometimes at intermediate stages. Logging involves lowering special measuring tools down the hole and recording data as the tool is withdrawn. Tools available for measurements will indicate properties such as formation density, porosity, fluid content, spontaneous electrical potential, electrical conductivity, seismic wave velocities (compressional and shear), and natural radioactivity. Several measurements are frequently combined in one tool. An extensive suite of geophysical logs will be run in each borehole, except for nested wells where only one hole needs to be logged with an extensive suite.

General procedures and equipment for the various logging techniques are quite similar from the viewpoint of environmental assessment. Some tools contain radioactive isotopes (see Section 4.2.1.9); these are used in accordance with well-established industry standards. All radiation sources will be licensed by the NRC and will be operated by licensed personnel where applicable. The logging will be conducted using a specially equipped truck that is brought to the site over existing roads.

Hydrologic Testing. Prior to hydrologic testing, drilling fluid will be flushed from the borehole, the borehole walls, and the sediments adjacent to the borehole walls. Contaminated or saline fluids produced during drilling or development (pumping) of the borehole will be stored on site in aboveground tanks (or lined pits) until the fluid can be transported off site and disposed of in accordance with applicable regulations. If fresh water is produced, it may be reused on site or be discharged to adjacent drainageways in accordance with applicable regulations. When hydrologic testing of an aquifer is conducted, well screens and appropriate pressure-monitoring devices will be installed in the well.

Controlled pumping is a commonly performed hydrologic test. A pump will be used to extract water from a well for a specified period to measure the aquifer's response in the pumped well and adjacent wells due to the stress placed on the aquifer. Hydraulic testing of aquifers may also be conducted in the borehole (during the course of drilling) through single well aquifer tests, such as drill stem tests (testing of portions of the hole), packer tests (testing selected sealed-off intervals of the hole), slug withdrawal, or injection tests.

Drill Site Restoration. When all drilling and testing activities have been completed, equipment and facilities will be removed from the site. The location and elevation of the well will be recorded. Pits will be filled, road and drill pad planking or gravel removed, and the site regraded. Stockpiled topsoil will be evenly spread over the site and, as required, the disturbed area will be seeded and fertilized. An access route for continued monitoring will be retained, and the remainder of the site will be restored as much as possible to its original condition. The exposed casing and cap or wellhead valves will be protected by a locked standpipe or steel railings and posted with proper identification.

Trenching. Limited numbers of trenches to identify the location and character of shallow geologic and engineering features, such as geological formation contacts, will be dug with a backhoe or similar type of excavation equipment. Materials excavated from the trench will be stored in piles on either side of the trench. The trench walls will be sloped or shored to protect personnel mapping the trench. All or portions of the trench may remain open for a week or more depending on conditions encountered. Upon completion of trench wall logging and mapping, the shoring will be removed, the trench filled, the fill compacted, and the site restored.

4.1.1.1 Basic Geotechnical and Hydrologic Studies

Field activities are discussed according to an order based on 10 CFR Part 960 conditions and summarized in Tables 4-1 and 4-2.

4.1.1.1.1 Surface Hydrologic Characterization. The surface hydrologic characterization activity will consist of surface-water sampling, flood analyses, and low-flow analyses.

Surface-water sampling activities will consist of quarterly field surveys to perform water-quality sampling and to measure stream flow. Sampling locations will be selected on the basis of accessibility, flow characteristics, geology, areas of unusually high stream salinity, and tributary influences. Where required, surface-water samples will be used for water quality tests to support environmental studies discussed in Section 4.1.3.1.4. If surface water saline anomalies are found, a salinity source survey and further sampling will be conducted. Stream-flow measurements will be conducted using a current meter and either a Parshall flume or weir plate for streams with low flow rates (less than 0.06 cubic meter per second [2 cubic feet per second]). These latter devices will require temporary obstruction of the stream course for up to four hours during measurements.

A detailed flood analysis will refine previously-conducted flood studies (BGI and LETCo, 1983, ONWI-293, p. 20). It will include field reconnaissance, surveys of stream channel cross sections, and analytic studies.

A low-flow analysis will be conducted to define the relationship between ground-water discharge and stream flow in the vicinity of the dome (BGI and LETCo, 1983, ONWI-293, p. 20). The low-flow analyses will consist of streamflow measurements along selected streams during expected times of low-flow conditions.

The above tasks will be conducted within the area shown in Figure 3-1. Activities requiring sampling, analysis, and stream-flow measurements will be done in accordance with U.S. Geological Survey procedures (USGS, 1967; Riggs, 1972, 1982). Transportation to all sites will be by light vehicle on existing roads or by foot.

4.1.1.1.2 Multiple Aquifer Hydronests. Hydrostratigraphic data in the site vicinity are needed to confirm and define more precisely the regional ground-water flow regime. Test data will be collected for the major regional aquifers at six well sites within 6 kilometers (4 miles) around the edge of Richton Dome (Figure 4-1). Planning of the final location and number of these wells will incorporate discussions with the State of Mississippi and the U.S. Geological Survey (BGI and LETCo, 1983, ONWI-293) along with requirements of recent ground-water modeling (Ertec, 1983, ONWI-456). Each well site will consist of nine wells: one production and two observation wells drilled into and completed in each of the three major aquifer units. These wells will range in depth from 150 to 2,195 meters (500 to 7,200 feet). At least one well at each site will be cored through the stratigraphic intervals to be tested. Downhole geophysical logging and a series of hydraulic tests will be performed during and at the completion of drilling. Drilling, testing, and site restoration activities will be performed by the methods described in Section 4.1.1. After drilling and testing have been completed, these wells will be monitored as described in Section 4.1.1.1.4. Temporary production wells will supply water at each drill site.

Multiple aquifer hydronest sites will occupy approximately 6 hectares (15 acres) each. Drilling and testing at each site will be accomplished utilizing one platform drill rig and one large truck-mounted drill rig. Major facilities at each site will include the following:

- Drilling rigs and auxiliary equipment:
  - Platform drill rig with a 40-meter (130-foot) mast using propane engines to power the drawworks, the drilling fluid circulation pumps, and the electrical generator. Total drilling configuration is operated on 597 kilowatts (800 horsepower).
  - Large truck-mounted drill rig with a 30-meter (97-foot) mast using diesel engines to power the drawworks, the drilling fluid circulation pumps, and the electrical generator. Total drilling configuration is operated on 672 kilowatts (900 horsepower).

- Auxiliary equipment for each of the above rigs:

  - Mud tanks or pits - a minimum of two 75-barrel (11,923-liter [3,150-gallon]) steel tanks or pits constructed for drilling fluid circulation

  - Solid waste storage area - one waste container or pit

  - Equipment laydown and storage areas

  - Supervisory quarters, offices, and lab space - up to nine trailers

  - Blowout preventers: one annular-type blowout preventer, one ram-type blowout preventer, one hydraulically operated preventer control unit, and one rotating head

  - Fluid storage tanks - two 500-barrel (79,485-liter [21,000-gallon]) steel tanks.

The 2 drill rigs will be operating simultaneously at each hydronest site. Three sites will be drilled concurrently in each of two 6-month periods A work force of 54 people (18 per shift) is expected at each multiple-well site.

4.1.1.1.3 Shallow Aquifer Hydronests. Data on the hydrostratigraphic characteristics of the shallow aquifer for the investigation of the dome area condition will be acquired by drilling. Five shallow aquifer hydronests and one observation well will be placed around the perimeter of the surface facilities area to provide data on the hydrostratigraphic characteristics of the shallow aquifer. These wells will be located over the dome at six sites as shown in Figure 4-1. The depth of the shallow aquifer hydronests and observation well will be between 150 to 244 meters (500 to 800 feet). Undisturbed samples will be taken of the stratigraphic interval to be hydrologically tested. Drilling, aquifer testing, geophysical logging, and site restoration will be performed in accordance with procedures defined in Section 4.1.1.

Each hydronest site would occupy approximately 4 hectares (10 acres). Major facilities at each drill site would include the following:

- Drilling rig and auxiliary equipment

  - A large truck-mounted drilling rig with a 30-meter (97-foot) mast using diesel engines to power the drawworks, the drilling fluid circulation pumps, and the electrical generator. Total drilling configuration is operated on 672 kilowatts (900 horsepower).

- Mud tanks or pits - A minimum of two 75-barrel (11,923-liter [3,150-gallon]) steel tanks or pits constructed for drilling fluid circulation.

- Solid waste storage area - One waste container or pit.

- Equipment laydown and storage areas

- Supervisory quarters, offices, and lab space - Up to nine trailers

- Blowout preventers:

  - One annular type blowout preventer
  - One ram-type blowout preventer
  - One hydraulically operated preventer control unit
  - One rotating head

- Fluid storage tanks - Two 500-barrel (79,485-liter [21,000-gallon]) steel tanks.

One drill rig will operate to complete one hydronest per month during each of two 3-month periods. A work force of 27 people (9 per shift) is expected at each hydronest site.

4.1.1.1.4 Monitoring and Sampling of Wells for Water Quality. Subsurface water levels and samples will be obtained from a number of existing DOE program wells, existing nonprogram (domestic) wells, and from numerous monitoring wells to be drilled (Table 4-2). Well sampling and monitoring will be performed in accordance with U.S. Geological Survey procedures (USGS, 1967) and in accordance with applicable regulations. Initially, samples will be taken to establish baseline conditions. Subsequently, water levels will be measured and water samples collected every 3 months during site characterization. Fresh water pumped from wells during sampling will be discharged into existing drainages in compliance with applicable regulations. Saline water pumped from wells will be collected for offsite disposal, in accordance with applicable standards.

Ground-water samples from the existing DOE and domestic wells, together with the water samples and aquifer materials from the proposed site characterization hydrologic test wells, will be analyzed to evaluate the chemical characteristics of rock and water at the site. This study is expected to assist in identification of ground-water recharge areas, residence times, an understanding of rock and water interactions, a basis for evaluating radionuclide retardation, and sources of salinity. Only access by light vehicle over existing routes will be required for sampling existing wells. Ongoing monitoring and sampling of newly drilled wells will only require access, in addition to effects described under drilling activities.

If any saline anomalies are detected during the monitoring period, one or more wells may be installed in the proximity of the anomaly to expand the monitoring data base in this area. One domestic well was reported to contain high concentrations of total dissolved solids (BGI and LETCo, 1983, ONWI-293, pp. 2-3 through 2-5) and is discussed in Section 3.2.5.7. Locations of saline anomaly monitoring wells would be based on surface resistivity surveys that would involve light brush clearing.

4.1.1.1.5 Surface Geologic Mapping. The objective of this mapping is production of detailed surficial geologic maps of the dome area and access routes. It will consist of field mapping all bedrock outcrops and surficial deposits. Ancillary activities may include use of survey crews to locate specific points of interest, hand-level surveys, trenching, and shallow hand-auger probes. Maps will be made on topographic base maps at a scale of either 1:480 (1 inch = 40 feet) or 1:1,200 (1 inch = 100 feet). Land access within the geologic mapping area for the dome (Figure 4-1) will entail using light-weight field vehicles on existing roads, or by foot where roads do not exist. If trenching is done, access by a backhoe or bulldozer will be required.

4.1.1.1.6 Flank Stratigraphic Boreholes. Seven boreholes will be drilled to study the stratigraphic and geologic characteristics of rock formations adjacent to the salt stock. Possible locations of these boreholes are shown in Figure 4-1. The depths of the boreholes will be approximately 1,000 meters (3,300 feet). Each flank stratigraphic borehole will be cored and sampled and geophysically logged for the total depth of the hole. Single-well aquifer testing (e.g., slug withdrawal, drill-stem test) may be performed. The proposed site preparation, drilling, testing, and site restoration phases of this activity will be performed as described in Section 4.1.1.

Drilling equipment needed to complete these boreholes is as described for the shallow aquifer hydronests in Section 4.1.1.1.3. One large truck-mounted drill rig will consecutively complete one borehole every 3 months over a 21-month period.

4.1.1.1.7 Overdome Stratigraphic Boreholes. At least six boreholes will be drilled to study the dome area stratigraphy and structure and to examine the caprock-salt interface. The proposed locations are shown in Figure 4-1. The completion depth of each hole will depend on its exact location over the dome but is expected to be about 150 to 400 meters (495 to 1,310 feet). Each hole will be cored and an appropriate suite of geophysical logs will be run. Hydrologic tests as described in Section 4.1.1.1 may be performed in selected holes. The proposed site preparation, drilling, testing, and reclamation phases of this activity will

be as outlined in Section 4.1.1. Drilling sites will be located based upon available information developed by geophysical means.

Drilling equipment needed to complete each of these boreholes is as described for the shallow aquifer hydronests in Section 4.1.1.1.3. Two large truck-mounted drill rigs operating simultaneously will each complete one borehole every 4 months over a 1-year period.

4.1.1.1.8 Microseismic Network. A seismic monitoring network will be installed to record possible microearthquake activity in the vicinity of Richton Dome and in the broader region around the dome. The network will have approximately 40 seismograph stations. Data from the network will be analyzed to determine the locations and characteristics of any microearthquakes observed. The microearthquakes will be evaluated to assess their possible relations to faults and to help characterize the current tectonic environment around the dome.

Each seismograph station will consist of a small (1-square-meter [10-square-foot]) concrete pad supporting a shelter for battery-powered electronic instruments, a seismometer placed in the ground, and an antenna 6 to 9 meters (20 to 30 feet) high for a low-powered directional radio transmitter. The seismometer will be either buried 0.3 to 0.6 meter (1 to 2 feet) in the soil or placed at the bottom of a small-diameter borehole approximately 30 meters (100 feet) deep.

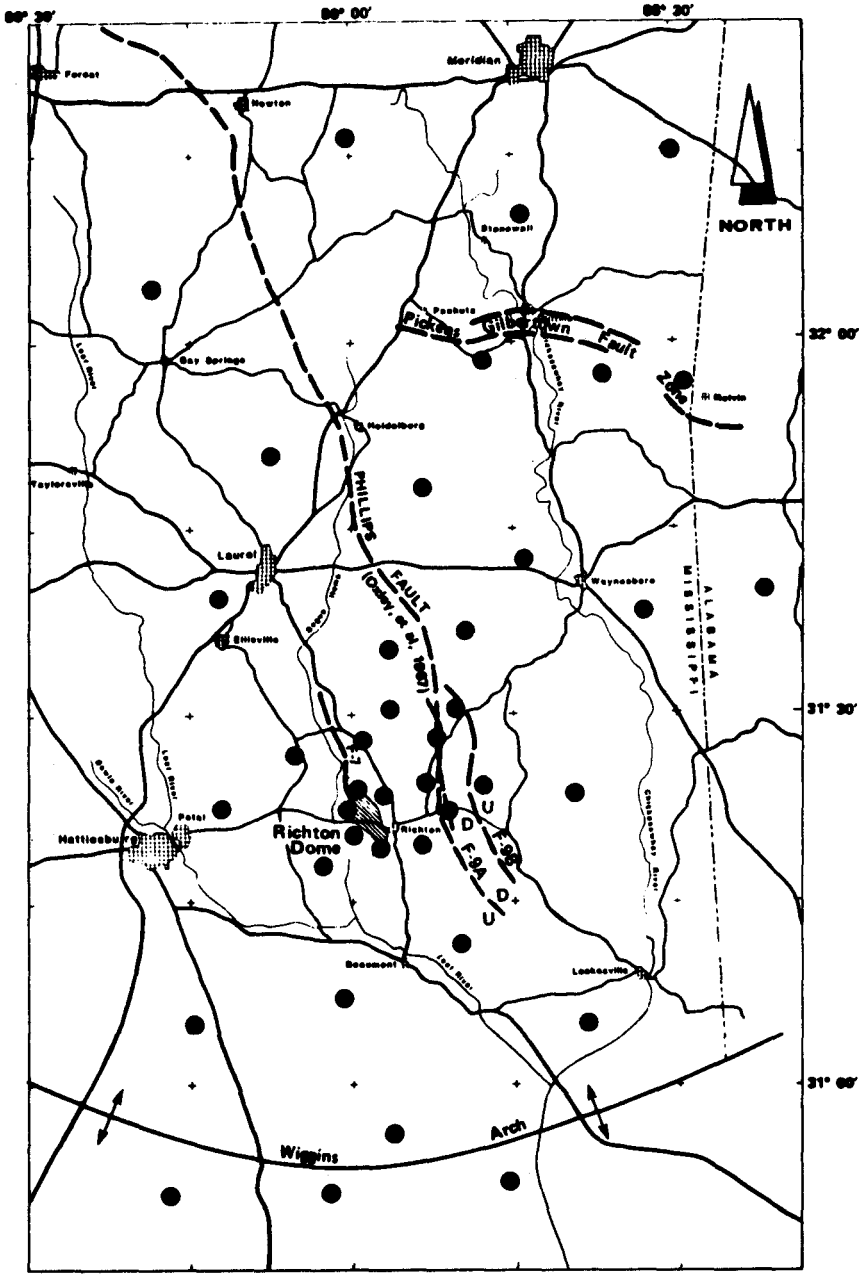
Exact station locations have not been determined, but preliminary estimates have been made. One possible arrangement, shown in Figure 4-4, will provide detailed coverage near the dome as well as more regional coverage to the north and south. The southern end of the Phillips Fault and the F-9a and F-9b faults lie 8 to 16 kilometers (5 to 10 miles) east of Richton Dome. LETCo (1982, ONWI-120) described the F-7 Fault as trending northwest from the west flank of Richton Dome. These faults are described in Section 3.2.5.1 and shown on Figures 3-14 and 3-15. Seismograph stations are more densely distributed in this area to record any possible microearthquake activity to the north of the Pickens-Gilbertown Fault Zone and the Phillips Fault, and to the south of the Wiggins Arch. The Wiggins Arch is a possible source of small earthquakes because it may be undergoing uplift. Some small earthquakes have occurred in the vicinity of the Pickens-Gilbertown Fault Zone. Final station locations will be determined according to actual field conditions based on a calibration-shot survey.

4.1.1.1.9 Seismic Reflection and Refraction Surveys. A 2-D seismic reflection technique will be used to investigate dome-area structure and dome configuration. Approximately 148 kilometers (92 miles) of reflection lines are planned over and adjacent to the dome. Dual precision data acquisition will be employed directly over and immediately adjacent to the dome.

Regional structural features will be evaluated with additional seismic reflection lines. Reflection lines totaling 101 kilometers (63 miles) will be located to investigate the Phillips Fault, the F-9A and F-9B faults, the Pickens-Gilbertown Fault, and the F-7 Fault (Figure 3-15). Actual seismic reflection lines will be located to minimize cultural disturbance.

Four short refraction surveys, each about 0.8 kilometer (0.5 miles) long, will be run in the vicinity of the exploratory shaft facility to determine, for engineering purposes, shallow seismic velocities. These surveys will use hand-portable equipment, two light trucks and a four-person crew. Disturbance will be limited to walking and driving along the lines. The seismic energy source will be a weight drop, blasting cap, or rifle bullet impact.

Geophone lines will be spaced over the dome about 30 meters (100 feet) apart. These lines will require clearing strips of land about 3 meters (10 feet) wide of bush and obstacles, so the geophones can be placed temporarily in the ground and locations surveyed. Energy-source lines will be spaced about 300 meters (1,000 feet) apart along selected geophone lines or on a perpendicular grid. Some minor grading and leveling may be required to provide access for the heavy vehicles. Existing roads and trails will be used where possible. Total cleared land will be approximately 150 hectares (380 acres). If explosives are used for energy source, holes less than 8 meters (25 feet) will be drilled and loaded with explosive



Explanation

- Perennial streams
- Anticline referenced in text
- Faults referenced in text
- Roads
- Proposed location of microseismic monitoring stations

Scale

0 10 20 km

0 10 20 mi

Source: Oxley et al., 1968; LETCo, 1982, ONWI-120.

Proposed Location of Microseismic Monitoring Stations Richton Dome

Figure 4-4

charges less than 5 kilograms (10 pounds). Localized heaving of soil might occur. Truck-mounted vibrators can vibrate on the roads and trails on 15-meter (50-foot) intervals with little disruption other than temporary noise.

Some hole-to-hole seismic surveys may be performed. These surveys will only require surface access to get to the drill hole locations. A hole-to-hole surface survey may be run over the dome. Access would be to sites developed for other seismic reflection work.

4.1.1.1.10 Potential Field Survey. A hole-to-surface resistivity survey may be performed in the engineering design borehole (before casing) as one way to examine the overdome stratigraphy (the method does not apply to the salt stock itself). This survey will require a truck-mounted winch and electrical generator at the borehole. Measurements will be made within a grid about the borehole, approximately 1.6-kilometer by 1.6-kilometer (1-mile by 1-mile) with lines 75 to 100 meters (250 to 500 feet) apart using the lines cleared of brush for the detailed seismic survey of the site, discussed above. Two copper electrodes will be inserted into the ground every 30 to 61 meters (100 to 200 feet), to measure the electric potentials.

The hole-to-surface resistivity survey shall be performed before the hole is cased and after the first full suite of geophysical logs has been run.

Additional gravity and magnetic surveys will be conducted to better resolve the configuration and structure of the dome. Gravity measurements will be made at approximately 20-meter (66-foot) intervals. Readings will be taken using a portable gravimeter and a portable magnetometer. Some brush cutting may be required to provide line of sight access for surveying station elevation determinations. Existing roads and trails will be used to gain access to gravity station locations.

4.1.1.1.11 Sulfur Exploration Wells. Thirty-four sulfur exploration wells, ranging in depth from 180 to 570 meters (600 to 1,880 feet) were drilled into the caprock and the uppermost portion of the salt stock at Richton Dome during the early 1940s (Figure 3-12). Of the 34 sulfur exploration wells drilled into the caprock, at least 8 penetrated salt. All were backfilled or plugged by unrecorded methods. This activity will first attempt to locate and assess the general conditions of the sulfur exploration wells. If a well is found to be in poor condition, one or more boreholes may be reentered, and geophysical measurements will be taken. The wells will then be plugged in accordance with State regulations. Drilling activities specified above will be performed in accordance with guidelines established in Section 4.1.1.

4.1.1.1.12 Borehole Search and Characterization. A search will be conducted for unrecorded wells within the site vicinity. Those that could have a potential impact on the stability of the repository may need to be reentered for testing and evaluation. No such boreholes are thought to exist at the site. Search techniques may include review of state and local drilling records, review of historical newspaper accounts and aerial photographs, door-to-door surveys, discussions with various historical societies, and possible walking of portions of the site with hand-held metal detectors. If an abandoned well is discovered, it may be necessary to excavate the well bore to gain additional information about hole conditions. Remedial measures or borehole plugging may require disturbance of a few acres.

4.1.1.2 Engineering Design Studies

Certain activities are directly related to design, construction, and testing of shafts and underground facilities. Activity requirements are summarized in Table 4-2. The proposed schedule for field activities is presented in Figure 4-2.

4.1.1.2.1 Engineering Design Borehole (EDBH). Each of two EDBHs will consist of a 15-centimeter-(6-inch) diameter borehole and will provide overburden samples and a continuous 10-centimeter-(4-inch) diameter core along the centerline of the exploratory shafts through the caprock and into the salt stock, to a total depth of approximately 700 meters (2,300 feet). Borehole geophysical testing will be performed. Aquifer tests consisting of

drill stem and packer tests will be performed at selected intervals during drilling. Water for drilling the EDBHs will be provided by two shallow water-supply wells drilled into the Upper Aquifer Unit to a depth of 75 to 110 meters (250 to 350 feet). Site preparation, drilling, testing, and reclamation will be as outlined in Section 4.1.1.

Two platform drill rigs will operate simultaneously. Drilling and completion will require 3 months. The work force on site is expected to be approximately 27 people (9 per shift). Approximately 4 hectares (10 acres) within the exploratory shaft facility area is required for each drill site. The drill rigs and equipment needed to complete each of these boreholes is as described for the platform rig in Section 4.1.1.1.2.

4.1.1.2.2 Early Foundation Design, Surface Facilities, Access Routes, and Utility Foundation Borings. Approximately 50 foundation boreholes for shaft facility design and about 400 foundation boreholes will be drilled within the area proposed for the surface facilities (Figure 4-1). The boreholes will be rotary drilled or augered and conventionally sampled using split spoon and Shelby Tube samples. The borings will extend from 3 to 60 meters (10 to 200 feet) in depth. Cone penetrometer tests (CPT) will be placed between borings to provide in situ measurements of soil properties (Krynine and Judd, 1957, p. 214).

Foundation borehole drilling will require little if any site preparation and cause minimal ground disturbance. A light truck-mounted rig will move between boreholes over the existing ground surface and will not require access roads or drill site preparation. For rotary drilling, water trucks or a small pit 1.5 meters x 3 meters x 1 meter deep (5 feet x 10 feet x 3 feet deep) dug next to the rig will be used for a water supply.

The boreholes will be drilled at locations beneath the proposed structure of the surface facilities, along proposed access routes and utility routes, and adjacent to the exploratory shaft facilities. In most cases, borings for a particular structure are several meters (tens of feet) apart and groups of borings for different structures are hundreds of feet apart. Twenty percent of the foundation holes will be 100 percent sampled.

4.1.1.2.3 Topographic Mapping. Aerial photography and ground surveys will be performed to provide detailed topographic maps at a scale of 1 inch = 40 feet for the site area and the access route. Ground control points will be located temporarily at about 40 positions in the site area. The specific number and location of points will depend on the flight lines for aerial photography and the accessibility and extent of roads. The control points will be surveyed by a surveying crew and will not require site preparation. Some brush cutting may be required to provide line of sight.

4.1.1.2.4 Freeze Wall Design Boreholes. Ten boreholes will be drilled to the caprock adjacent to the shaft locations. Hydrologic data necessary for design input for the ground freezing operation will be gathered. This method will be used to form an ice curtain around the shafts before they are excavated and lined through the Upper Hydrostratigraphic Unit. Information will be gathered from borehole samples for appraisal of effects upon the thermal and hydrologic properties of the rocks. The ten holes will help to define material variability surrounding the shafts.

Drilling equipment needed to complete each of these wells is as described for the shallow aquifer hydronests in Section 4.1.1.1.3. Two large truck-mounted rigs will be operating concurrently over a 5-month period.

4.1.1.2.5 Water Supply Wells. Two water-supply wells will be drilled near the two shaft sites. These wells will be used to supply drilling water for the engineering design boreholes and other nearby boreholes. Two small truck-mounted rigs will be used to complete these wells in 1 month.

4.1.1.2.6 Shaft Monitoring Wells, Exploratory Shaft Facility Monitoring Wells, and Repository and Surface Facility Monitoring Wells. Six shaft monitoring wells may be drilled within a 61- to 152-meter (200- to 500-foot) radius of the EDBH boreholes. They will penetrate the Upper Hydrostratigraphic Unit from 150 to 244 meters (500 to 800 feet) in depth.

Aquifer tests will be conducted to measure hydraulic properties and interconnection of units within the upper aquifer system over the dome. Sampling and monitoring of ground-water wells will be conducted as described in Section 4.1.1.1.4. Because drilling of the shaft monitoring wells will use the EDBH drill pads, no construction of new access roads is required.

Drilling equipment needed to complete each of these wells is as described for the shallow aquifer hydronests in Section 4.1.1.1.3. Two large truck-mounted rigs will be operating concurrently over a 3-month period.

Thirty additional wells will be drilled within the 28 hectares (68 acres) of the exploratory shaft facility area. The 30 exploratory shaft facility monitoring wells are designed to record baseline conditions and to monitor potential local changes in the Upper Hydrostratigraphic Unit that might result from shaft construction. Approximately 100 wells will be installed within the 165 hectares (407 acres) of the repository and surface facility area to establish baseline conditions and to monitor ground-water quality and water levels, should the site be chosen as a repository. A small truck-mounted rig will be used to complete these wells.

Potential scopes of these activities are indicated on Table 4-2. Specific locations for most of the monitoring wells will be developed based on final site-design layouts for specific facilities. Minor brush clearing may be necessary, but no additional road construction is expected.

4.1.2 Exploratory Shaft Facility (ESF)

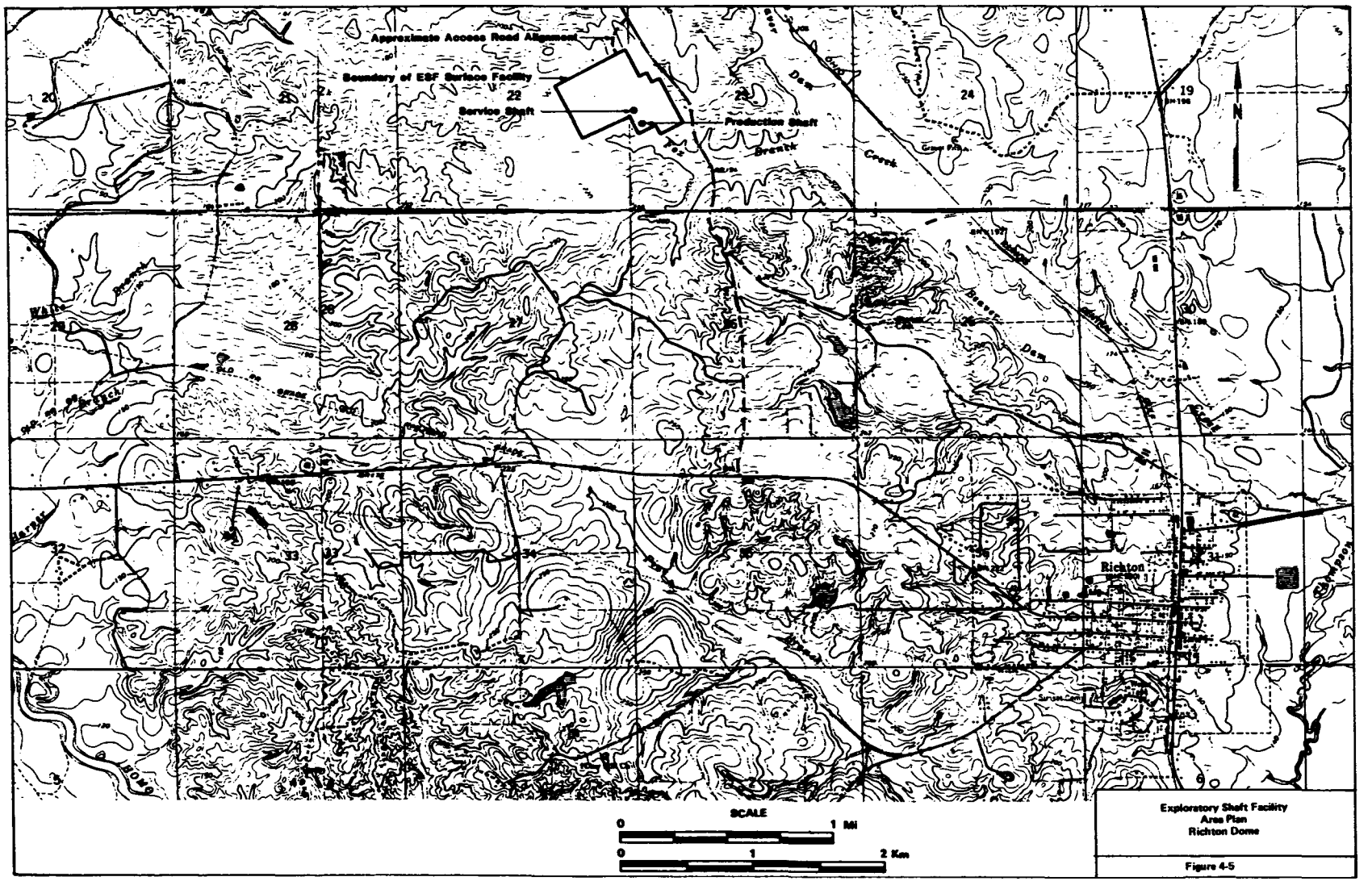
The exploratory shaft facility (ESF) is to be constructed to gain access to the potential repository salt horizon and to perform in situ tests for site characterization (PB/PB-KBB, 1985; 1986). The facility will consist of two shafts: the production shaft and the service shaft. The service exploratory shaft is required for personnel transport (Section 4.3.2) and ventilation. Both shafts will be constructed by conventional shaft sinking techniques and each will have a finished diameter of 3.6 meters (12 feet). The underground excavation totals approximately 1,597 linear meters (5,240 linear feet) necessary for subsurface testing. The remainder of this section is based on a preliminary-level design that reflects compliance with "gassy" mine regulations. The ESF design elements are conservative in nature and will be finalized upon completion of engineering boreholes described in the previous section.

The ESF site will occupy approximately 28 hectares (68 acres) (Figure 4-5). Access to the ESF site will be from the nearest paved, two-lane road (a county road off Mississippi State Highway 42). The access road will be approximately 0.4 kilometer (0.25 mile) in length.

The exploratory shaft facility (Figure 4-6) will be arranged to accommodate the following:

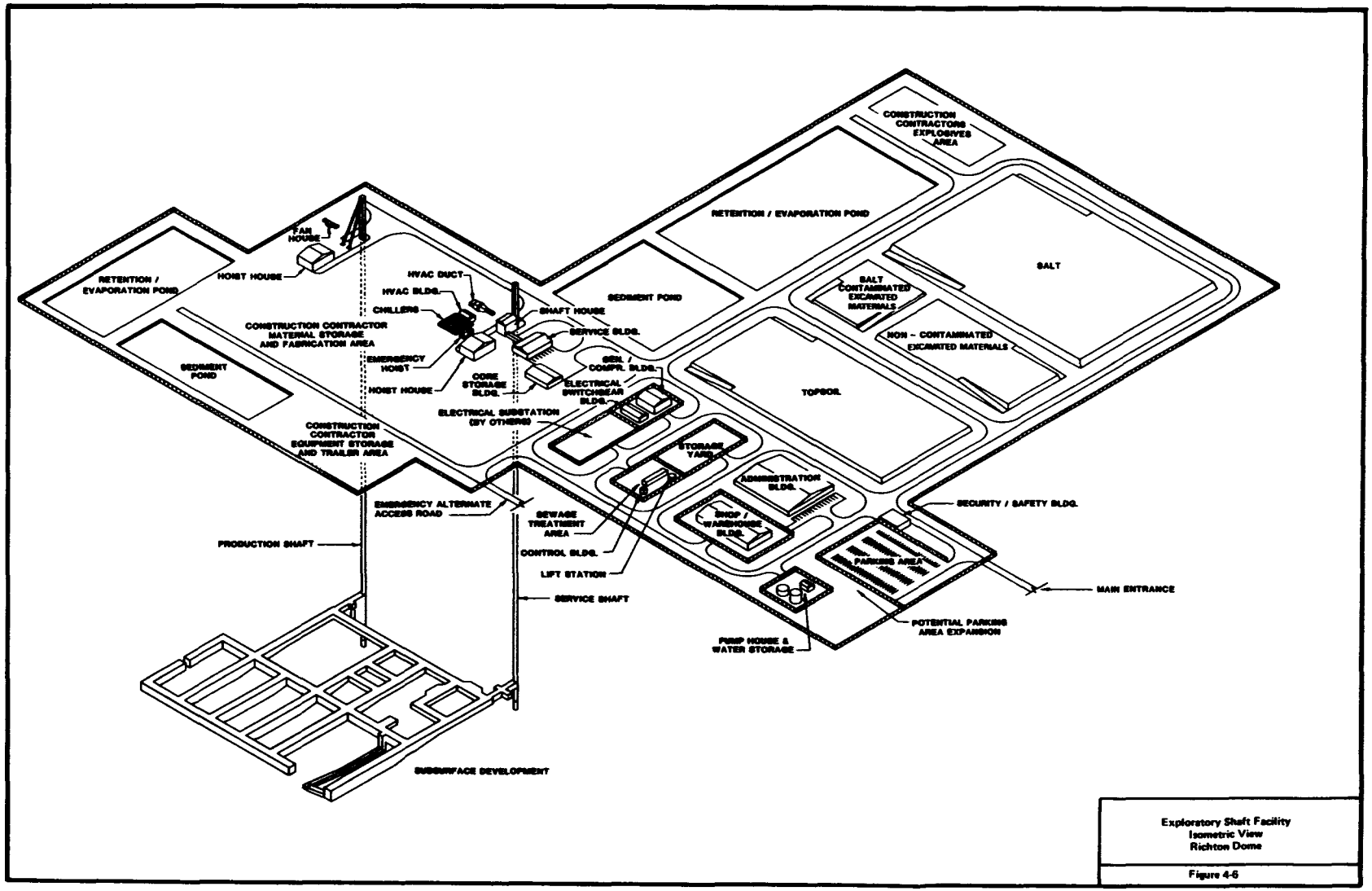
- The simultaneous construction of two shafts
- Onsite construction management
- Consolidation of all excavated wastes into one area for ease of handling, maintenance, and control of salt-contaminated material.

The ESF site will be enclosed by a 2.1-meter-(7-foot-) high chain link security fence that will be constructed along the outside perimeter. All traffic to and from the ESF site will be directed through the main access roadway via the security building located near the parking area. An alternate access roadway is provided near the shaft working area for emergency use only and shall normally be kept closed. A perimeter roadway to provide additional security control and emergency access to the ESF site will be considered in final design. The ESF site arrangement has been designed to do the following:



Exploratory Shaft Facility
Area Plan
Richton Dome

Figure 4-5



Exploratory Shaft Facility
Isometric View
Richton Dome

Figure 4-6

- Fit the natural contour of the land as closely as possible and practical, and minimize erosion and sedimentation within and around the site
- Minimize clearing and disturbance
- Restrict grading to requirements for structures and facilities, roadways, parking areas, utilities, drainage ditches, and surface storm-water runoff control.

4.1.2.1 Land Requirements

The total amount of land required for the Richton ESF and parking lot is approximately 28 hectares (68 acres). This does not include land approximately 0.74 hectare (1.8 acres) needed for a 7.3-meter-(24-foot-) wide, 0.4-kilometer-(0.25-mile-) long access roadway with an 18-meter (60-foot) right-of-way to connect with the county road off of Mississippi State Highway 42. These land requirements will be confirmed during final design.

The ESF site will be supplied with commercial power from existing power supplies to the site. The transmission lines will be the type which run along existing roadways, thereby reducing the amount of additional land required for construction and associated environmental impacts.

The Richton ESF is located on privately owned land. The DOE will obtain the needed access by purchasing surface and subsurface rights to at least 28 hectares (68 acres). To gain access to the exploratory shaft facility site, rights-of-way, or other appropriate interest, will be obtained from private landowners. Boundary surveys and establishment of construction survey monuments will be part of the activities leading to the above agreements.

4.1.2.2 Construction

ESF construction will have the following stages: site preparation, shaft and surface facility construction, shaft outfitting, and underground excavation. A summary of the exploratory shaft project characteristics is provided in Table 4-3.

The estimated schedules for construction and testing activities and for reclamation are summarized in Figures 4-7 and 4-8, respectively. The estimated average number of personnel at the site during each construction and testing phase is listed in Table 4-4.

The phasing of construction activities determines those periods when the environmental impact of site operations may be the greatest. Table 4-5 identifies 15 discrete periods defined by different sets of concurrent construction activities during the construction and testing operation. Table 4-5 lists the peak cumulative horse-power usage by period. From this, two conservative cases have been identified which have been used as a basis for the air quality impact analysis presented in Section 4.2.1.3.

4.1.2.2.1 Site Preparation. Construction activities are initiated with construction surveys and establishing field monuments. The types and amounts of equipment needed for ESF site preparation and construction of the access road are shown on Table 4-6. Estimated resources consumed during site preparation are shown in Table 4-7. Access road construction consists of the development of a 0.4 kilometer (0.25 mile) access roadway from the nearest existing hard-surfaced, two-lane public road (a county road off Mississippi State Highway 42) to the entrance of the ESF site. The 18-meter (60-foot) right-of-way selected will require approximately 0.74 hectare (1.8 acres) of additional land.

Construction will begin as soon as possible so that equipment for shaft collar work and freeze hole drilling can be delivered and these construction activities can proceed.

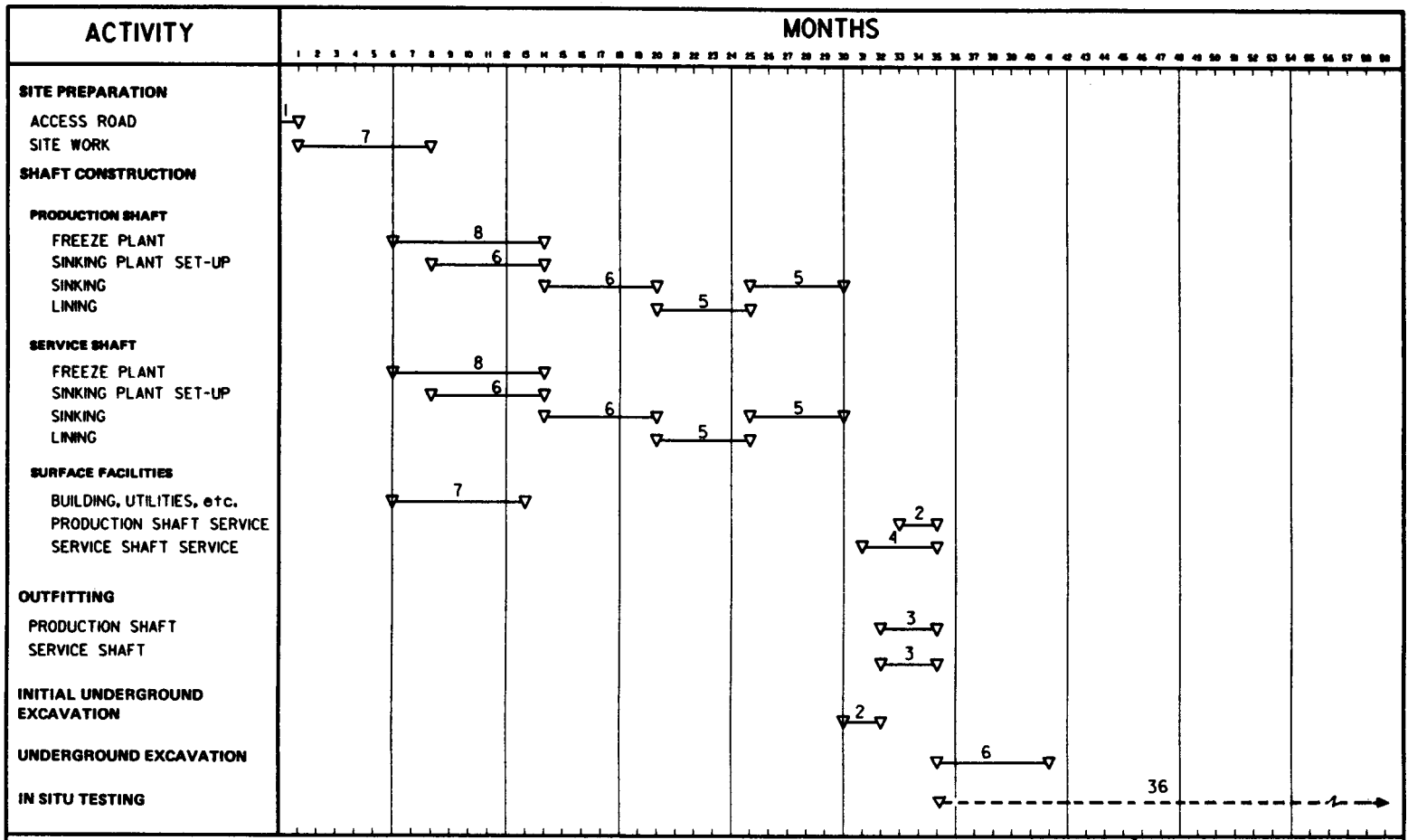
Table 4-3. Exploratory Shaft Project Characteristics, Two 12-Foot Conventionally Mined Shafts

Construction Detail	Approximate Quantitative Description[a]
Surface area for exploratory shaft activities	68 acres
Conventionally mined shafts:	
Finished diameter	12 feet
Lining depth	1,070 feet
Total shaft depth	
Production shaft	2,200 feet
Service shaft	2,120 feet
Depth to shaft stations	2,085 feet
Horizontal workings at base of shafts	5,240 feet
Initial excavation and connection drift between shafts	800 feet
Expanded excavation	4,440 feet
Access road (length)	0.25 miles
Access road (width)	24 feet, 4-foot shoulders
Access road right-of-way (width)	60 feet
Highest structure (headframe)	125 feet
Electric power source	Offsite commercial electric power
Standby power	Three 800-kW diesel fired generators
Capacity of excavated material storage pile areas	
- Noncontaminated	26,000 cu yd
- Salt-contaminated	8,000 cu yd
Capacity of salt storage pile area	201,000 cu yd
Capacity of topsoil storage pile area	79,000 cu yd
Material excavated	164,000 cu yd
- Noncontaminated	22,000 cu yd
- Salt-contaminated	6,000 cu yd
- Salt	136,000 cu yd
Maximum height of salt and other spoil piles	25 feet
Capacity of evaporation/retention ponds	13.1 million gallons

Table 4-3. Exploratory Shaft Project Characteristics
(Page 2 of 2)

Construction Detail	Approximate Quantitative Description[a]
Capacity of sediment detention basins	7.6 million gallons
Surface facilities (total) - Prefabricated building units	70,000 sq ft (approx.)
Foundations	Concrete slabs for prefabricated building units, concrete footings for shaft collar and shaft hoisting equipment
Total freshwater demand	172 acre-feet (55.9 million gallons)

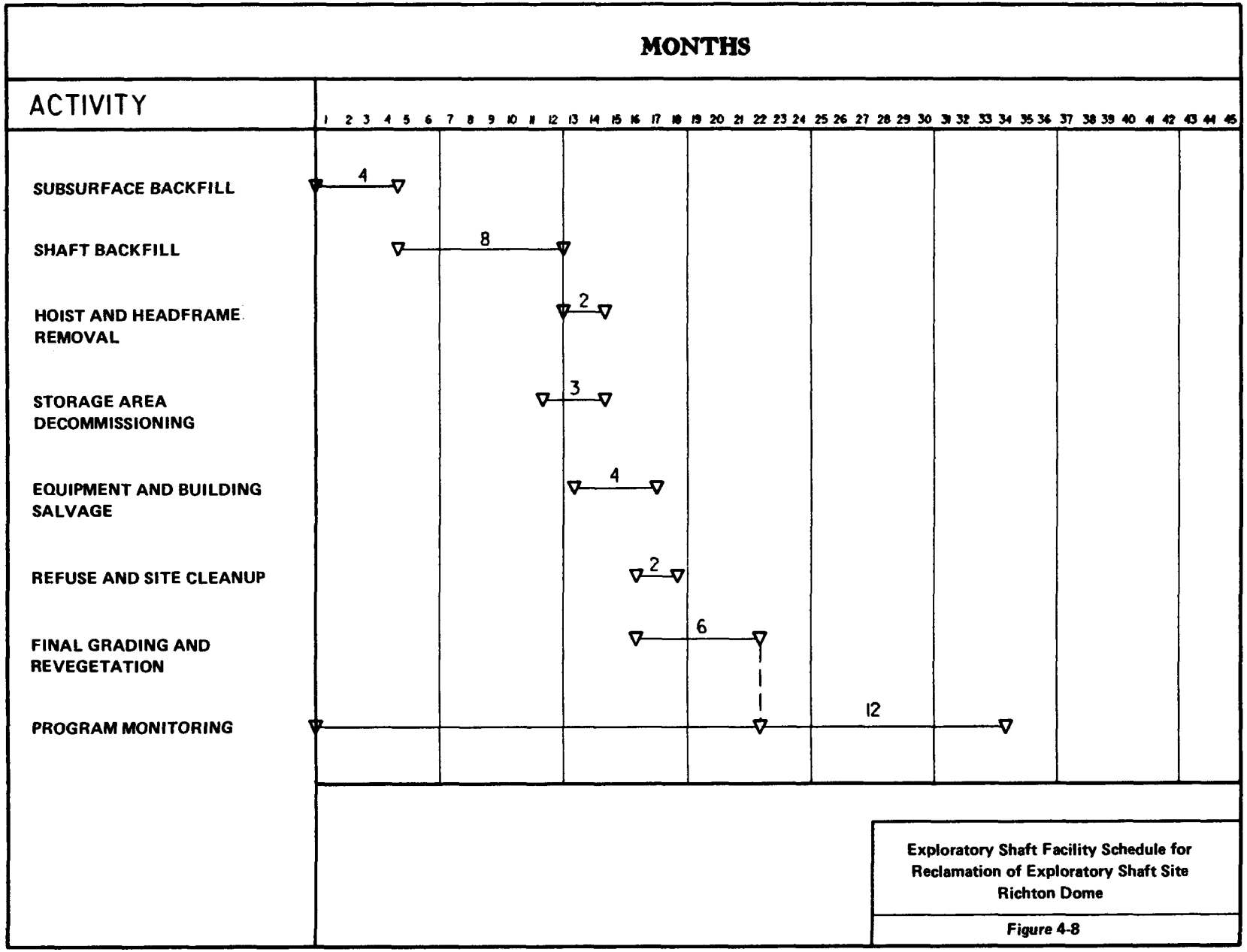
(a) Exploratory shaft site parameters are based upon preliminary design information. Site-specific data used for final design may change these.



Sources: PB/PB-KBB, 1986; McIntosh, 1986.

Exploratory Shaft Facility Construction/Testing Schedule Richton Dome

Figure 4-7



Exploratory Shaft Facility Schedule for Reclamation of Exploratory Shaft Site Richton Dome

Figure 4-8

Table 4-4. Estimated ESF Personnel Requirements, Richton Dome

Exploratory Shaft Facility Phase	Number of Personnel (average)[a]
Site preparation	160
Shaft and surface facility construction/outfitting	290
Initial underground excavation	245
Expanded underground excavation	280
Testing	230
Final disposition	100

(a) Includes contractor and noncontractor personnel.

Table 4-5. Concurrent Construction Activities, Richton Dome ESF Site

Period	Month	Tables Used	Peak Cumulative hp
1	1	Access Road (4-6)	2,970
2	2-6	Site Work (4-6)	4,775
3	7, 8	Site Work (4-6) Freeze Plant for Production Shaft (4-10) Freeze Plant for Service Shaft (4-10) Surface Facility Construction (4-10)	12,054
4	9, 10	Freeze Plant for Production Shaft (4-10) Sinking Plant Set-up for Production Shaft (4-10) Freeze Plant for Service Shaft (4-10) Sinking Plant Set-up for Service Shaft (4-10) Surface Facility Construction (4-10)	10,069
5	11-13	Freeze Plant for Production Shaft (4-10) Sinking Plant Set-up for Production Shaft (4-10) Freeze Plant for Service Shaft (4-10) Sinking Plant Set-up for Service Shaft (4-10) Surface Facility Construction (4-10)	4,069
6	14	Freeze Plant for Production Shaft (4-10) Sinking Plant Set-up for Production Shaft (4-10) Freeze Plant for Service Shaft (4-10) Sinking Plant Set-up for Service Shaft (4-10)	2,610
7	15-20	Shaft Sinking for Production Shaft (4-10) Shaft Sinking for Service Shaft (4-10)	2,240

Table 4-5. Concurrent Construction Activities, Richton Dome ESF Site
(Page 2 of 2)

Period	Month	Tables Used	Peak Cumulative hp
8	21-25	Final Lining Installation for Production Shaft (4-10) Final Lining Installation for Service Shaft (4-10)	2,240
9	26-30	Shaft Sinking for Production Shaft (4-10) Shaft Sinking for Service Shaft (4-10)	2,240
10	31	Initial Underground Excavation (4-11)	1,370
11	32	Service Facilities for Service Shaft (4-10) Initial Underground Excavation (4-11)	2,649
12	33	Service Facilities for Service Shaft (4-10) Outfitting Production Shaft (4-12) Outfitting Service Shaft (4-12)	2,109
13	34, 35	Service Facilities for Production Shaft (4-10) Service Facilities for Service Shaft (4-10) Outfitting Production Shaft (4-12) Outfitting Service Shaft (4-12)	3,131
14	36-41	Underground Excavation (4-13) Testing (4-15)	2,655
15	42-71	Testing (4-15)	900

Table 4-6. Equipment for Construction of Access Road and Site Preparation Phase, Richton Dome

Phase (Time Period)	Equipment No.	Equipment Name	Equipment hp	Peak Cumulative hp
SITE PREPARATION				
Access Road (1 month)	1	Dozer	300	300
	1	Grader	180	180
	2	Trucks	250	500
	1	Vibratory compactor	210	210
	1	Wheel loader	270	270
	1	Excavator	195	195
	1	Paver	145	145
	1	Scraper	450	450
	1	Water truck	250	250
	1	Oiler	200	200
	2	Pickup trucks	135	270
				2,970
Site Work (7 months)	1	Dozer	300	300
	2	Scrapers	450	900
	1	Grader	180	180
	8	Trucks	250	2,000
	1	Vibratory compactor	210	210
	1	Hydraulic excavator	195	195
	1	Wheel loader	270	270
	1	Water truck	250	250
	1	Oiler	200	200
	2	Pickup trucks	135	270
				4,775

Table 4-7. Estimated Resources Consumed During Exploratory Shaft Facility Activities, Richton Dome

Resource, Unit	Site Prep.	Shaft & Surface Facility Const.	Initial Underground Excavation	Shaft Outfitting	Underground Excavation	Testing	Final Disposition	Total Consumption
Diesel fuel, 1,000 gal	143	775	14	8	65	49	246	1,300
Natural gas, 1,000,000 scf (freeze hole drill rigs)	-	30	-	-	-	-	-	30
Electric energy 1,000 kWh	-	36,000	1,400	2,400	3,100	32,000	6,000	80,900
Water, 1,000 gal	1,800	20,000	860	1,100	1,100	16,000	15,000	55,860
Concrete, 1,000 yd^3	-	13	-	-	-	-	1	14
Plastic liner, 1,000 yd^2	270	-	-	-	-	-	-	270
Steel, tons	-	2,200	18	420	34	-	-	2,672
Blasting powder, 1,000 lb	-	110	13	-	-	-	-	123
Resin, 1,000 lbs.	-	57	13	2	54	-	-	126
Asphalt/Bitumen, tons	800	2,200	-	-	-	-	-	3,000
Gravel, 1,000 yd^3	16	-	-	-	-	-	-	16
Fertilizer, ton	-	-	-	-	-	-	2	2
Seed, 1,000 lb	-	-	-	-	-	-	3	3
Polymer Seal, 100 gal	-	-	-	-	-	-	32	32

The access road will be designed as an all-weather road with a 7.3-meter (24-foot) width (two 3.7-meter [12-foot] lanes) and 1.2-meter (4-foot) rounded shoulders on each side. The roadway will accommodate two-way traffic at an 80-kilometer-(50-mile-) per-hour design speed and will be designed to support a 14,500 kilograms (32,000 pounds) per axle loading. The roadway will have a 20-centimeter (8-inch) flexible base constructed of an acceptable material that is used locally for roadway base construction and has demonstrated strength and serviceability. The sub-grade will be prepared in place or constructed of a suitable material to provide a uniform, continuous, and permanent base support. The road will be surfaced and paved with asphalt.

A preliminary study of the surface hydrology indicates that the access road is located above the 500-year and probable maximum precipitation (PMP) floodplains. Major portions of the roadway are located on the high ground such that runoff from the adjacent drainage area is drained away from the roadway. No major drainage structures are required for the access roadway. One 61-centimeter (24-inch) CMP culvert is required where the proposed access road crosses the existing drainage ditch of the county road. Where the roadway crosses an established drainage course, the characteristics and flow elevations will be established to ensure a compatible design.

The roadway design will minimize environmental damage, present an acceptable appearance, and minimize the amount of necessary removal of surface terrain. This will be accomplished by limiting the removal of trees or alterations of other natural features. Natural land drainage patterns will be maintained to the maximum extent practical to ensure that the roadway does not impede the natural drainage pattern.

The access road will be designed to conform to applicable Federal, State, and local requirements and all applicable environmental standards. Grading will be arranged for safe and efficient traffic operations. The intersection of the access road and the existing roadway will comply with applicable Federal, State, and local alignment and sign regulations.

Commercial power sources will be used, with three diesel fired generators for emergency power. This will require a new power line to deliver electrical service from the utility-selected connect point to the site. Voltage requirements are for 69 kilovolts or more. A double pole structure as shown in Figure 4-9 will be used.

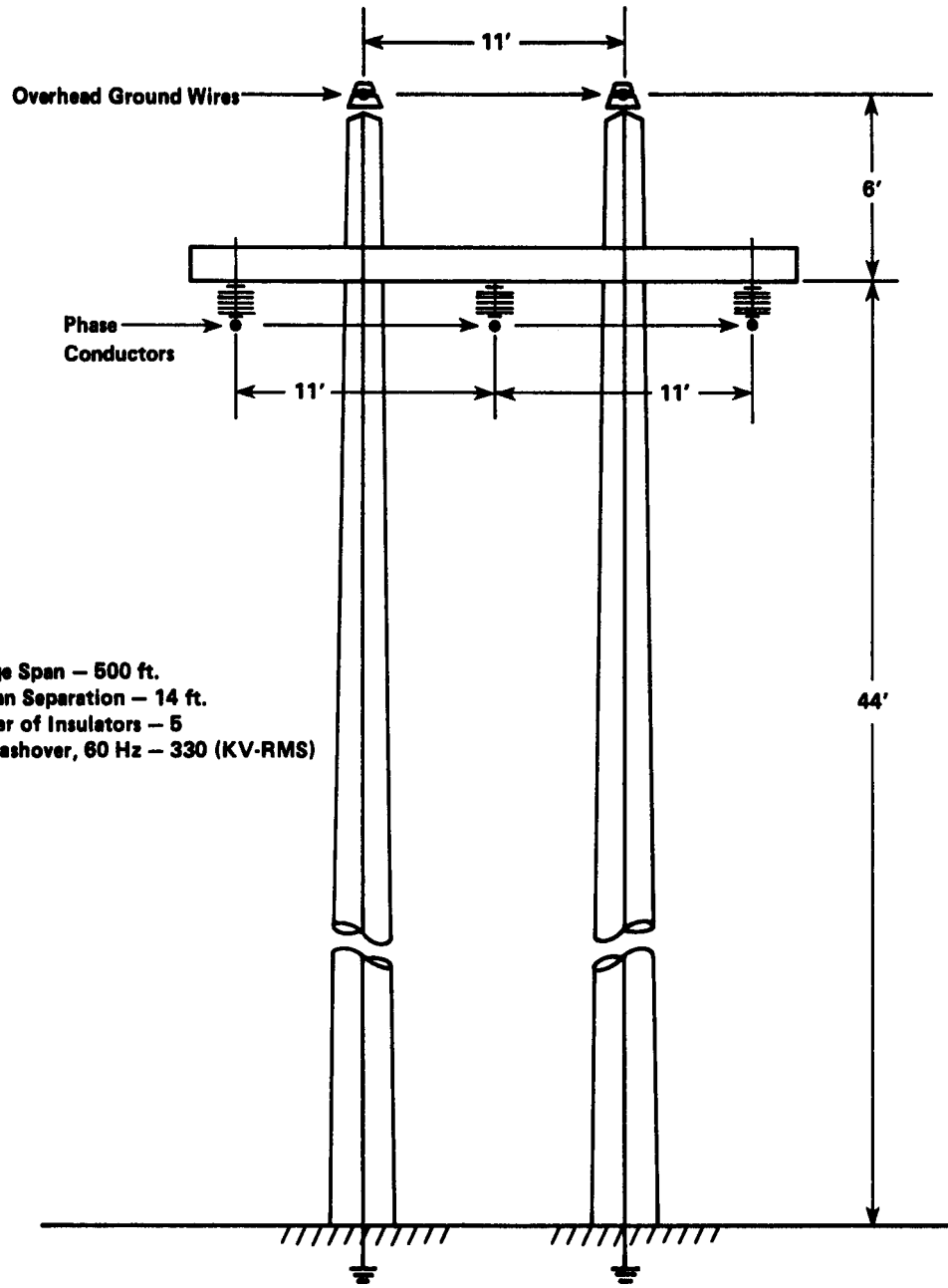
Due to the amount of ground cover and woody vegetation at the site, extensive cleaning will be required. Of the total 28 hectares (68 acres) of land required, 20 hectares (50 acres) will be disturbed during construction.

Prior to grading, about 15 centimeters (6 inches) of surface soil will be stripped and stockpiled. Rocky material, if any, will be removed and stockpiled separately.

Earthwork will be required to excavate the evaporation/retention pond, and sediment pond. Additional earth work will be required near the service buildings associated with each shaft to direct storm runoff away from the shafts. Suitable excavated materials will be used for the construction of site roads, fill area, and dikes. Other excavated materials will be stockpiled.

The average daily automobile round trips would increase from preproject levels to include approximately 150 passenger vehicles per day during the site preparation stage. Truck traffic is expected to increase by 380 truck trips per month. The estimated vehicular traffic during the ESF construction and testing phase is given in Table 4-8.

4.1.2.2.2 Shaft and Surface Facility Construction - Purpose of Shafts. The purpose of the exploratory shafts is to gain access to the potential repository horizon and perform in situ tests for site characterization. Shafts are excavated for a variety of purposes, including access to underground mining operations for extracting economic minerals or creating storage space. These shafts will also be used to circulate fresh air to the underground operations and contain conveyances for material or personnel handling requirements.



Typical Two-Pole Structure Capable of 69 Kilovolts

Source: Parsons Brinckerhoff/PB-KBB, 1984.

Figure 4-9

Table 4-8. Estimated Vehicular Traffic During ESF Construction and Testing Phase, Richton Dome

Phase[a]	Daily Automobile Round Trips[b]	Monthly Truck Round Trips
Site preparation	150	380
Shaft and surface facility construction	260	255
Initial underground excavation	220	95
Shaft outfitting	240	95
Expanded underground excavation	250	40
Testing	210	95
Final disposition	90	45

(a) Phases are as shown in the schedule appearing in Figure 4-7. When schedule phases overlap, truck traffic is additive; passenger vehicle traffic is not.

(b) Based on Table 4-4 and 1.1 persons per vehicle.

From the surface to its final depth, a shaft passes through many different rock types. Whereas strong rocks may not require any external support, unconsolidated or weakly cemented materials require some form of support to keep the shaft open. The rocks may either be completely dry, partially saturated or, when below the water table, saturated. Therefore, the shaft liner, in addition to supporting the rocks, also aids the seals in water inflow control to permit safe underground operations. This is especially critical in water-soluble evaporites such as rock salt and potash.

Conventionally mined shafts have been constructed to depths in excess of 3,049 meters (10,000 feet). Shaft depths of 915 meters (3,000 feet) are common for North American and European mining operations. South Africa and India have some of the deepest shafts in the world.

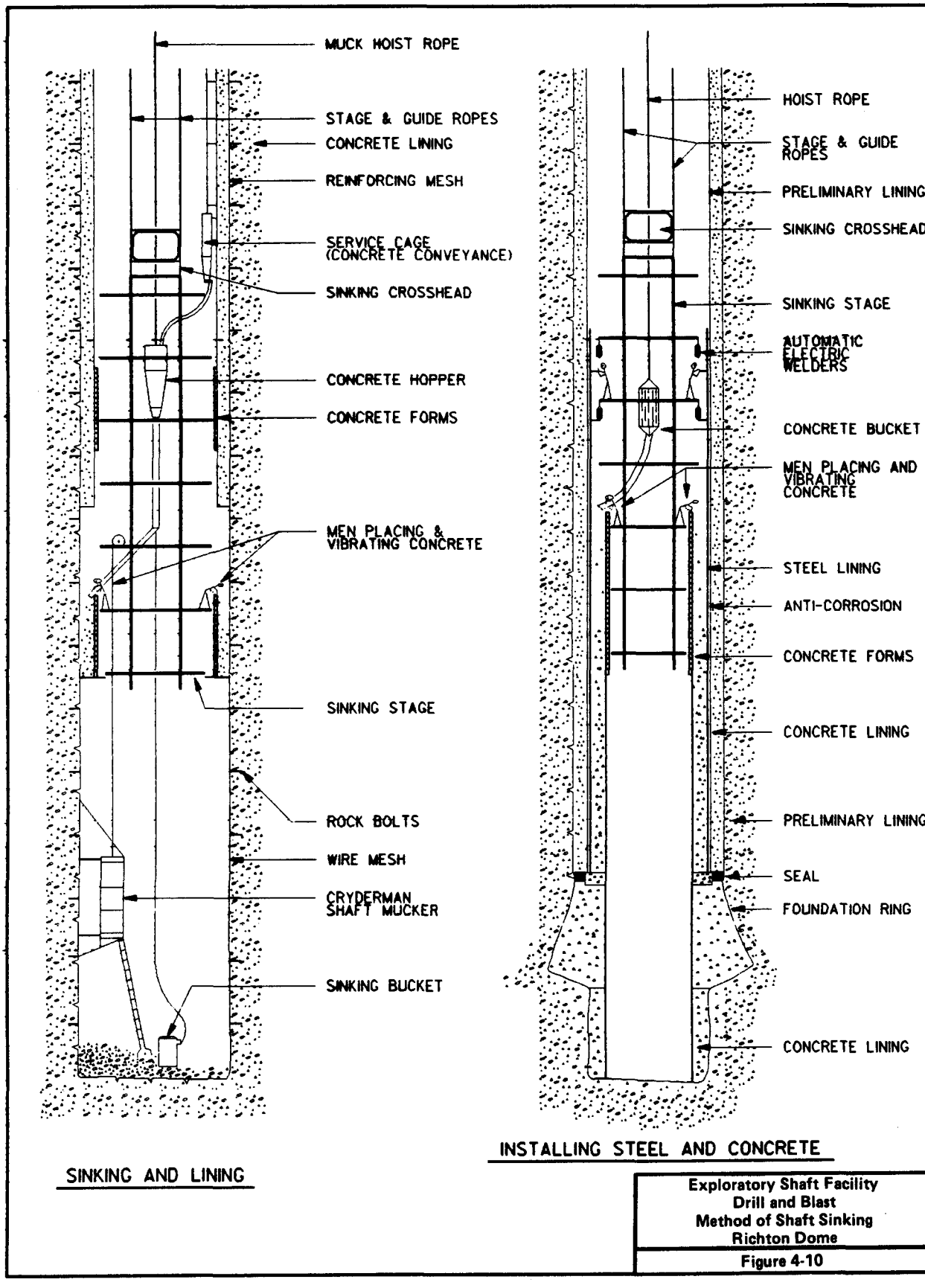
A circular cross-sectional shape is most prevalent in modern shafts. The circular shape is the most stable configuration to resist lithostatic and hydrostatic pressures acting against the shaft lining. For ventilation purposes also, a circular shaft is more efficient than other shapes because it offers the least resistance to the ventilating current.

Shaft Sinking Methods, Ground and Water Control. The drill and blast method of shaft sinking employs the basic cycle of drilling, blasting and removing muck (broken rock) from the shaft. A preliminary ground support lining system follows a few feet behind the advancing shaft bottom. A number of holes are drilled in the shaft bottom, loaded with an explosive and blasted. The blasted material (muck) is hoisted to the surface in the muck bucket. For efficiency of operations and schedule, two buckets are usually used for muck removal. Once the muck has been hoisted to the surface, the cycle is repeated. Figure 4-10 is a schematic illustrating the drill and blast method of shaft sinking. A preliminary lining is installed in the shaft, as the sinking progresses, to protect the workers in the shaft from rock falls. Information obtained from the engineer design boreholes is used to determine the extent and method of ground and water control in the shaft during sinking.

The ground support system required to support the preliminary lining, and if necessary, the final shaft lining, will be designed for the expected mechanical behavior of the shaft walls.

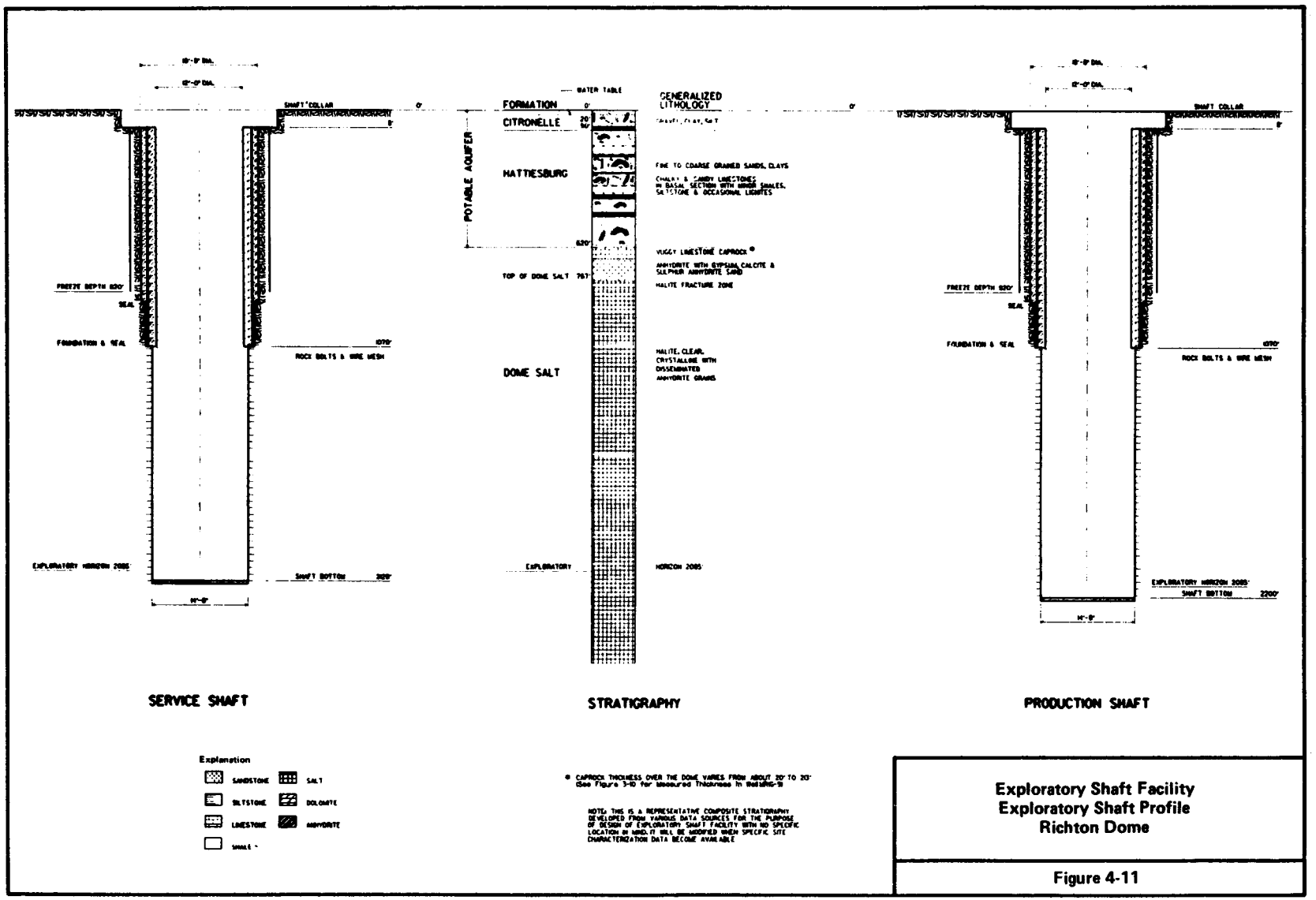
Shaft Construction. At Richton Dome, the two shafts will be constructed using the conventional drill and blast method. One of these shafts will be used for hoisting excavated material, the production shaft, while the other, called the service shaft, will be used for hoisting personnel and materials. The production shaft will be 677 meters (2,220 feet) deep while the service shaft will have a depth of 646 meters (2,120 feet). The production shaft is deeper in order to accommodate the material handling and loading area at the bottom of the shaft. The shafts will be excavated with an approximate diameter of 6 meters (20 feet), which will provide a finished diameter of 3.7 meters (12 feet) after completion of final lining.

The shaft excavation must penetrate the Hattiesburg Formation, which is the local source of potable water, and the Catahoula Formation before breaching the caprock. Figure 4-11 illustrates formations through which the shafts will be constructed. To control water migration and to stabilize the ground sufficiently for the shaft penetration, the ground is frozen to a depth of approximately 250 meters (820 feet). The freezing process is accomplished by excavating a freeze collar and drilling approximately 33 slanting freeze holes to an approximate depth of 250 meters (820 feet) on a diameter of approximately 10 meters (33 feet) on the surface, and 12 meters (39 feet) on the bottom from the centerline of the shaft. Additional holes are drilled for temperature monitoring of the ground, and a central hole as a relief hole is drilled. All holes for the freezing process are drilled by controlled means. A steel freeze pipe is installed into the freeze hole casing and is equipped with a plastic brine circulation pipe. The cooled brine is circulated from the freeze plant through each freeze pipe. The brine volume and temperature is controlled. The temperature control holes are equipped with thermocouples at strategic locations which permit constant temperature control of the frozen ground structure. The center relief hole acts as a vent for formation water which is forced out of the ground by the freezing action.



Exploratory Shaft Facility
Drill and Blast
Method of Shaft Sinking
Richton Dome

Figure 4-10



Exploratory Shaft Facility
Exploratory Shaft Profile
Richton Dome

Figure 4-11

Once the ground is frozen sufficiently, a 30-meter (100-foot) shaft collar is constructed, a headframe is installed on the surface, a sinking stage is installed in the shaft, and the shaft sinking commences. A sinking stage is a multideck work platform (a 7-deck stage is shown in Figure 4-10). During shaft sinking operations, it supports the shaft bottom operations of drilling, loading with explosives, and mucking (removing broken rock). The preliminary rock support measures (rock bolting, preliminary lining, etc.) and temporary utilities are installed directly from the stage, simultaneously with the shaft bottom operations.

Probe holes are drilled during shaft sinking, extending to a depth of several blasting rounds in advance of the shaft bottom. These probe holes are drilled at constant intervals to safeguard against unexpected water or gas occurrences during shaft sinking.

Through the frozen section, the ground is carefully excavated to ensure that the ice wall is not damaged. This may require presplitting or other controlled blasting techniques. The shaft is sunk to a depth of 244 meters (800 feet), and a 25-centimeter-(10-inch-) thick preliminary concrete lining is placed concurrently with the progress of shaft sinking. From 244 meters (800 feet), probe holes are drilled to find any evidence of water. Grout holes are drilled to grout any fractures in the caprock. The shaft is sunk to 265 meters (870 feet) and secured with rock bolts and wire mesh. Thereafter, a foundation for final lining is constructed at 326 meters (1,070 feet). A final lining is then installed, from this base upward, leaving a gap of 6 inches between it and the preliminary lining. The preliminary lining is interrupted at 119-125 meters (390-410 feet) and 186-192 meters (610-630 feet) to ensure isolation of the aquifers by preventing migration of water vertically and horizontally. This final lining consists of an outer welded steel shell 1.3 centimeters (0.5 inch) thick, and about 56 centimeters (22 inches) of concrete up to 229-meters (750-foot) depth. Beyond that the lining consists of an outer and inner steel shell sandwiching 56 centimeters (22 inches) of concrete. The welded steel shell serves as a water barrier. The annulus between the final lining and the preliminary lining is filled with bitumen seal. This continuous seal from the base of the final lining to about 3 meters (10 feet) from the surface, with interruptions in the preliminary lining at 122 meters (400 feet) and 189 meters (620 feet) ensures isolation of aquifers, prevents the vertical and horizontal migration of water, and maintains watertight shafts.

Up to the time of completion of the final lining, the freeze plant is kept in continuous operation. However, once the final lining is installed from 326 meters (1,070 feet) to the surface, freezing operations are discontinued. Thereafter, the shaft is sunk conventionally to its final depth, using only rock bolts and wire mesh for rock support from 326 meters (1,070 feet) to 646 meters (2,120 feet) in the service shaft and to 677 meters (2,220 feet) in the production shaft. Concrete shaft plugs are then constructed at the shaft bottom to prevent uplift. These plugs are approximately 6 meters (20 feet) high in both the shafts.

The shafts are connected at a depth of 636 meters (2,085 feet) by a drift. This connection establishes a ventilation circuit in the subsurface workings. Fresh air enters the underground workings through the service shaft and exhausts back to the surface through the production shaft.

Preliminary Lining. The type of preliminary support varies from rockbolts and wire mesh in good competent rock to stabilization by grouting or freezing of waterbearing rock. A single ground control system is seldom sufficient for shafts except for shallow near-surface openings. The initial ground support for deep shafts is usually augmented by lining the shaft walls with monolithic concrete or precast concrete blocks grouted in place.

The ground support system used during excavation depends on the stability of the free standing/unsupported shaft walls. This unsupported height, which provides some flexibility about how soon the preliminary lining is installed after excavation, is a function of the time dependent behavior of the material being excavated. Zones of structural weaknesses, joints, and fracture patterns may require ground support systems. These systems may include steel ribs, liner plates, shotcrete, etc., and may be combined for specific intervals of shaft walls. Soils or rocks too weak to support themselves long enough to place ground support systems may require pretreatment. Pretreatment is carried out prior to reaching the weak

strata and may consist of stabilization by grouting, dewatering or by freezing the strata. Where the average particle size of rocks is large (greater than 5 millimeters (0.2 inch)) and water volumes are not excessive, grouting or dewatering can be used for water control. However, in unconsolidated materials with small particle size, the most frequent water control measure is freezing, which has been used for over 100 years to stabilize weak strata for shaft sinking (Jessberger, 1979; Braun and Nash, 1985; Shuster, 1972; Roesner, 1980). Freezing not only prevents water from entering the shaft excavation, but also controls ground movement. Figure 4-12 shows a typical ground freezing arrangement.

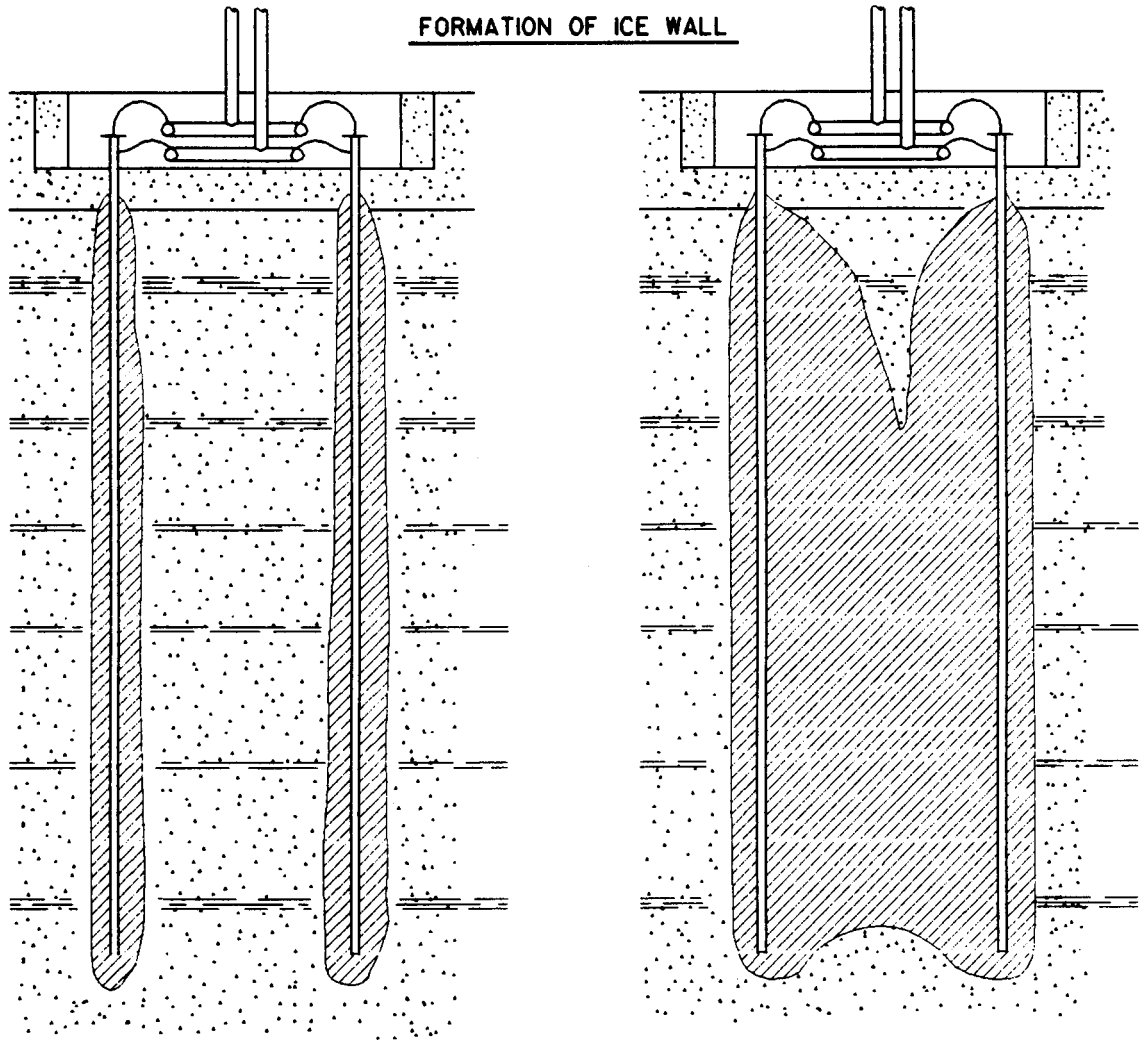
Water control in shaft construction is basically a two-phase approach. The first phase deals with the control of water during shaft sinking while the second phase is based on the criteria of permissible flows into the shaft after the shaft has been constructed. Water control systems employed in shaft construction are, therefore, based on the ultimate dryness criteria for the completed shaft. While the ultimate dryness is part of the design of the final shaft lining, the methods used for water control during shaft construction can be different. Strata producing minor water flows usually do not require any action to control water. The minor flows are either handled with the excavated rock and hoisted to the surface or collected by water rings, drained to a sump and then pumped or bailed to the surface.

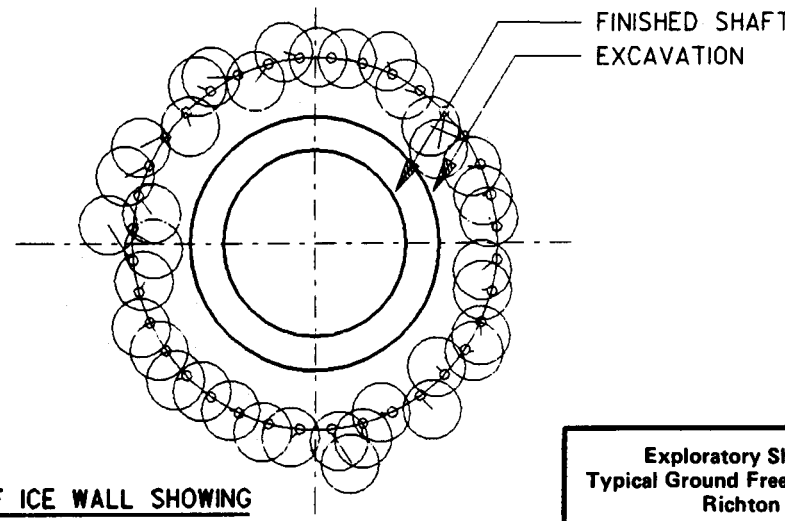
Grouting by pressure injection of cement slurries, resins, or gels has been used successfully to control water flows in shafts. Joints and fractures in impermeable rocks are usually more easily sealed by grouting than are sections of permeable rocks or soils. Most soils, and some rocks with very fine cracks, do not readily lend themselves to the control of water flows by grouting. In addition to grouting, water is sometimes controlled by pumping around the prospective shaft area from wells on the surface.

For deeper shafts, waterbearing soils and rocks are usually frozen. The ice wall must be designed for stability, i.e., for strength to bear the stresses acting on it. The compressive strength of the frozen soil increases as the temperature is lowered. The temperature is lowered by circulating a freezing agent in holes drilled around the shaft. The freezing point of any material depends on the natural salt content. The greater the salt content, the lower the freezing point.

A review of the literature indicates that the technique of ground freezing has stabilized saturated sediments during sinking of mine shafts, driving mine drifts, tunnels, and during foundation excavation in civil and nuclear projects (see references cited earlier in this section). Table 4-9 summarizes North American mining experience with ground freezing. The first ground freezing in North America was carried out in 1888 on such a shaft for Chapin Mining Company in Iron Mountain, Michigan. Since this first application of the technology, at least 30 additional mine sites in North America have employed ground freezing (see references cited earlier in this section). A majority of these shaft freezing projects have been completed for evaporite mines. Many of these projects handled similar shaft dimensions while several involved greater shaft diameters and freeze depths. Few problems have been encountered with the actual freezing of the rock. Frozen rock has not only a significant compressive strength, but also a considerable tensile strength. Nevertheless, care must be used in the thawing process. During the thawing process, it has been shown that rocks have reduced void ratio (overconsolidation) and increased vertical permeability. This has been shown to be highest in fine grained, plastic clays. The geologic texture of the Citronelle is gravel, silts, and clays. The Hattiesburg is fine- to coarse-grained sands, silts, and clays with chalky and sandy limestones in basal settings with minor shales, siltstone, and occasional lignites. The caprock above the dome salt is a vuggy limestone. Anhydrite with gypsum, calcite, and sulphur, and an anhydrite form the caprock of the dome salt, followed by the halite fracture zone. The amount of reduced void ratio and increased vertical permeability, given these soil horizons, is expected to be minimal.

The rate and distribution of thawing can be regulated to ensure that uniform thawing is achieved. Uniform thawing can regulate the settling of the concrete lining and reduce the possibility of deforming the concrete lining.





TYPICAL PLAN OF ICE WALL SHOWING COMPLETE CLOSURE

Exploratory Shaft Facility
Typical Ground Freezing Arrangement
Richton Dome

Figure 4-12

Table 4-9. North American Mine Shaft Ground Freezing

Mine	Location	Year Started/ Ended	Shaft Dimensions (meters)	Shaft Depth (meters)	Freeze Depth (meters)	Type of Formation	Remarks
Chapin Mining Co.	Iron Mt., MI	1988	4 x 5		30	Glacial till	
Morton (Myles Salt Co.)	Louisiana	1901/'03	4.9	228	761	Domal salt	
Potash Corp. of America	Carlsbad, NM	1952	4.6	233	107	Bedded Potash	
Potash Corp. of America	Sask., Canada	1955	4.9	1,051	914	Bedded Potash	
International Minerals & Chemicals Corp.	Esterhazy, Sask., Can.	1957	5.5	1,030	0-70 363-437	Bedded Potash	
Morton (Weeks Island)	Louisiana	1958	5.5	243	76		
Duval Corporation	Carlsbad, NM	1963	4.26 & 3.65	305 & 279	128	Bedded Potash	
International Minerals	Esterhazy, Sask., Can.	1963/'67	5.64	1,021	468	Bedded Potash	Glacial till, Blairmore; Wet dolomites and salt; Freezing 0 to 473 m; Grouting 473 to 915 m
PCS[a] (Allan Potash Mines #1)	Sask., Canada	1964	4.9	1,089	625	Bedded Potash	
PCS (Allan Potash Mines #2)	Sask., Canada	1964	4.9	1,089	625	Bedded Potash	
PCS (Alwinsal Potash of Can. #1)[b]	Canada	1964	5.5	1,004	527	Bedded Potash	
Noranda Mines Ltd. #1	Canada	1965/'68	4.9	1,052	591	Bedded Potash	Glacial till, Blairmore; Wet dolomites and salt; Freezing 0 to 548 m; Grouting 548 to 915 m

Table 4-9. North American Mine Shaft Ground Freezing
(Page 2 of 3)

Mine	Location	Year Started/ Ended	Shaft Dimensions (meters)	Shaft Depth (meters)	Freeze Depth (meters)	Type of Formation	Remarks
Noranda Mines Ltd. #2	Canada	1965/'68	4.9	1,052	591	Bedded Potash	Glacial till, Blairmore; Wet dolomites and salt; Freezing 0 to 548 m; Grouting 548 to 915 m
Cominco Ltd.	B.C., Canada	1965/'68	4.9 & 5.64	1,089	684	Bedded Potash	Glacial till, Blairmore; Wet dolomites and salt; Freezing 0 to 610 m; Grouting 610 to 915 m
Potash Corp. of America	Sask., Canada	1967/'69	5.5	1,068	548	Bedded Potash	Glacial till, Blairmore; Wet dolomites and salt; Freezing 0 to 548 m; Grouting 548 to 915 m
PCS (Sylvite #1)	Canada	1967	4.9	1,021	461	Bedded Potash	
PCS (Sylvite #2)	Canada	1967	4.9	1,000	469	Bedded Potash	
Cargill, Inc.	Louisiana Belle-isle	1967/'71	4.9	378	70	Domal Salt	Ground frozen to 70 m; Conventional sinking in salt dome thereafter.
Cargill, Inc.	Louisiana Belle-isle	1973/'76	4.9	478	76	Domal Salt	Extensive ground investigation, ground frozen to 76 m.
PCS (Alwinsal #2)[b]	Canada	1974	4.26	1,004	527	Bedded Potash	
Amax Coal Co.	Illinois	1974	6.09	228	38	Coal	
Diamond Crystal	Louisiana	1975	2.44	470	70	Domal Salt	
Island Creek Coal Co.	Kentucky	1975	6.09	122	54	Coal	
Mortan Salt Co.	Louisiana	1977	5.5	381	64	Domal Salt	
Peabody Coal Co.	Illinois	1978	6.09	122	53	Coal	

Table 4-9. North American Mine Shaft Ground Freezing
(Page 3 of 3)

Mine	Location	Year Started/ Ended	Shaft Dimensions (meters)	Shaft Depth (meters)	Freeze Depth (meters)	Type of Formation	Remarks
Selco Mining Corp.	Quebec, Can.	1979	3.65	61	61		
White County Coal Corp.	Illinois	1979	6.7 x 9.8.6	335	41	Coal	
Domtar, Inc.	Goderich, Ont.	1980	6.09	518	61	Bedded Salt	Involves freezing to 107 m and grouting to 229 m.
Les Mine Salin	Mad. Is., Can.	1980	6.70	122	43	Bedded Salt	
Turris Coal Co.	Illinois	1981	5.5, 6.09 & 7.3	87	64	Coal	
Asarco Exploration	Timmons, Ont.	1981	3.65	174	43	Glacial Till	

(a) PCS: Potash Corporation of Saskatchewan.

(b The PCS's Lanigan Mine was originally built, owned, and operated by Alwinsal Potash of Canada, Ltd.

Shaft linings for circular shafts may consist of rockbolts and wire mesh, brickwork, precast concrete blocks, monolithic concrete, cast iron with concrete, single and double shells of steel with concrete and combinations of steel profiles with concrete.

The shaft lining may be bonded to the strata by grouting, or it may be separated from the strata by an annulus filled with viscous material such as bitumen. The structural stability of a free-standing shaft lining in a bitumenous envelope is carried by a substantial foundation at the base of the liner. This design has the advantage of isolating the shaft liner from stresses arising from mining and tectonic activities. This design has an added advantage in that the bitumen acts as a continuous waterproof seal.

Final Lining. A final shaft lining constructed with monolithic concrete is the standard lining where water-tightness is not required. It may be combined with compressible material placed between it and the shaft wall in plastic zones. This material will deform with the creeping strata and thus result in a reduction of strata pressure on the concrete lining. The concrete lining may be installed in dry or waterbearing strata.

Final shaft lining, which requires various degrees of watertightness, may be constructed in stable and unconsolidated waterbearing strata. These linings are mainly composed of cast iron tubbings with concrete, or of various cast or rolled steel segments as a watertight membrane in combination with concrete.

Seal System. In salt and other evaporite mining operations, it is necessary to prevent the movement of water along the interface between the host rock and liner in order to ensure that progressive dissolution of salt behind the lining does not occur. A seal is also required to isolate various aquifers thus preventing cross-contamination.

A "seal system" consists of the shaft lining, which prevents the movement of water in a horizontal direction, and a shaft seal between the liner and the host rock to prevent water movement in a vertical direction. The locations of the seals below aquifers and above the salt bed is therefore an important consideration since a seal is only as effective as the rock in which it is placed. It should be located in an essentially impervious rock.

Three types of seals are commonly used. The traditional sealing method used with cast iron tubbing, a commonly used lining in waterbearing rocks in early mining practice, employs a wedge ring set between the tubbing rings. This wedge ring has a greater horizontal depth than the tubbing rings above and below. The space between the wedge ring and the shaft walls is sealed by hammering in precisely cut wooden wedges, or "pikotage," until the space is so tightly packed that even a tapered steel needle can not be driven in. The wood, when it comes in contact with water, expands and the seal is further tightened. The material cost for this type of seal is low but the labor cost and installation time requirements are high.

For complete effectiveness, chemical seals are used in modern practice - especially in salt and potash mines. These chemical seals use a polymeric sealing compound (CSR). CSR, mixed with gravel, is placed as a pumpable slurry which is pliable enough to penetrate cracks in the rock. This polymer material expands considerably in contact with water and thus further tightens the seal. After emplacement, the slurry hardens to form an insoluble elastic solid. Allowance is made in the design to pressurize this seal for greater effectiveness. A schematic for such a seal system is shown in Figure 4-13.

The third form of seal uses a continuous column of asphalt or bitumen from below the lowest aquifer to a few feet below the surface. In this system, the annular space between the lining and the shaft walls is filled with a mixture of asphalt and limestone blended to a specific gravity slightly higher than the specific gravity of brine. Since the hydrostatic head of the asphalt mixture is higher than the brine head, the mixture flows into any cracks that may be present.

Surface Facilities Construction. Surface facilities will be constructed concurrently with shaft construction operations. Included in the surface facilities construction phase are the following: a fuel storage system, the water supply system, excavated material storage

areas, sewerage systems, communications systems, power distribution system, explosives magazine, safety system, and shaft services facilities.

Diesel fuel would be stored on site in a buried fiberglass storage tank with a capacity of approximately 162,755 liters (43,000 gallons). The tank would be located near the three diesel generators used for emergency power. The supply level would be monitored by a liquid level gage, mounted on the wall in the generator building. Leak detection requirements as applicable at the time of installation will be satisfied.

The excavated material storage areas will accommodate 6,113 cubic meters (8,000 cubic yards) of salt contaminated overburden, 19,878 cubic meters (26,000 cubic yards) of nonsalt-contaminated overburden, and 153,675 cubic meters (201,000 cubic yards) of salt. These capacities exceed the planned excavation volumes (Table 4-3).

Liners will be used to prevent the possible leaching of brine into the ground. Liners are made of either natural (clays) or synthetic materials (polyvinyl chloride, polyethylene, or polypropylene). The existing topsoil is stripped before emplacement of the liner and subbase. If a synthetic liner is used, an additional layer of compacted backfill material is placed on top of the liner so that heavy equipment can move across without damaging it.

The salt industry has found that stockpiled salt is not a source of windblown particles. When salt is exposed to the weather, a hard surface crust forms in a few days which tends to shed rain water (Ver Planck, 1958, p. 57; DOE, 1983, WIPP-DOE-161) and prevents particles from blowing away. Crusting can be accelerated by wetting the pile. The salt pile will be monitored to assure that crusting is effective.

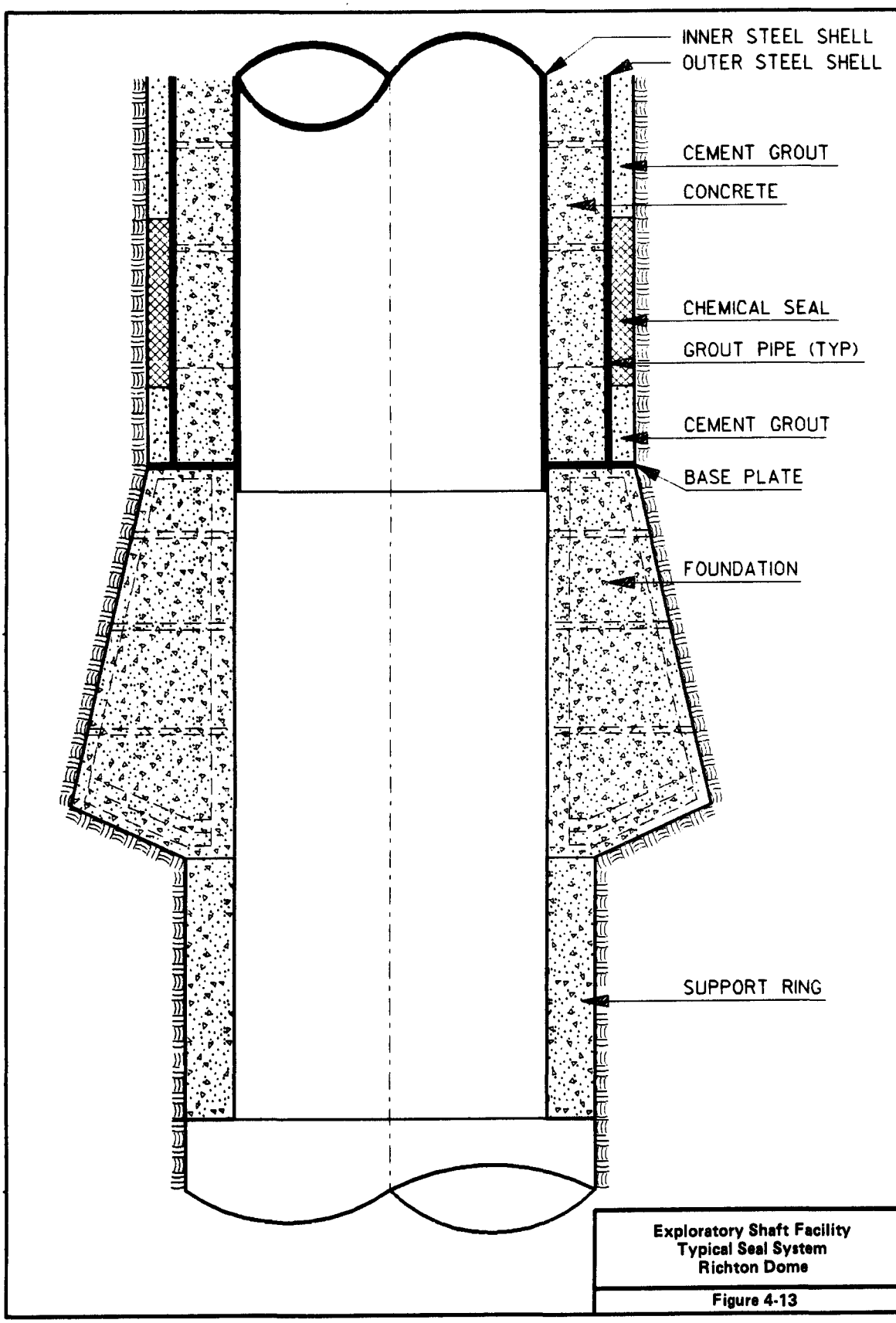
It is possible during salt handling, namely the transfer of the salt from hoist to trucks or other conveyances and salt pile buildup (pile working surface), that salt particles may become windblown. Any salt carried by wind would deposit in a decreasing volume as the distance from the salt piles increases.

Salt-contaminated and potentially salt-contaminated runoff from the shafts area, haul roads and mined material stockpiles will be collected by a system of lined drainage ditches which gravity flow and are routed to the evaporation/retention ponds. Water collected in the production and service shaft sumps will be pumped to the lined ditches for collection at the evaporation/retention ponds. The ditches will be sized, based on the time of concentration of the local watershed, to convey runoff from a storm of an intensity that would be matched, on average, only once in 500 years. This will allow the drainage ditches to have the capability to convey short duration storms which produce higher peak flows than a 24-hour storm event.

The evaporation/retention ponds will be sized to provide an operational volume equivalent to 100 percent of the rainfall volume from a 500-year, 24-hour storm falling on the areas of salt and potential salt contamination. The maximum volume of the pond will include an additional 61 centimeters (2 feet) of freeboard above the storm level.

If, during design, it becomes evident that an acceptable evaporation rate of the water cannot be achieved due to area or depth constraints of the pond, the water would be periodically removed for transport to an acceptable offsite disposal facility. Disposal of similar liquids (brine) is a common oil industry practice.

The evaporation/retention ponds and associated drainage ditches will be lined with suitable materials to prevent seepage of salt-contaminated water into the ground. Lining of brine ponds is commonly practiced in the oil and salt industries (Staff Industries, Inc., 1983). Ponds as large as 20 hectares (50 acres) have been successfully lined with polyvinyl chloride membranes where the liner is not exposed to direct sunlight, or chlorinated polyethylene with fabric reinforcement where the liner is exposed to sunlight. Natural materials which may be available on site, such as brine-resistant clay, can also be used with or in place of synthetic liners.



Exploratory Shaft Facility
Typical Seal System
Richton Dome

Figure 4-13

The evaporation/retention pond liners are installed over an engineered subgrade which has one or more networks of perforated pipes in an aggregate backfill. The perforated pipe system connects to vertical pipes which terminate above finished grade at the perimeter of the pond. These vertical pipes serve as a vent for gases which may collect under the membranes and a observational well for the effectiveness of the liner system to contain liquids (leachate) above the liner. Monitoring wells, if necessary, can also function as wells for removal of leachate by pumping for transport to an acceptable off site disposal facility. The observational wells will be sampled frequently to insure the integrity of the liner system.

Runoff from areas not salt contaminated, such as the administration area, parking area, topsoil stockpile and roads not used for hauling mined material, will be collected in drainage ditches which gravity flow to the sediment pond. The ponds will be designed to contain 100 percent of the rainfall volume from a 25-year, 24-hour storm falling on the non-contaminated areas. The design of these sediment ponds will provide sufficient retention time to settle suspended solids to the extent necessary to meet discharge parameters for solids concentration.

The efficiency of the sediment ponds to accomplish solids removal may be increased by the addition of baffles, partitioning, inlet energy dissipator, coagulants or siphon type riser and spillway design. Periodic removal of collected sediment for transport to an acceptable offsite disposal facility will be required.

The drainage ditches which convey runoff to the sediment ponds will be designed for a 25-year storm of a duration and intensity related to time of concentration in the local watershed. This allows the drainage system to convey short duration storms which produce higher peak flows than a 24-hour storm.

The potable water system will be a pressurized distribution network supplied by onsite wells capable of providing up to 147,000 liters per day (39,000 gallons per day). The estimated peak demand is 1,211 liters per minute (320 gallons per minute). The potable water supply will be stored in a dedicated tank with a capacity of 340,650 liters (90,000 gallons). Water will be required for human consumption, sanitation, dust control, grout and concrete.

A system of underground pipes will carry sanitary wastes to a treatment facility. During construction, the collection system will be supplemented by chemical toilets. These wastes will be trucked to an offsite treatment/disposal facility. The wastewater treatment facility will have a capacity of about 49,200 liters per day (13,000 gallons per day) based on a peak of 230 project and construction management people. The aerated sludge will be periodically transported to a permitted disposal facility.

Oily wastewater from surface facilities, such as the maintenance shop, fire truck garage, and mechanical equipment room, will be collected by a network of underground piping. One or more oil and water separators will be provided in the appropriate maintenance drains in the service building, generator building and other buildings which may have oil or grease contributions. Effluent from the oil and water separators will flow to the sanitary waste collection system. Liquids accumulated in the oil and water separators, waste cleaners, solvents, thinners and other similar materials that may be hazardous will be properly disposed of off site in a licensed facility. Solid waste, such as wood, metal, plastic and paper generated at the ESF site will be collected for offsite disposal. Prefabricated buildings will house the various office and laboratory facilities required for the project, and for the equipment service and core storage building areas which will be used for testing and excavation. A total of 6,470 square meters (70,000 square feet) of work area will be constructed.

During construction an area of approximately 35,674 square meters (384,000 square feet) adjacent to the shafts is available for accommodating construction contractor facilities. An additional 4,088 square meters (44,000 square feet) is available north of the shaft area for construction trailers, waterwells and equipment storage. The explosives magazine, provided by the construction contractor, will be located at the southeast corner of the ESF site.

The ESF site fire protection system will provide detection and alarms for smoke, gases, and fire. Fire and smoke detectors will be installed in surface structure and the subsurface area and will activate audible alarms and extinguishing systems. The water supply for the fire protection system will be stored in a dedicated tank with a capacity of 228,000 liters (60,000 gallons). Chemical fire suppression systems will be used in those areas where water is not suitable. These systems will include Halon, foam, dry chemical, and carbon dioxide, as appropriate. A four-wheel-drive truck, foam truck, and ambulance will be located in the fire station at the security building.

The operating status of all systems important to safety will be monitored to ensure proper performance. Especially important will be methane and hydrogen sulfide gas detectors located in the shafts and subsurface workings. If excessive gas levels are detected, alarms will be sounded in equipment and monitoring rooms on the surface. Individual detectors will be provided on heavy equipment in the subsurface workings. The detectors sound an audible alarm to warn workers that a gas concentration above a preselected level is detected. Detection devices will automatically shut off equipment at this level.

Table 4-5 identifies the concurrent surface facility and shaft construction activities. The equipment associated with the shaft and surface facility construction stage is listed in Table 4-10 and estimated resources to be consumed are summarized in Table 4-7.

Based on estimated staffing of this phase, average daily automobile traffic would increase from preproject levels by approximately 260 passenger vehicles per day. Truck traffic would increase from preproject levels by approximately 255 trucks per month, based on the quantities of fuel, building materials, and other items required. Estimated vehicular traffic during the shaft construction and testing periods is given in Table 4-8.

Worker Health and Safety. Health and safety provisions for personnel will be provided at key points throughout both the subsurface and surface facilities. These provisions include one or more subsurface refuge chambers, Mine Safety and Health Administration (MSHA) approved self-rescuers, first aid kits and an onsite ambulance.

The Mine Safety and Health Administration (MSHA) is authorized to administer and enforce certain kinds of safety and health standards for protecting employees in the mining industry pursuant to the "Mine Safety and Health Act of 1977," 30 USC Sections 801 et seq. The question of formal involvement of MSHA with the Civilian Radioactive Waste Management Program is not resolved at this stage. The principal design, construction, and operating features of the exploratory shaft facility will include provisions for worker protection by following the relevant requirements of "Safety and Health Standards - Metal and Non-Metal Underground Mines" (30 CFR Part 57). Fire control, ventilation, illumination, and use of equipment and explosives are being designed to comply with MSHA regulations governing "gassy" mine conditions.

Specific areas of interest in maintaining occupational safety during mining include the following:

- Mining Methods
- Fire Prevention and Control
- Working Environment
- Ventilation Systems
- Materials Handling and Storage
- Underground Utility Systems
- Occupational Safety Programs and Personnel Protection
- Emergency Plans
- Inspection, Testing, and Maintenance.

Table 4-10. Equipment for Shaft and Surface Facility Construction Phase, Richton Dome

Phase (Time Period)	Equipment No.	Equipment Name	Equipment hp	Peak Cumulative hp
SHAFT CONSTRUCTION				
Freeze Plant for	2	Freeze hole drill rigs	1,500	3,000
Production Shaft	1	Freeze plant	1,350	1,350
(8 months)	1	Pickup truck	135	135
				3,135/135
Sinking Plant	1	Crane	180	180
Set-up for	1	Forklift	50	50
Production	1	Truck	250	250
Shaft (6 months)	2	Welding rigs	50	100
	1	Wheel loader	270	270
	1	Backhoe	135	135
	1	Mobile compressor	50	50
	1	Vent fan	25	-
	1	Pickup truck	135	135
				1,170
Shaft Sinking for	1	Forklift	50	50
Production Shaft	1	Crane	180	180
(11 months)	1	Hoist	1,000	-
	4	Stage hoists	40	-
	1	Vent fan	60	-
	3	Compressors	80	-
	1	Mucker winch	20	-
	1	Batch plant	70	-
	1	Truck	250	250
	1	Wheel loader	270	270
	1	Welding rig	50	-
	1	Freeze plant	560	-
	1	Oiler	200	200
	2	Pickup trucks	135	270
				1,220
Final Lining	1	Forklift	50	50
Installation for	1	Freeze plant	560	-
Production Shaft	1	Vent fan	60	-
(5 months)	1	Hoist	1,000	-
	2	Compressors	80	-
	1	Batch plant	70	-
	1	Truck	250	250
	3	Welding rigs	50	-
	4	Stage hoists	40	-
	1	Crane	180	180
	1	Wheel loader	270	270
	1	Oiler	200	200
	2	Pickup trucks	135	270
				1,220

Table 4-10. Equipment for Shaft and Surface Facility Construction Phase, Richton Dome
(Page 2 of 3)

Phase (Time Period)	Equipment No.	Equipment Name	Equipment hp	Peak Cumulative hp
Freeze Plant for Service Shaft (8 months)	2	Freeze hole drill rigs	1,500	3,000
	1	Freeze plant	1,350	-
	1	Pickup truck	135	135
				3,135/135
Sinking Plant Set-up for Service Shaft (6 months)	1	Crane	180	180
	1	Forklift	50	50
	1	Truck	250	250
	2	Welding rigs	50	100
	1	Wheel loader	270	270
	1	Backhoe	135	135
	1	Mobile compressor	50	50
	1	Vent fan	25	-
	1	Pickup truck	135	135
				1,170
Shaft Sinking for Service Shaft (11 months)	1	Forklift	50	50
	1	Crane	180	180
	1	Hoist	1,000	-
	4	Stage hoists	40	-
	1	Vent fan	60	-
	3	Compressors	80	-
	1	Mucker winch	20	-
	1	Batch plant	70	-
	1	Truck	250	250
	1	Wheel loader	270	270
	1	Welding rig	50	-
	1	Freeze plant	560	-
	2	Pickup trucks	135	270
				1,020
Final Lining Installation for Service Shaft (5 months)	1	Forklift	50	50
	1	Freeze plant	560	-
	1	Vent fan	60	-
	1	Hoist	1,000	-
	2	Compressors	80	-
	1	Batch plant	70	-
	1	Truck	250	250
	4	Welding rigs	50	-
	4	Stage hoists	40	-
	1	Crane	180	180
	1	Wheel loader	270	270
	2	Pickup trucks	135	270
				1,020

Table 4-10. Equipment for Shaft and Surface Facility Construction Phase, Richton Dome
(Page 3 of 3)

Phase (Time Period)	Equipment No.	Equipment Name	Equipment hp	Peak Cumulative hp
Surface Facility Construction (7 months)	1	Batch plant	70	-
	2	Concrete finishers	7	14
	2	Cranes	180	360
	1	Forklift	50	50
	2	Trucks	250	500
	2	Welding rigs	50	-
	1	Backhoe	135	135
	1	Track loader	65	65
	1	Compressor	200	-
	1	Oiler	200	200
	1	Pickup truck	135	135
				1,459
Service Facilities for Production Shaft (2 months)	1	Forklift	50	50
	1	Crane	180	180
	1	Batch plant	70	-
	1	Truck	250	250
	1	Welding rig	50	-
	1	Compressor	200	-
	1	Backhoe	135	135
	1	Track loader	65	65
	1	Concrete finisher	7	7
	1	Oiler	200	200
	1	Pickup truck	135	135
				1,022
Service Facilities for Service Shaft (4 months)	1	Track loader	65	65
	1	Backhoe	135	135
	1	Forklift	50	50
	1	Crane	180	180
	1	Batch plant	70	-
	2	Trucks	250	500
	2	Welding rigs	50	-
	1	Compressor	200	-
	2	Concrete finishers	7	14
	1	Oiler	200	200
	1	Pickup truck	135	135
				1,279

The Occupational Safety and Health Administration (OSHA) administers the Occupational Safety and Health Act of 1970, as amended. The purpose of OSHA is to establish standards which industries are generally familiar, and on whose adoption interested and affected persons have already had an opportunity to express their views. Such standards are either (1) national consensus standards whose adoption by affected persons has reached substantial agreement, or (2) Federal standards already established by Federal statutes or regulations. The DOE will utilize the OSHA regulations, in particular "Occupational Safety and Health Standards" (29 CFR Part 1910), and "Safety and Health Regulations for Construction" (29 CFR Part 1926), as applicable.

Based on MSHA's experience, during the 5-year life of the ESF project, with approximately 2.94 million work hours, 69 injuries and one fatality are projected. However, by rigid implementation of the DOE Orders 5480.1A and 5480.4 for "Environmental Protection, Safety and Health Protection Program for DOE Operations," the actual injury experience should be less than projected.

4.1.2.2.3 Initial Underground Excavation. A shaft station consisting of 46 meters (150 feet) of drift from both shafts is included in this initial phase. A total of 244 meters (800 feet) (which includes the shaft stations) of drifts will be excavated in this phase. The drill and blast method will be used until a continuous miner can be assembled underground. A small load/haul/dump vehicle will be used to move muck (excavated material) for hoisting to the surface.

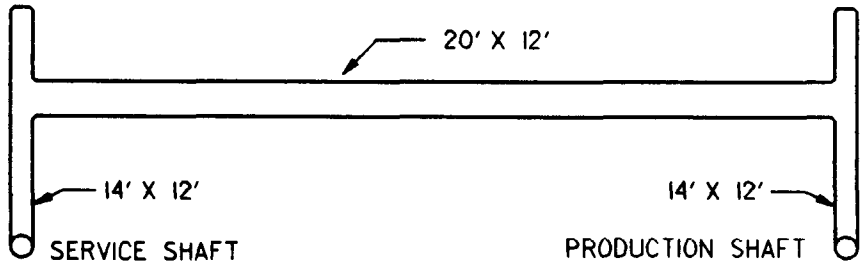
The initial excavation will support some requirements for testing that will be performed concurrently with the excavation of the connection drift. When the connection drift and outfitting are completed, sufficient ventilation and alternate emergency access from the underground workings will be provided to support the testing phase. Figure 4-14 illustrates the initial underground excation. Figure 4-7, the exploratory shaft facility construction and testing schedule, illustrates the relationship between underground excavation and the testing programs.

Equipment required for the initial underground excavation is listed in Table 4-11. The estimated primary consumable resources needed are listed in Table 4-7. Vehicular traffic is expected to increase from the preproject levels by approximately 220 passenger vehicles per day and 95 trucks per month. The estimated vehicular traffic is given in Table 4-8.

4.1.2.2.4 Outfitting. Outfitting is the equipping of the shafts with conveyances and utilities necessary for testing and drift excavation. The shaft outfitting phase will commence after initial underground excavation to connect the two shafts. The installation and construction of shaft service facilities will coincide with shaft outfitting. These facilities include a permanent ventilation system, the tie in with site utilities (power and communications) and a shaft service building.

Both shafts are to be outfitted to accommodate expanded underground excavation and testing. The service shaft will be outfitted for personnel access and will supply the underground workings with fresh air and utilities. The production shaft will be used for transporting muck to the surface during testing and excavation, and for the subsurface exhaust.

The equipment associated with the outfitting is listed in Table 4-12. Estimated resources consumed during this phase are listed in Table 4-7. The increase to local traffic over preproject levels for outfitting is estimated to be 240 passenger vehicles per day and 95 trucks per month. The delivery of a majority of construction materials to the ESF site during the shaft construction phase explains the low number of monthly truck round trips.



Exploratory Shaft Facility
Subsurface Plan –
Initial Underground Excavation
Richton Dome

Figure 4-14

Table 4-11. Equipment for Initial Underground Excavation Phase, Richton Dome

Phase (Time Period)	Equipment			Peak Cumulative hp
	No.	Name	hp	
INITIAL	1	Wheel loader	270	270
UNDERGROUND	2	Vent fans	60	-
EXCAVATION	1	Auxiliary fan	50	-
(2 months)	1	Hoist	1,000	-
	1	Hoist	500	-
	8	Stage hoists	40	-
	2	Compressors	80	-
	1	Mucker winch	20	-
	1	Continuous miner	410	-
	2	Welding rigs	50	-
	1	Scooptram (5 cu yd)	150	150
	1	Crane	180	180
	1	Forklift	50	50
	1	Truck	250	250
	1	Oiler	200	200
	2	Pickup trucks	135	270
				1,370

4.1.2.2.5 Underground Excavation. An additional 1,354 linear meters (4,440 linear feet) of drifts will be excavated during the 6-month phase. The subsurface plan, when completed, will consist of approximately 1,597 linear meters (5,240 linear feet) of interconnecting drifts. Figure 4-15 depicts this configuration necessary for the testing that will be conducted during the testing phase.

Equipment necessary for the underground excavation is listed in Table 4-13. The primary consumable resources are listed in Table 4-7. Vehicular traffic is expected to increase from preproject levels by 250 passenger vehicles per day and 40 trucks per month as shown in Table 4-8.

4.1.2.3 Testing

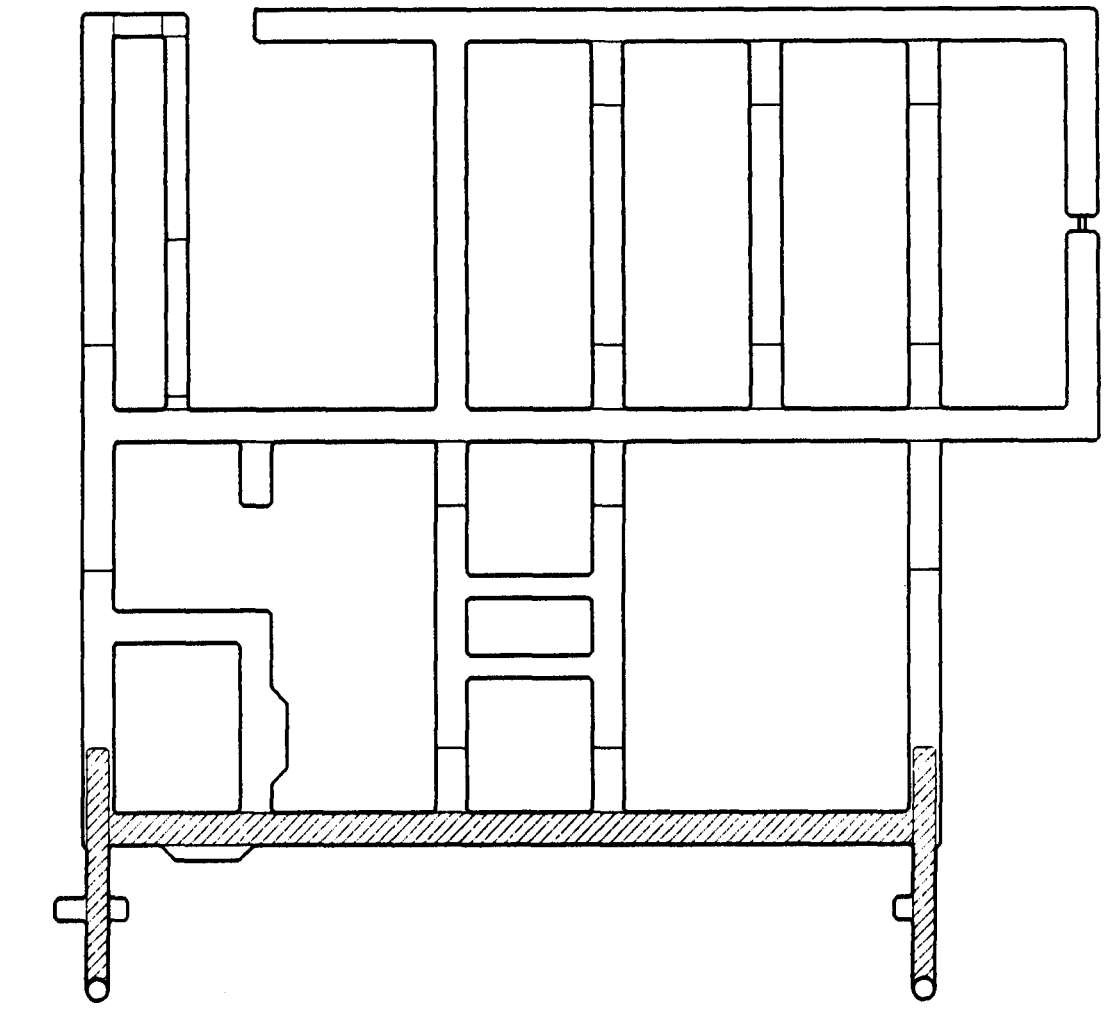
A test plan for the candidate salt sites has been developed. This plan outlines a proposed program of in situ testing which constitutes part of the overall efforts to determine site suitability for development as a repository, provide data for repository design and performance assessments, and prepare licensing documentation for radioactive waste disposal in salt. The latter includes compliance with the regulatory requirements for performance (e.g., 10 CFR 60.113 (a)(2), Information; 10 CFR 960.4-2-1 (b)(4)(i), Geohydrology; and 30 CFR 57.3-53, Testing.

The proposed test methods are categorized as being either surface-based, within boreholes drilled from the surface, in the laboratory, or within an in situ test facility. At this stage, all available test methods are being considered because many of the information needs may be more satisfactorily addressed by surface-based and laboratory testing, thus eliminating the need for certain in situ tests. However, in situ tests are generally more suitable for model validation and design evaluation.

In situ testing will be performed in two phases. The first phase of testing is termed Construction Testing, which starts with the beginning of shaft construction and ends when the shafts are connected underground. Specifically, Construction Testing includes the following activities:

- Initial monitoring of shaft behavior
- Initial monitoring of aquifer seal performance
- Horizon selection and verification
- Geologic mapping of shafts
- Geologic mapping of initial underground openings
- Blasting performance monitoring
- Initial air quality measurements
- General observations of underground stability
- Documenting any evidence of ground-water inflow or seeps
- Initial ground closure observations.

Following completion of the underground connection between the two shafts, access to the second phase of testing can begin. This second phase of testing, termed In Situ Testing, will include ongoing Construction Testing type activities such as geologic mapping and geomechanical and hydrological performance monitoring of the expanded facility. In addition, detailed Site Characterization Testing (e.g., in situ stress measurement, in situ strength of bedding surfaces, thermal conductivity, hydraulic conductivity, etc.) will be undertaken during and immediately following the completion of the ESF construction. Finally, specific engineered system designs will be evaluated and performance and design models validated by a series of major in situ tests (e.g., canister scale and room scale heater tests, backfill tests, etc.). In situ testing phase will support the Environmental Impact Statement (EIS) and the license application.



NOTES:

1. ROOM SIZE VARIES FROM 14'w x 8'h TO 20'w x 24'h
2. INITIAL EXCAVATION
3. EXPANDED EXCAVATION

Exploratory Shaft Facility
Subsurface Plan --
Underground Excavation
Richton Dome

Figure 4-15

Table 4-12. Equipment for Shaft Outfitting Phase, Richton Dome

Phase (Time Period)	Equipment No.	Name	hp	Peak Cumulative hp
	1	Vent fan	60	-
	1	Crane	180	180
OUTFITTING	2	Forklifts	50	100
Production Shaft	4	Stage hoists	40	-
(3 months)	1	Hoist	500	-
	1	Compressor	80	-
	2	Welding rigs	50	-
	1	Pickup truck	135	135
				415
	1	Vent fan	60	-
	1	Crane	180	180
OUTFITTING	2	Forklifts	50	100
Service Shaft	1	Hoist	500	-
(3 months)	4	Stage hoists	40	-
	1	Compressor	80	-
	2	Welding rigs	50	-
	1	Pickup truck	135	135
				415

Table 4-13. Equipment for Expanded Underground Excavation Phase, Richton Dome

Phase (Time Period)	Equipment No.	Equipment Name	Equipment hp	Peak Cumulative hp
UNDERGROUND EXCAVATION (6 months)	1	Wheel loader	270	270
	1	Hoist	1,000	-
	1	Scooptram (2 cu yd)	100	100
	2	Scooptram (5 cu yd)	150	300
	2	Trucks	250	500
	2	Continuous miners	410	-
	1	Roof bolter	40	-
	1	Scaler	85	85
	2	Auxiliary fans	50	-
	1	Crane	180	180
	1	Forklift	50	50
	2	Pickup trucks	135	270
				1,755

The In Situ Testing program consists of five major categories and specific testing subproblems of in situ tests, each category being supported by a suite of specific tests. Table 4-14 lists the categories and their respective tests. Details of the current test program for the salt sites can be found in the "Draft Test Plan for In Situ Testing in an Exploratory Shaft in Salt" (Golder Associates, Inc., 1985).

An estimate of the equipment required to conduct testing is identified in Table 4-15. Estimated resources expected to be consumed during the testing period are listed in Table 4-7. Vehicular traffic for this phase is expected to increase from preproject levels by 210 passenger vehicles per day and 95 trucks per month (Table 4-8).

4.1.2.4 Final Disposition

If the site is found suitable and is selected for the first repository, the exploratory shaft facility in full or in part may be incorporated into the repository design, as discussed in Chapter 5 under the two-phase repository design scheme.

If this site is not selected for the first repository, but considered for use as a second repository, the site (including all buildings, the headframe, and the access road) will be kept operational. Full security will be maintained.

If the site proves unsuitable for further development, it will be restored as closely as possible to its original condition. Site restoration will proceed in accordance with applicable Federal and State requirements, but in general will include the following:

1. Subsurface excavations will be filled with stored salt and other mined rocks as needed to protect waterbearing strata and provide structural stability.

2. Use of salt or salt-contaminated material will be limited to layers below potable water bearing strata to protect water quality.

3. Concrete, polymer seals, or clay plugs will be placed at required intervals to prevent vertical migration of water. A plug will be located at the bottom of the lined portion of each shaft.

4. Prefabricated buildings, temporary pipelines, and other surface facilities, including the electric and communication lines, will be removed.

5. The site will be returned to its approximate original contour, including the site access road. Topsoil stockpiled on site will be used as appropriate.

6. Top soil will be replaced; disturbed areas will be mulched, reseeded and revegetated.

Site restoration is estimated to take 22 months (Figure 4-8). The actual time needed for site restoration will be based on the final reclamation plan which will be prepared in accordance with applicable Federal, State, and local regulations. The necessary activities and the sequence could be as follows:

- Subsurface backfill
- Shaft backfill
- Hoist and headframe removal
- Surface storage area reclamation
- Equipment and building salvage
- Excess salt disposal
- Refuse and site cleanup
- Final grading, topsoil replacement, and revegetation.

The current plans for site characterization at the Richton Dome site do not include the use of high level radioactive waste. Therefore, no decontamination of the site is required after site characterization.

Table 4-14. Proposed In Situ Test Program

Geology	Thermomechanics
Geologic Mapping (Exploration Drifts)	Thermal Conductivity Probe
Drilling (Core Sampling/Field Logging)	Canister-Scale Heater Test
Geophysical Well Logging	Room-Scale Heater Test
Electric Surveys	Facility Thermal Response Monitoring
Underground Gravity Surveys	Room Backfill Test
Radar Probing	**Geohydrology**
Seismic Surveys	Single Borehole Hydraulic Conductivity Test
Seismicity Monitoring	
Block Sampling (for Laboratory Testing)	Cross-Hole Hydraulic Conductivity Test
Geomechanics	Cross-Hole Tracer Test
In Situ Stress Measurement	Tracer Diffusion Test
Borehole Pressuremeter/Jacking	Borehole Seal Performance Test
Borehole Condition/Convergence Monitoring	Room Seal Performance Test
Torsional Shear Test	Brine Migration Test
Acoustic Emission Monitoring	Grout Injection Test
Mine-by Test	Facility Hydrological Response Monitoring
Rock Bolt Pullout Test	
Facility Mechanical Response Monitoring	**Geochemistry**
	Formation Fluid Sampling

Table 4-15. Equipment for Testing Stage, Richton Dome

Phase (Time Period)	Equipment No.	Equipment Name	Equipment hp	Peak Cumulative hp
TESTING (3 years)	4	Auxiliary fans	25	-
	1	Vent fan	300	-
	1	Vent air conditioning system	1,200	-
	1	Hoist	500	-
	1	Compressed air system	200	-
	-	Test equipment	80	-
	-	Heaters	260	-
	1	Forklift	50	50
	1	Shop (Subsurface)	80	-
	2	Core drills	50	-
	1	Dewatering system	85	-
	1	Scooptram (2 cu yd)	100	100
	1	Utility truck	100	100
	1	Crane	180	180
	1	Shop (Surface)	150	-
	1	Oiler	200	200
	2	Pickup trucks	135	270
				900

4.1.2.4.1 Subsurface Backfill. The subsurface backfilling would begin by setting up a bulkhead in the center of the connection drift and working back to both shafts. The procedure would begin with the backfilling of the test alcoves and fill setup areas that are farthest from the shaft station. Previously excavated salt stored above ground in the salt storage stockpile area would be transported by truck from the stockpile back to the headframes, and loaded into crusher units to reduce the salt to an acceptable size for transport down to the shaft stations. Backfilling of the drift areas by using a pneumatic stowing system will ensure that all void areas will be filled to approximately 65 percent of the original in situ salt rock density. This will facilitate proper roof support and ground stabilization for the test alcoves, fill setup areas and main access drifts.

As the farthest drift areas are completely backfilled, the pneumatic stowing operation will continue working back to the shafts until the subsurface drift area has been completely backfilled, including the shaft stations and sump areas. Pneumatic stowing will continue placing crushed salt in the unlined portion of the shafts to the bottom of the lining of each shaft. Excess salt will be disposed of off site.

Concrete plugs with polymer seal rings will be constructed at the location of the manually placed seals at the bottom of the lining of each shaft. A keyway will first be cut into the shaft walls. The concrete plugs will then be poured into place.

4.1.2.4.2 Shaft Backfill. After the concrete plugs are in place, the remaining sections of the shafts will be backfilled. The backfill material to be used in the shafts will be salt contaminated mined material to the base of the potable aquifer. Concrete plugs with polymer seals will be located at the base of the potable aquifer and will isolate the salt contaminated backfill. Above the plugs, non-salt-contaminated mined materials will fill the parts of the shafts which extend through the potable aquifers to within approximately 5 meters (17 feet) of the surface ground elevation.

Final concrete plugs will then be constructed. These plugs will be approximately 3 meters (10 feet) thick. The remaining 2.1 meters (7 feet) above the plugs will be backfilled with the surface material and topsoil. The plugs will be designed to withstand the overburden and any planned activity that will be conducted over them in the future and to prevent the seepage of ground waters into the abandoned, backfilled shafts.

4.1.2.4.3 Hoist and Headframe Removal. When shaft backfilling operations are complete, equipment will be removed from the shaft collar areas. The headframe foundations, structural steel supports and shaft collars will be removed to a depth of 2.1 meters (7 feet) below the final reclamation grade and backfilled with the surface material and topsoil. The final concrete seals and caps will be below the root zone of crops and the normal cultivation zone.

4.1.2.4.4 Surface Storage Area Decommissioning. The drainage system around the shafts, which empties into the storage area, will be kept intact until backfill operations have been completed. The mined materials stockpiled in the storage areas that are not used as backfill will be removed from the site and disposed of in an offsite permitted landfill as needed.

The sediment pond will be maintained throughout the reclamation period until the disturbed area is restored, vegetation requirements met and all drainage entering the basin meets the applicable State and Federal water quality requirements. The sediment pond will be reclaimed after final site grading, soil stabilization and revegetation.

The evaporation/retention pond will remain functional until all the stockpiled material is removed and all associated salt contaminated soil is properly disposed of. The concrete pavement around the shaft houses and service buildings and the subsurface drainage system will be removed before the evaporation/retention pond is reclaimed. Fluids in the pond will be reduced by evaporation and residuals transported to an acceptable disposable area.

The liner under the storage area will be removed and will be handled so it does not contaminate the soils beneath it. Once the material and liner are removed, the pit will be backfilled with acceptable material and graded to a final configuration consistent with the surrounding topography and land-use patterns.

Additional evaluations of these options and any other option available are required before the preferred salt-disposal alternative is identified.

4.1.2.4.5 Equipment and Building Salvage. Salvageable items will be separated, stockpiled in a protective manner, and prepared for offsite salvage. All buildings and structures will be emptied of their contents, disassembled, and trucked off site. All unsalvageable items will be disposed of in an appropriate landfill.

All underground utilities less than 61 centimeters (24 inches) from final reclamation grade will be removed from the site. Utilities that are buried at depths greater than 61 centimeters (24 inches) will be left in place unless they are considered a hazard or would preempt future land-use plans. The sewage treatment facility and system will be removed and salvaged, or disposed of in an appropriate landfill.

4.1.2.4.6 Excess Salt Disposal. Approximately 65 percent of the salt excavated from the exploratory shaft and subsurface test areas will be required for backfilling the shaft and underground facility if the site is not selected for use as a repository. The variety of options currently being evaluated for the disposal of the remaining 35 percent (Section 4.3.4.2) includes the following:

- Commercial disposal
- Ocean disposal by dumping solid salt
- Land surface disposal at the exploratory shaft site
- Subsurface disposal in abandoned mines
- Surface disposal at the site of existing mine tailings
- Subsurface disposal through brine injection.

Federal, State, and local officials have been contacted about the disposal of salt and salt contaminated wastes. It was concluded that these wastes can be disposed of in licensed commercially operated hazardous waste facilities. There is more assured capacity in these commercially operated facilities than there is in either nonhazardous commercial facilities or those operated by local units of government.

A viable hazardous waste management facility for disposal of salt and salt contaminated wastes at the Richton Dome site is located near Emelle, Alabama. The distance to this licensed facility from the Richton Dome ESF site is approximately 175 to 210 kilometers (110 to 130 miles) to the east.

This facility will have assured capacity for at least 10 years. Cells are excavated, double lined, and incorporate a leachate collection and monitoring system to meet the applicable standards for hazardous solid waste disposal sites.

The transportation route selected from the Richton Dome ESF site to the facility is from Richton Dome to I-59 to I-20 to Alabama Route 17 to Emelle, and local routes to the site. Excess salt and salt contaminated material that is transported can be contained and cleaned up relatively easily should a traffic accident occur. Long-term adverse effects will not persist after cleanup, given the nature of the material. Proper loading and protection of the load from wind during transport will minimize adverse effects from routine operations.

4.1.2.4.7 Refuse and Site Cleanup. Waste generated during construction and testing of the ESF includes sewage treatment effluent; combustible solids, such as paper and cartons; and excavated solids other than salt. These wastes are not expected to be hazardous. The sewage treatment facility will be designed so that the effluent can be discharged to surface waters or used on site for nonpotable purposes.

An identified option for the disposal of nonhazardous construction wastes is in a licensed landfill. Mississippi has no licensed nonhazardous industrial solid waste landfills. The nearest licensed facility that can accept ESF site construction wastes is the licensed hazardous waste facility located near Emelle, Alabama, described in Section 4.1.2.4.6, Excess Salt Disposal.

4.1.2.4.8 Final Grading, Topsoil Replacement, and Revegetation. Grading and backfill may commence in a sequential fashion as various areas of the site are decommissioned or in accordance with applicable procedures specified by regulating agencies. The planned preparation and development of the site was based on performing minimum grading and earth moving to provide adequate drainage and acceptable slopes. Fill used during site development will be graded and come from the stockpiled materials excavated from the ponds, pits, and site areas.

The site will be regraded to a configuration consistent with the surrounding topography. Stabilized areas will be disked and stockpiled material replaced. When a road or pad is to remain for continued use, the surrounding surface grading and the associated drainage structures will also remain. Adjacent areas will be blended to provide surface drainage in a condition suitable for continued use.

Backfilling is to be accomplished in a manner that minimizes the movement of earth and dust generated by the grading activity. Once backfilling and surface grading have been performed, the topsoil will be replaced and graded to final contour to blend as nearly as possible with the natural topography.

Regraded subsoil will be scarified prior to topsoil redistribution to ensure adhesion of the topsoil layer to the subsoil. Topsoil material will then be replaced over the disturbed areas to a depth corresponding to the amount removed from any given area. The area will be mulched with clean straw or cotton gin waste at the rate of 6.7 metric tons per hectare (3 tons per acre) to provide protection from wind and water erosion. At the first appropriate season, the site area will be seeded. Fertilizer requirements have been addressed in Table 4-7. Actual types and quantities of fertilizer and water requirements will be influenced by time of planting, sodding, seeding and rainfall amounts. Procedures will follow recommended and acceptable agronomy practices.

The equipment used for the final disposition phase is listed in Table 4-16. The projected consumable resources for final disposition are presented in Table 4-7. Vehicular traffic would increase from preproject levels by approximately 90 passenger vehicles per day and 45 trucks per month (Table 4-8).

4.1.2.5 Required Permits and Approvals

The DOE intends to comply with all applicable Federal, State, and local permits not inconsistent with its responsibilities under the NWPA. The DOE intends to consult with State and local officials concerning sites that are recommended.

4.1.2.6 Detailed Discussion of Exploratory Shaft Facility Waste Management

Waste disposal planning is based on an analysis of the types of wastes generated by ESF activities and a telephone survey to identify existing municipal and commercial disposal facilities.

Table 4-17 presents details important to waste management by type of waste. Column 5 identifies a feasible method of disposal for each waste. Existing permitted offsite facilities which appear available for disposal of ESF wastes are preferred over DOE-constructed facilities. Table 4-17 indicates the location of usable disposal facilities available for each waste. "Usable" means that it can lawfully accept wastes of the type generated, and can accommodate the volume of waste to be disposed. "Available" means the operator (or owner) have indicated that the DOE should be able to obtain the applicable permits or approvals necessary to use the facility.

Other existing disposal locations, at approximately the same distance indicated in the table, were not surveyed once a usable and available facility was identified for each waste. Therefore, selection of disposal facilities for the various types of waste will be deferred until after ESF site selection.

Eight waste disposal methods have been identified. Rubbish, defined to be combustible material containing not more than 20 percent garbage, can be reduced in volume by onsite

Table 4-16. Equipment for the Final Disposition Phase, Richton Dome

Phase (Time Period)	Equipment No.	Equipment Name	Equipment hp	Peak Cumulative hp
Subsurface Backfill (8 months)	3	Compressors	125	-
	2	Hoists	500	-
	1	Vent fan	300	-
	1	Vent air conditioning system	1,200	-
	1	Auxiliary fan	60	-
	2	Crushers	75	-
	2	Trucks	250	500
	2	Wheel loaders	270	540
	1	Crane	180	180
	1	Forklift	50	50
	1	Oiler	200	200
	1	Dozer	300	300
	2	Pickup trucks	135	270
				2,040
Shaft Backfill (8 months)	1	Compressed air system	200	-
	2	Hoists	500	-
	4	Stage hoists	40	-
	2	Vent fans	60	-
	2	Crushers	50	-
	2	Trucks	250	500
	2	Wheel loaders	270	540
	1	Dozer	300	300
	1	Crane	180	180
	1	Forklift	50	50
	1	Oiler	200	200
	2	Pickup trucks	135	270
				2,040
Hoist and Headframes Removal (2 months)	2	Cranes	180	360
	1	Wheel loader	270	270
	2	Trucks	250	500
	1	Compressor	100	-
	1	Pickup truck	135	135
				1,265
Storage Area Decommission (3 months)	1	Dozer with ripper	300	300
	2	Trucks	250	500
	1	Wheel loader	270	270
	1	Oiler	200	200
	1	Pickup truck	135	135
				1,405

Table 4-16. Equipment for the Final Disposition Phase, Richton Dome
(Page 2 of 2)

Phase (Time Period)	Equipment No.	Equipment Name	Equipment hp	Peak Cumulative hp
Equipment and Building Salvage (4 months)	2	Cranes	180	360
	1	Forklift	50	50
	2	Trucks	250	500
	1	Cherry picker	50	50
	1	Dozer	300	300
	1	Wheel loader	270	270
	2	Breakers	50	100
	1	Oiler	200	200
	1	Pickup truck	135	135
				1,965
Refuse and Site Cleanup (2 months)	1	Wheel loader	270	270
	1	Dozer	300	300
	1	Oiler	200	200
	2	Trucks	250	500
	1	Pickup truck	135	135
				1,405
Final Grading and Vegetation (6 months)	1	Grader	180	180
	1	Scraper	450	450
	4	Trucks	250	1,000
	2	Dozers	300	600
	1	Wheel loader	270	270
	1	Water truck	250	250
	1	Oiler	200	200
	1	Hydroseeder	100	100
	1	Pickup truck	135	135
				3,185

Table 4-17. Description of Wastes and Estimated Quantities Relating to Disposal, Richton Dome Site

Waste Type	Nature of Waste	Volume[b] Generated	Rate of Generation	Disposal Method[c]	Volume[d] Disposed (Truck Loads)	Location[e]
1. Rubbish[a]	Combustible with no more than 20 percent garbage. Non-hazardous.	13,400 cu yd	11.9 cu yd/ day	Offsite landfill. Disposed off site.	13,400 cu yd (638)	Rubbish hauled to permitted landfill within 30 miles near Laurel, MS[1].
2. Excavated Material, Non-Salt-Contaminated	Rock and unconsolidated material removed from the shaft which has not been intimately mixed with salt. Expected to be nonhazardous.	21,700 cu yd	160 yd^3/day	Used as backfill during reclamation; residual will be disposed in approved offsite landfill.	10,000 cu yd (476)	Emelle, AL; 110 miles from site.
3. Salt-Contaminated Rock	Rock and unconsolidated material removed from the shaft which has been intimately mixed with salt. Expected to be nonhazardous.	6,000 cu yd	160 yd^3/day	Used as backfill during reclamation; residual will be disposed in approved offsite landfill.	3,000 cu yd (143)	Emelle, AL; 110 miles from site.
4. Salt	Salt excavated from the target horizon. Nonhazardous.	134,000 cu yd	340 yd^3/day	Used as backfill during reclamation; residual will be disposed in approved offsite landfill.	53,000 cu yd (2,924)	Emelle, AL; 110 miles from site.
5. Potentially Salt-Contaminated Runoff[a]	Runoff from salt handling and storage areas and water pumped out of the mined shaft during construction. Expected to be nonhazardous.	12,215,000 ft^3	Varies with rainfall	Removed from site or injected.	9,100,000 ft^3	Can be disposed in facility near Laurel[1].
6. Domestic Wastewater[a]	Wastewater from human activities and vehicle washwater. Nonhazardous.	6,600,000 gal	4.1 gal/min	Treatment on site for non contractor staff; off site for contractor. Liquids discharged or reused for nonpotable purposes; sludges disposed off site.	6,600,000 gal	Discharged to drainage for onsite plant; municipal sewage plant for contractor.
7. Non-Salt-Contaminated Runoff[a]	Runoff from areas not contaminated by salt. Suspended solids reduced in sediment retention pond. Nonhazardous.	21,170,000 ft^3	Varies	Discharged from site.	19,300,000 ft^3	Discharged to drainage.
8. Miscellaneous[a]	Oils and other fluids drained from vehicles during maintenance, cleaners and solvents, and the like. Hazardous.	To be determined	To be determined	Collected and stored in drums for recycling or disposal at a permitted offsite facility.	To be determined	Emelle, AL; 110 miles from site[2].

(a) Waste streams expected to continue through testing at the following generation rate:
Rubbish - 15 lb/person/day
Potentially salt-contaminated runoff - 3,960,000 ft^3/yr (91 acre-feet)
Domestic wastewater - 35 gal/cap/day
Non-salt-contaminated runoff - 158 acre-feet per year
Miscellaneous - to be determined.
(b) Estimated total volume generated through end of expanded underground excavation.
(c) Most reasonable method based on information currently available.
(d) Remaining volume after allowing for backfill or discharge as appropriate.
(e) A facility which has capacity and accepts wastes of the type generated is located at or within distance indicated. References to cities does not imply any landfill has agreed to accept ESF generated waste, now or in the future.

Sources: (1) Sullivan, 1984.
(2) Walton, 1984.

incineration. However, current plans call for disposal of rubbish in an offsite permitted sanitary landfill.

The volume of excavated solids to be disposed of is reduced by using this material for backfilling the underground workings and shafts if the site is to be decommissioned. If the site is selected for a repository, this material would be included in repository planning. There are few limitations on the disposal of excavated material that is not contaminated by salt or brine. It was assumed that all material would be disposed of off site.

The ESF is designed to control runoff volume of a 500-year storm that could be contaminated by salt. Runoff from the area around the headframe, where salt may be spilled, is directed to the evaporation/retention pond. This pond, designed to accommodate a 500-year storm event, also collects runoff from the storage area. A concrete apron around the headframe will facilitate cleaning up salt spills to minimize the potential for contamination. The water collected in the evaporation/retention pond is expected to have a low ionic content once the salt storage pile has been formed and the contents exposed to atmospheric conditions. Water will be discharged from the evaporation/retention pond only if testing verifies that it meets applicable discharge criteria. If it does not meet discharge criteria, the water will be trucked to a permitted offsite disposal facility. If chronic elevated ion concentrations are detected, improved house cleaning, covering the salt pile, isolating salt pile runoff or other management techniques will be investigated. Runoff from the site, where salt handling has not occurred, will be directed to a sediment pond. The accumulations of solids in both the evaporation/retention and sediment detention ponds will depend on actual suspended solids concentrations, evaporation rates, etc. The solids will be disposed of, as required, in offsite facilities.

Domestic wastewater will be contributed from commodes. These wastes will be treated in an onsite sewage treatment facility. Effluent from the wastewater treatment facility will undergo tertiary treatment consisting of duplex dual media gravity filters. Such treatment will reduce effluent suspended solids to approximately 1 milligram per liter and produce an effluent containing not more than 20 milligrams per liter Biochemical Oxygen Demand (BOD). Any liquid discharge to surface systems will meet permissible levels for such discharge. Construction contractors will provide chemical toilets for their employees and truck the waste to an offsite treatment plant.

The only wastes generated at the ESF which will be classified as hazardous will be oils, thinners, solvents and lubricants. These wastes were not included in the waste report and their volume has not been estimated. If a recycling facility is not readily available, these fluids can be disposed in hazardous wastes landfills as indicated in Table 4-17.

4.1.3 Other Activities

This section describes other site-specific investigations that will be performed in conjunction with site characterization, including environmental and socioeconomic studies. Many of these activities will begin before the construction of the exploratory shafts. The total onsite work force for environmental and socioeconomic activities would range from 4 to 20 persons.

This section has two objectives. The first is to describe the type and extent of environmental and socioeconomic field studies and site activities to allow identification of potential impacts arising from these activities.

A second objective is to describe briefly the planned environmental and socioeconomic studies. These studies are predicated on information needed to satisfy diverse requirements for the following:

- Permit and statutory compliance information for site characterization activities
- Monitoring of site characterization impacts

- Development of monitoring and planning reports on the effects of site characterization
- Analyses of the repository and the site to determine safety
- Analyses of the repository and the site for evaluation against the DOE guidelines (10 CFR Part 960)
- Determination of engineering design parameters for the exploratory shaft facility (ESF) (final design) and for the repository
- Determination of existing environmental and socioeconomic conditions to satisfy the needs of the Environmental Impact Statement.

After the Environmental Impact Statement scoping hearings, environmental studies for the EIS will be devised and implemented.

Regulatory agencies and the public will have specific opportunities to comment on the design of the environmental and socioeconomic studies during the permitting process.

The scheduling of the environmental field studies is tied to the activities described in Sections 4.1.1 and 4.1.2, and is shown in Figure 4-16. The 10 months between site selection and the beginning of scheduled ESF site clearing provides adequate time to collect data on existing environmental and socioeconomic conditions undisturbed by ESF construction. The initial period without any site activities allows qualitative biological surveys and archeological field work. Subsequent to this period, but prior to the start of the ESF, borehole drilling activities and geophysical surveys will be conducted. Neither of these activities is expected to significantly interfere with environmental and socioeconomic field data collection.

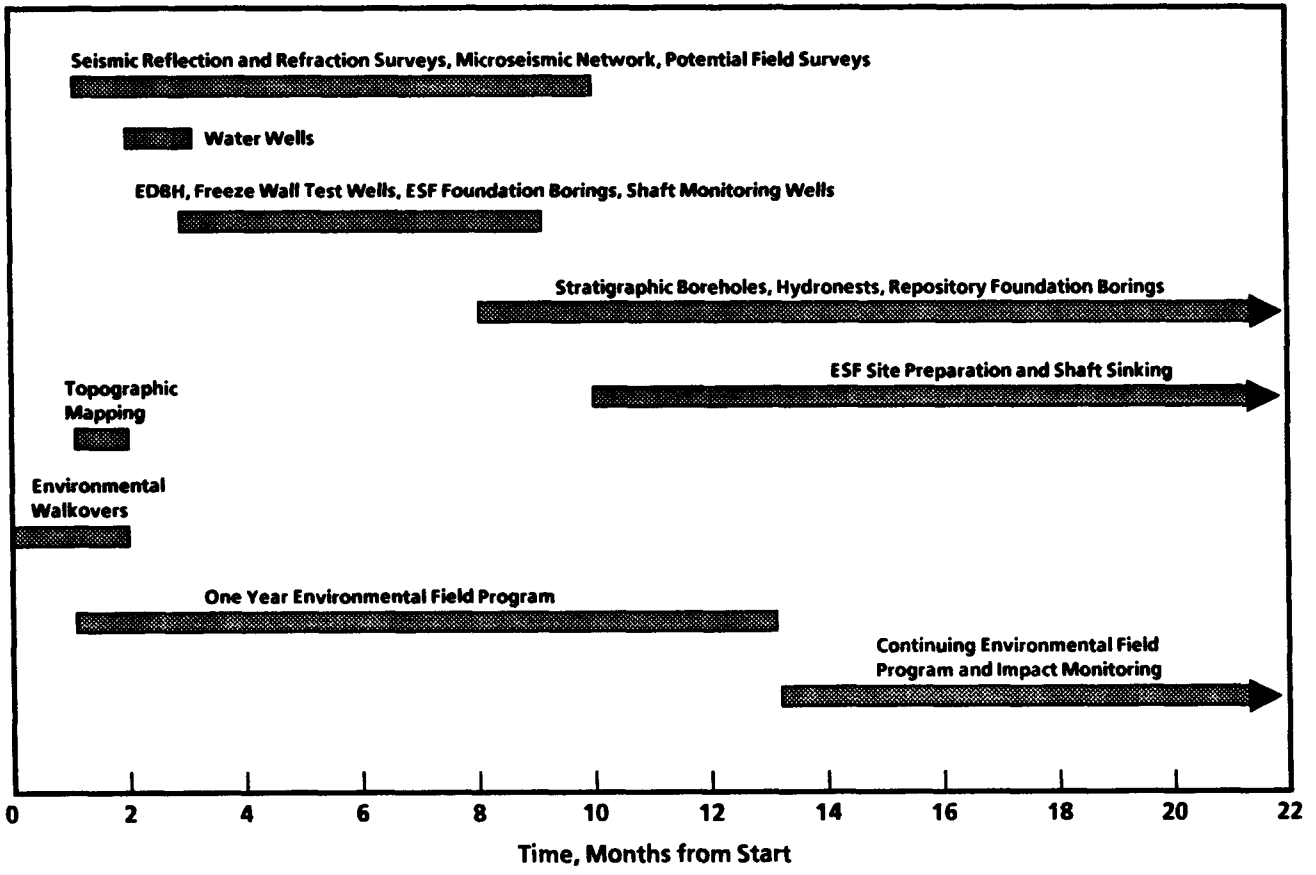
4.1.3.1 Environmental Field Studies

This section describes environmental studies to be conducted during site characterization, including studies of land use and mineral resources; terrestrial and aquatic ecosystems; meterology and air quality; hydrology and water quality; soils; noise; aesthetic resources; archaeological, cultural, and historical resources; radiological levels; and transportation and utilities.

4.1.3.1.1 Land Use and Mineral Resources. The initial purpose of these studies is to document specific land uses to allow for the layout of utilities and roads to the repository site, and to determine whether there are sensitive land uses that need to be protected during repository development. This land-use determination, to a radius of 80 kilometers (50 miles) will support repository safety analyses, which in turn also determine repository design.

The land-use study will expand the existing data base described in Section 3.4.1 by acquiring detailed information on existing and planned uses at the site and in proximity to the site. Additional data to be collected include the following:

- Extent of land-use areas, including agriculture (e.g., crop type), forestry, pastureland, public areas, and built-up areas
- Productivity for each land use (e.g., crop yields, grazing capacities)
- Soil survey to identify prime farmland
- Economic value of harvested crops and livestock
- Land ownership
- Current oil and gas and other mineral commodity production.



Relationship of Environmental Field Program to Geotechnical and Exploratory Shaft Programs Richton Dome Site

Figure 4-16

Data will be based on the interpretation of aerial photographs, supplemented by site reconnaissance and review of data from local planning agencies and other resource agencies. Geologic data obtained from site characterization will be reviewed for indications of mineral resource potential. The study areas to be examined are presented in Figure 4-17.

4.1.3.1.2 Terrestrial and Aquatic Ecosystems. These studies serve two purposes. The first purpose is to conduct biological surveys of the site for evidence of species protected by Federal and State statutes. The second purpose is to perform a quantitative assessment of biological pathways for repository safety studies and repository design work. Terrestrial and aquatic studies will be conducted in two separate programs: (1) monitoring of areas affected by field activities (Section 4.1.1), and (2) seasonal ecological studies in areas affected by construction of the exploratory shafts (Section 4.1.2) and by potential repository development (Section 5.1), and at selected control stations.

Prior to initiation of geologic and hydrologic borehole drilling or other land disturbing activities described in Section 4.1.1, a site reconnaissance for threatened and endangered species will be conducted at each activity location. Each reconnaissance will require a plant ecologist and a wildlife ecologist to investigate both the area to be disturbed and a surrounding buffer strip of a minimum of 61 meters (200 feet), depending upon duration and intensity of the proposed activity. If threatened or endangered species or their habitats are identified at each location, discussions will be conducted between the DOE and the Fish and Wildlife Service to modify the field activities or in some other way provide adequate mitigation for the species of concern.

The seasonal studies of the exploratory shaft facility area, the controlled area, and access corridors will be detailed ecological baseline studies designed and implemented to fully characterize existing conditions in these areas. The U.S. Nuclear Regulatory Commission (NRC) Regulatory Guides 4.2 (1976) and 4.11 (1977) will be used to guide the field baseline programs. The studies will focus on qualitative and quantitative assessments of existing terrestrial and aquatic ecosystems. A comprehensive radiological program will be integrated into these studies for an evaluation of radionuclide uptake and content in edible crops and natural vegetation, livestock, wildlife, milk, and components of the aquatic ecosystems.

The seasonal ecological study will identify seasonal variation in major habitat type within the study area and associated variation in species occurrence and abundance. Site-specific information relative to species lists and associations will be generated with particular emphasis given to threatened and endangered species. Control locations, selected in adjacent areas of comparable physiognomy where no project impacts are anticipated, will serve as reference locations for an assessment of project-related impacts.

Terrestrial Ecology. The terrestrial field program will survey and sample all major components of the terrestrial ecosystem. The focus of the field program will be a complete ecological description, including species composition, population abundance, location and extent of vegetation types and wildlife resources, successional stage of plant community, wildlife movement patterns, preferred habitats and habitat requirements, trophic structure and productivity, and preexisting environmental stress.

Vegetation studies for site-specific information will utilize aerial photography with ground-truth surveys for development of vegetation-habitat maps (forest, wetlands, etc.), including detailed information on species composition within each identified plant community or association (occurrence and relative abundance). Existing aerial photos will be interpreted and supplemented with additional flyovers if necessary. Approximate sampling locations are presented in Figure 4-18.

Faunal surveys will be conducted to provide supplementary information on species presence, abundance, seasonal distribution, and important ecological interrelationships. Standard field sampling techniques will be used for these studies including trapping of small-to medium-sized mammals, spotlighting for large mammals, auditory and visual surveys of birds, and trapping and visual surveys of reptiles, amphibians, and invertebrate species. The local

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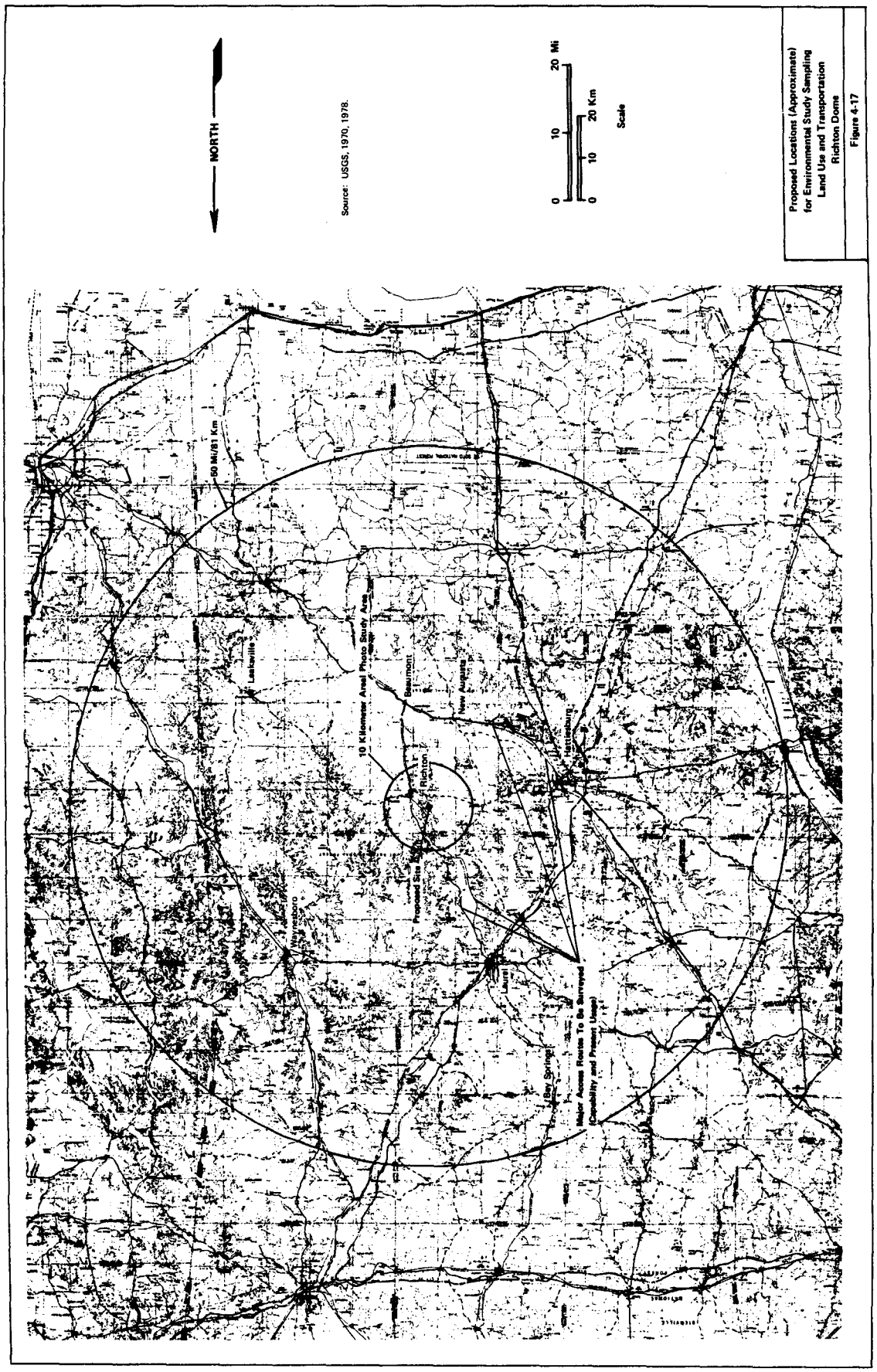
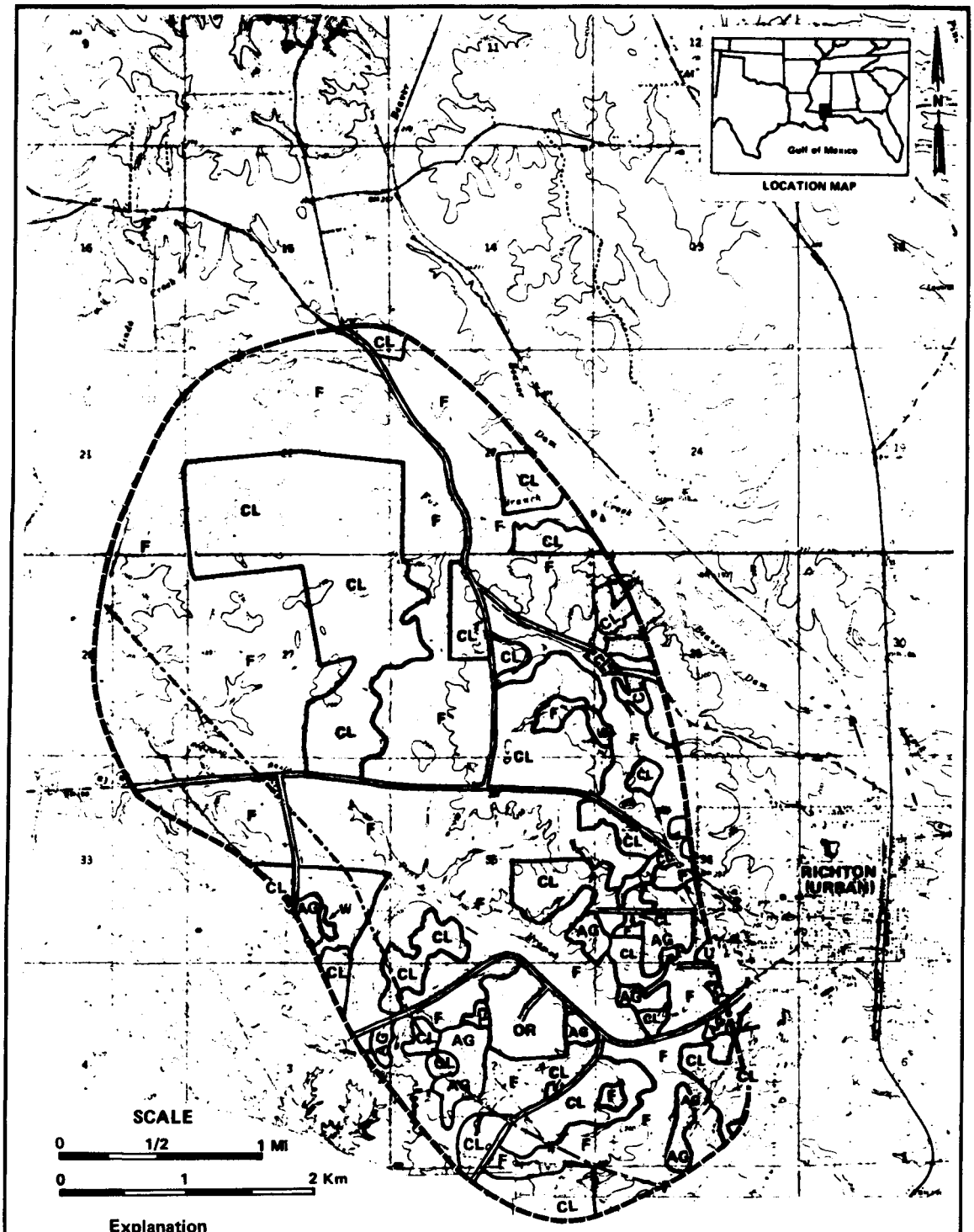




Source: Airborne Systems, Inc., 1983.

Proposed Locations (Approximate) for Environmental Study Sampling Biota/Ecosystems Richton Dome

Figure 4-18

value of wildlife to sport, commercial, and recreational users will also be evaluated in part through contacts with local resource agency personnel.

A program to monitor salt impacts on components of the terrestrial ecosystem will be established. Test plots established near and distant from the salt pile (see Figure 4-19) will be intensively studied. Before, during, and after salt excavation, the salt conditions and biotic responses in the test plots will be monitored.

Aquatic Ecology. An aquatic ecology baseline program will be conducted concurrently with the terrestrial program. This program will serve to characterize existing aquatic ecosystems within and downstream from the Richton Dome area. Control sites located in upsteam aquatic systems will also be established to allow a comparison of project-induced changes with natural changes in community structure.

Data collection efforts will focus on defining species composition, distribution, age structure, and relative abundance of important game and nongame fish species, including those of commercial value. Any evidence of preexisting environmental stresses, such as pollution, disease, parasitism, or overfishing, will be determined.

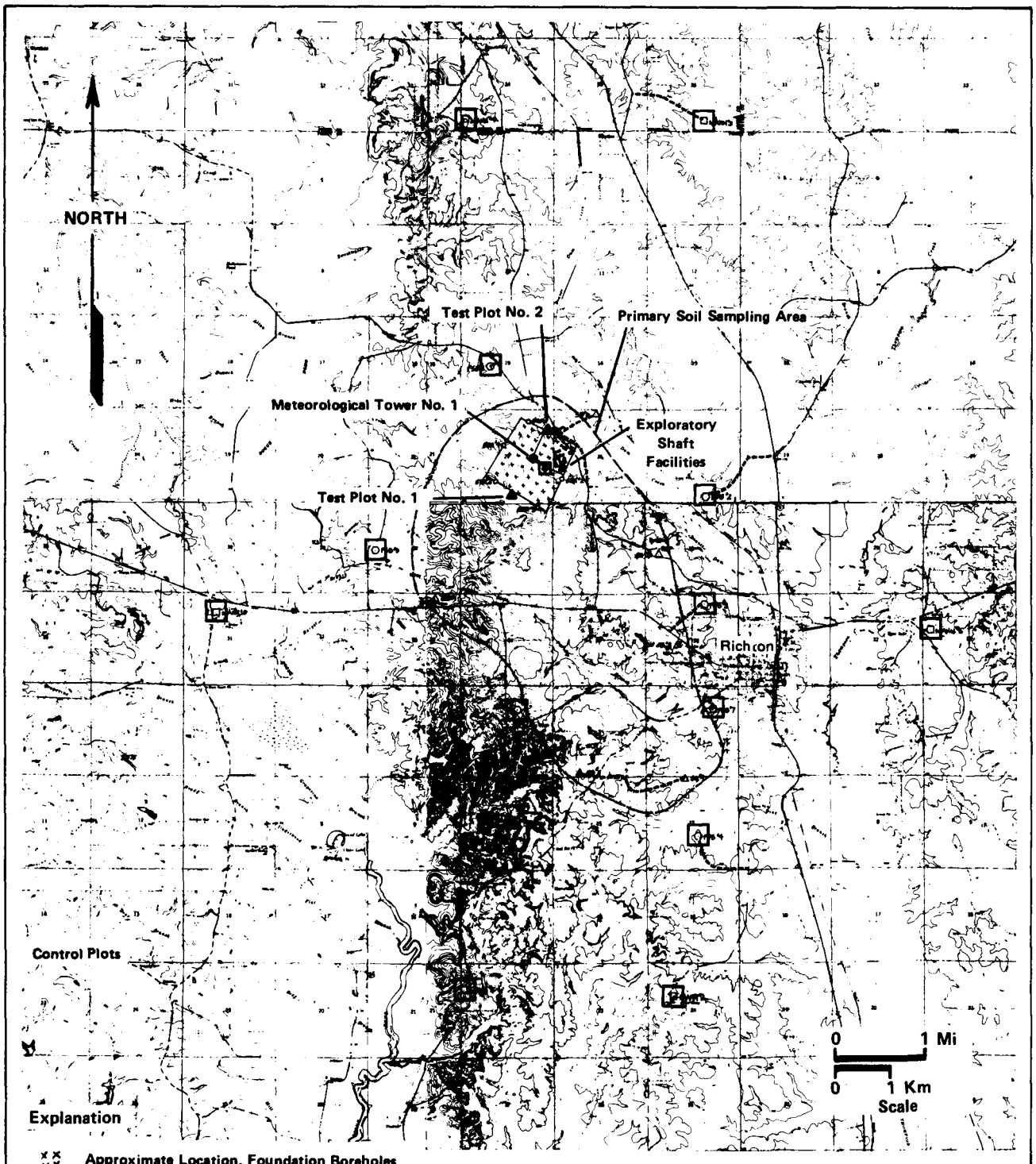
Aquatic macroinvertebrate and macrophyte surveys will be performed along with the fish surveys to assist in evaluating the quality of existing habitats. Species lists will be compiled and indices of diversity and abundance subsequently computed. Biological studies and study sites will be coordinated with water quality studies where possible, but ancillary measurements of water quality and various physical parameters may be required during biological sampling efforts. Aquatic communities will be sampled using standard techniques such as electrofishing, seining, and gill-netting for fish (EPA, 1973).

A field program will be implemented to obtain information regarding the biological characteristics of the local aquatic environment. Biological water-quality parameters such as phytoplankton and indicator organisms will be sampled. Physical and chemical surface-water data will be collected during the surface-water field program. In addition, the locations of point and nonpoint sources of pollution will be identified, and data on temporal variations, quantities, and characteristics of pollutants will be presented.

4.1.3.1.3 Meteorology and Air Quality. The immediate need for onsite meteorology data is to satisfy information requirements for the design of the repository. Depending upon State agency requirements, local meteorology and/or air quality data will likely be required for permitting of site characterization activities. Air flow patterns and atmospheric stability will be studied on a continuous basis with a 60-meter (197-foot) meteorological tower similar to that described in NRC Regulatory Guide 1.23 (1980). The meteorological tower and instrument building will require a secured site of approximately 0.4 hectare (1 acre) of land. The site will be cleared to minimize air frictional effects. Due to the relatively flat terrain surrounding the site, only one tower is required. The location of the planned tower is shown in Figure 4-19.

Meteorological parameters to be monitored at the station will include wind direction, wind speed, and temperature at two or three levels; dewpoint temperature; precipitation; incoming sunlight; and barometric pressure. Additional meteorological data will be collected from records available from the National Weather Service and nearby weather stations.

Air quality monitoring may be conducted to obtain estimates of background concentrations of all atmospheric contaminants regulated by the "National Primary and Secondary Ambient Air Quality Standards" (40 CFR Part 50) (NAAQS) and the Mississippi Air Pollution Control Regulations (MAPCR) (Mississippi Air and Water Pollution Control Commission, 1983). These regulations are discussed in Section 3.4.3.1. Federal Prevention of Significant Deterioration of Air Quality (PSD) regulations (40 CFR 52.21), if applicable, would require 1 year of onsite meteorological data. Air quality parameters such as total suspended particulates, PM_{10} particulates, sulfur oxides, nitrogen oxides, carbon monoxide, ozone, and lead will be measured and monitored.



Approximate Location, Foundation Boreholes

10 Acre Soil Sampling Area For Remote Boreholes
(4 Samples Per Borehole Location)

Salt Particulate Monitoring Station

*Note : Radiological monitoring (i.e. grab samples and pole mounts) will coincide with these and other mapped sampling locations.

Source: USGS, 1973.

Proposed Locations (Approximate) for Environmental Study Sampling Soils, Radiological, Meteorological/ Air Quality, and Salt Impacts Richton Dome

Figure 4-19

All gaseous pollutants will be monitored on a continuous basis on a schedule agreed to with the permitting agencies.

Information from the onsite meteorological and air quality monitoring station and recent nearby air quality and meteorological records will be used to describe the site with respect to the following:

- The influence of terrain on meteorological factors
- Monthly and annual joint frequencies of wind speed and direction by atmospheric stability class
- Total precipitation (rain and snow) by month, the number of hours with precipitation, and the rainfall rate distribution
- Ambient air quality
- Cumulative frequency curves of monthly average precipitation and evaporation
- Estimates of the wind erosion index
- Monthly and annual joint dry-bulb air temperature, vertical temperature difference, and dew-point temperature summaries, including averages, measured extremes, and diurnal range.

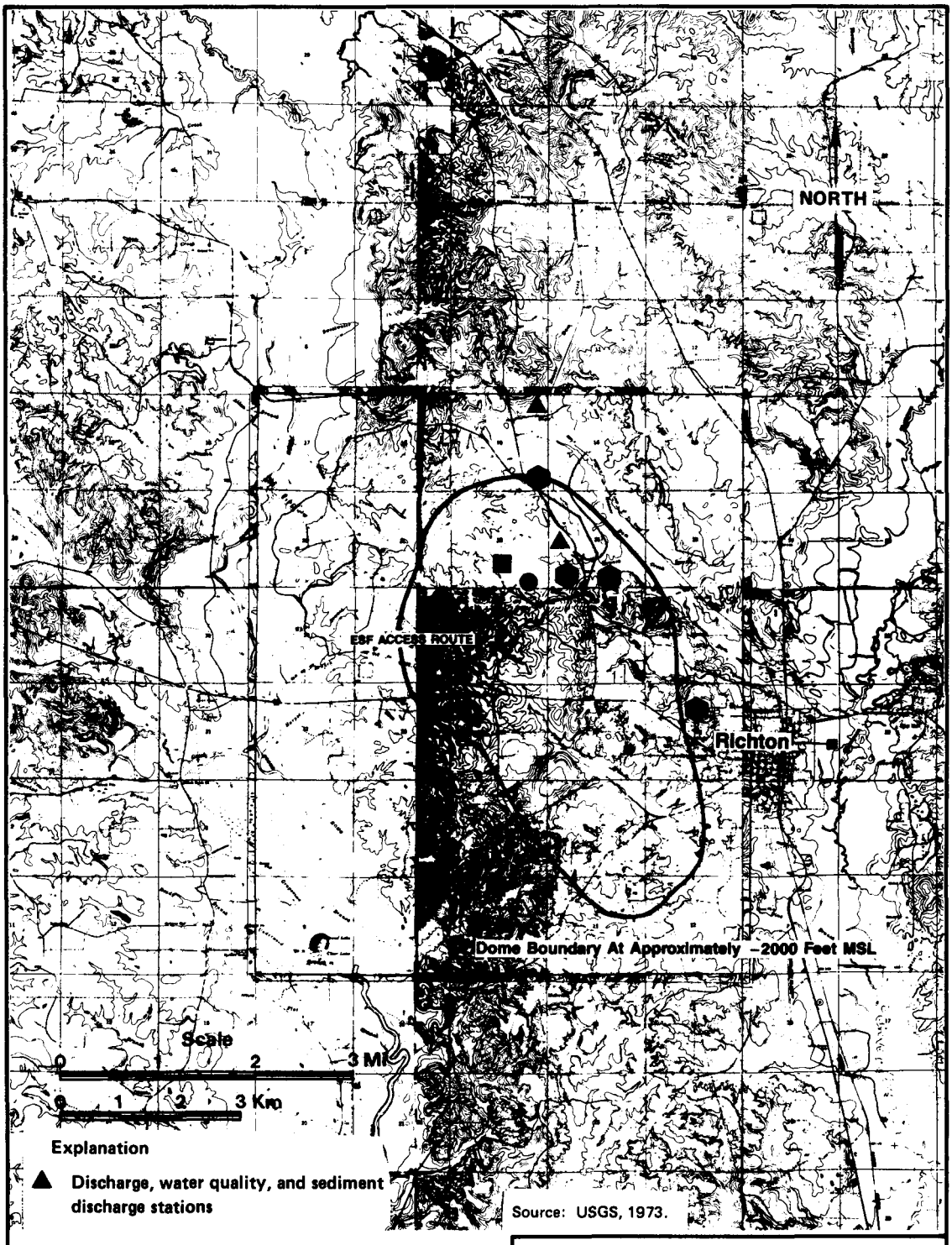
4.1.3.1.4 Hydrology and Water Quality. An intensive field investigation and data collection program is planned to define the hydrologic and water-quality conditions of the area, monitor the impact that site characterization activities and future repository operations may have on the streams draining the Richton Dome, and identify site-specific mitigation measures. Detailed characterization of the hydrologic regime and water quality of the surface water will include a program of stream gaging, discharge measurements, and water quality sampling and analysis. Initial studies will collect data to satisfy National Pollutant Discharge Elimination System (NPDES) permitting requirements for site characterization activities, and to support additional floodplain analyses for the repository design. Subsequent studies will include monitoring according to the provisions of the NPDES permit and to confirm the floodplain analyses.

Continuous-recording stream-flow gaging stations (Figure 4-20) will be established at selected locations along the streams draining the dome area. Periodic discharge measurements will be taken over a range of flow conditions to establish a rating curve at each of the gaging locations.

Five water-quality sampling stations are proposed for Richton Dome. Suggested stations are located on the ephemeral Fox Branch Creek, which drains the project area, Linda Creek and Beaver Dam Creek. These three are generally located down the prevailing wind from the site, and one is coincident with U.S. Geological Survey water stream flow station 02474798. Additional grab sampling will be performed in support of aquatic ecology studies.

Water quality sampling will be conducted at all stream gaging stations selected for the surface-water study (Section 4.1.1.1.1) and at various additional monitoring stations throughout the study area. The water quality sampling program will include water sampling for analyses of general chemical, physical, nutrient, and organic parameters on a monthly basis, while bimonthly samples will be collected for analyses of trace metals and radioactive elements. Suspended sediment samples will be obtained on a monthly basis.

Final locations of the stream gaging and water-quality sampling stations will be determined during the startup field reconnaissance. Sampling locations will be selected on the basis of factors such as accessibility, hydraulic conditions at the site, and existence of bridge crossings that facilitate the stream gaging and water-quality sampling effort. These



Proposed Locations (Approximate) for Environmental Study Sampling Sound Levels and Water Resources Richton Dome

Figure 4-20

field studies will be coordinated with the surface hydrologic characterization studies (Section 4.1.1.1.1) and the aquatic ecology baseline studies (Section 4.1.3.1.2).

Ground-water-quality samples will be obtained from existing wells in the vicinity of the site. The same parameters sampled for surface water will be sampled for ground water using standard techniques. Geohydrologic properties of the aquifer and water-quality samples of the deep aquifers will be obtained from the geotechnical field studies program as part of site characterization (see Section 4.1.1).

The surface-water-quality and ground-water-quality field study will require access and entrance to private or State lands to sample wells or surface-water bodies.

4.1.3.1.5 Soils. The purpose of these studies is to provide repository and ESF design data. Specifically needed are shallow soil engineering property data, data on soil depth and classification (to allow development of a stripping/stockpiling/reclamation plan), and data on soil hydrologic properties (to estimate and mitigate soil erosion). Information on soils will be obtained for the controlled area by conducting a standard soil survey. The survey will use the the methods of the U.S. National Cooperative Soil Survey Handbook No. 18 (Soil Survey Staff, 1951), and Soil Conservation Service Handbook 436 (1975). General soil survey locations are presented in Figure 4-19.

Soils in the dome area will be mapped with respect to soil type and character. Shallow (1.5 meters [5 feet]) hand augering will be performed to obtain data on soil characteristics such as texture, color, and calcium carbonate percentage, volume of coarse fragments, and depth to a limiting layer. Field estimates will be made of permeability, drainage, and structures. Slope, aspect, nature, and extent of natural vegetation will be recorded. Cropping history for cultivated soils will be estimated for each mapping unit.

4.1.3.1.6 Noise. Several goals are established for the noise field program. The first goal is to determine existing background sound levels. The second is to collect site-specific sound attenuation (propagation) data for calibration and validation of noise propagation models to be used in future noise analyses. The third is to monitor sound levels from site characterization activities and repository development in order to determine the effectiveness of noise control measures and to determine the need for further mitigative measures. Studies are necessary to determine ambient noise levels that exist prior to construction and other site-disturbing activities. A survey of general sound levels in the repository area will be made using sound measuring equipment to take 24-hour measurements at locations such as proposed in Figure 4-20. The survey will identify noise sources and characterize the sound environment at the repository site and at noise-sensitive areas near the site. Measurements will be made for day and night during each quarterly period and include A-weighted and octave band sound pressure levels. Further measurements will be taken to evaluate the noise attenuation effects of forests and vegetation.

Seasonal sound measurements will be conducted during some of the field characterization studies and during some phases of ESF construction using portable sound measurement equipment. These measurements will identify areas that may require mitigation measures.

4.1.3.1.7 Aesthetic Resources. An inventory of visual resources at and near the site and along transportation corridors will be performed as a basis for determining site-specific visual impacts and for developing mitigation measures. Field studies to determine the potential visual impacts associated with repository construction, operation, and decommissioning activities will be conducted. Potential impacts attributable to dust plumes and to transportation and utility corridors will be identified and evaluated.

4.1.3.1.8 Archaeological, Cultural, and Historical Resources. Intensive cultural resource surveys will be conducted in the project area, pursuant to the requirements of the Programmatic Memorandum of Agreement between the DOE, the Mississippi State Historic Preservation Officer (SHPO), and the Advisory Council on Historic Preservation. Studies that will be coordinated with the State Historic Preservation Officer may include the following:

- A pedestrian survey of 100 percent of the areas occupied by the exploratory shaft, access routes, and those parts of the study area which are judged to have probability of containing prehistoric and early historical cultural resources

- A pedestrian survey of a sample of the remainder of the study area to test the proposition that the area has a low probability of containing prehistoric and early historic sites

- An intensive archival and information search to identify important historic sites in the study area, followed by a reconnaissance survey of the historic site locations identified.

The goals of these investigations will be to locate all cultural resources in the areas surveyed, to assess the significance of the resources located, and to make projections concerning the number, kind, and significance of the resources located. Projections of the number, kind, and significance of resources in areas not surveyed will also be made. In addition, recommendations for further cultural resources work will be provided.

The results of the surveys will be used to determine the location and significance of cultural resources that may be affected by repository activities.

4.1.3.1.9 Radiological Background. A radiological baseline sampling program will be established to evaluate background radiation levels in and adjacent to the dome area. The initial purpose of this program is the development of safety analyses to determine repository design. Subsequent work would support the repository license application to the NRC. Preoperational radiation surveillance of the environment will be carried out for 1 year prior to site development in order to

- Identify the probable critical exposure pathways
- Identify affected geographical areas
- Characterize sample media and sample site locations
- Interpret data to determine background levels.

Collection of samples will be coordinated with the soils, ecosystems, water quality, and air quality monitoring programs as discussed below and as shown on Figure 4-19.

Soils. Samples will be collected (Section 4.1.3.1.5) to measure radionuclides in the soil. Livestock feed, grains, and edible crop areas will be included in the sample locations.

Terrestrial and Aquatic Ecosystems. Radiological analyses of background radiation conditions in terrestrial and aquatic ecosystems will be integrated into the ecosystem program described under Terrestrial and Aquatic Ecosystems (Section 4.1.3.1.2). These studies will emphasize radionuclide uptake and content in important food chains (including edible crops and vegetation, livestock, wildlife, milk, fish, invertebrates, benthic sediment, and plankton).

Surface and Ground Water. Surface- and ground-water samples will be collected and analyzed for radionuclide contamination in conjunction with the water quality program (Hydrology and Water Quality, Section 4.1.3.1.4). Surface water samples will be taken upstream and downstream from the site. Ground-water samples will be taken upgradient and downgradient from the site. Several stations will measure domestic water supplies as well as recreational areas of lakes and rivers.

Air and Precipitation. The background radiation monitoring program will be operated in conjunction with the air quality monitoring program (Meterology and Air Quality, Section 4.1.3.1.3). Air samples measuring airborne particulates and gaseous radionuclides will be collected from locations on and off the proposed repository site.

Precipitation samples will be collected at the sampling station nearest the site in the direction of the prevailing wind.

Ambient Beta and Gamma Radiation. Environmental levels of beta and gamma radiation will be monitored at several onsite and offsite locations. Locations will include points along the perimeter of the proposed repository surface facilities area, and locations within a 16-kilometer (10-mile) radius of the surface facilities area in the greatest and least prevalent annual wind directions.

4.1.3.1.10 Transportation. This section discusses the transportation related studies that will be conducted while site characterization activities are ongoing. Transportation requirements for site characterization are specified in Section 4.1.2 and consequential environmental impacts are discussed in Section 4.2. These siting studies are primarily conducted to support engineering design of access corridors for the exploratory shaft facility (ESF) and for the repository. These efforts include environmental and safety analyses of alternative repository corridor alignments, and monitoring for possible traffic congestion during site characterization.

Monitoring programs for congestion, traffic problems, and road deterioration caused by site characterization activities will take place during site characterization. This may include traffic monitoring along Mississippi State Highways 15 and 42 and the intersection of these highways with two county access roads (Figure 4-17). Section 4.2.1.10 identifies mitigation measures that might be employed, if monitoring results determine a need.

During site characterization, detailed repository transportation studies will be conducted to further assess the existing transportation infrastructure, State and local emergency response capability, overflight hazards, and potential sites for development of highway and railroad access for repository operations. This information will be used to support the decision regarding preferred transportation routes.

These studies will be performed to determine necessary infrastructure development and mitigation for anticipated repository related traffic congestion at key locations in the site vicinity. Detailed studies of the existing highway and rail transportation infrastructure will include evaluation of the local and regional highway and rail characteristics, condition, and need for upgrading; planned changes or improvements; present traffic levels and capacities; accident and weather disruption experience; transportation infrastructure compatibility with repository-generated traffic; and assessment of costs and types of potential mitigative actions. The results of these studies will be used to better define potential impacts from repository related traffic and the necessity for and location and nature of any improvements or modifications to the existing infrastructure.

Studies will be performed to assess the capability of local and State agencies to respond to transportation-related emergencies, including identification of agencies responsible for disaster and accident response; evaluation of response plans, available equipment, and trained personnel; examination of the degree of interagency coordination; and determination of the need for Federal assistance and funding. These studies will ultimately be used to determine the necessity of improving existing capabilities and the nature of such improvements.

Studies of the overflight hazard will include detailed examination of the use of airspace in the repository area by volume and type of aircraft as well as an assessment of capabilities and use characteristics of airports at various distances from the repository.

Studies will be conducted to further identify engineering requirements and environmental and social impacts from the siting of highway and rail access routes (Section 5.1.2.2). The studies will include defining and locating the constraints and opportunities to siting which exist in the region.

Siting the rail and highway access route will be guided by the Siting Guidelines, program and engineering requirements, public concerns and applicable local, State, and Federal laws. The evaluation of environmental impacts will require the conduct of studies to assess existing environmental conditions along proposed alignments. The preferred access routes will be selected based on the results of these studies and a comparison of economic, safety, social,

environmental, and cost impacts and engineering requirements for each alternative route (Section 5.1.2.2).

Additional studies will be conducted to investigate nationwide transportation issues. This will include studying the feasibility of barge transport with rail connections made in Memphis, Tennessee, and the ports at Gulfport, Mobile, and New Orleans (Appendix A).

4.1.3.1.11 Utilities. Utility-related studies during site characterization will be centered around supplying and siting of the utilities required for repository construction and operation and meeting the repository generated waste disposal needs. Utility requirements for site characterization are specified in Section 4.1.2 and consequential environmental impacts are discussed in Section 4.2.

Initially, an evaluation of project utility needs will be made. These include natural gas, electric power, water, sewage sludge disposal, and communications. Water will be supplied from nearby wells. Natural gas, electricity, and communications capabilities will be supplied by connecting with existing offsite systems. Studies will involve assessing current and forecasted demand and capacity of these offsite systems and the effects that the project will have on them. Connecting the existing systems with the repository will involve the study of alternative utility access corridors (Section 5.1.2.2) and the impacts associated with the alternatives.

Waste disposal studies will involve defining the quantities, types, and production schedule for projected generated wastes. An inventory will be developed based on evolving repository designs of potential offsite disposal areas for hazardous and nonhazardous wastes. This will include locations, projected capacities, and waste types which each facility will accept. These studies will also assess regional waste disposal plans and the potential need for new facilities.

4.1.3.2 Socioeconomic Studies

Impact assessment, monitoring, mitigation, and planning activities will occur during site characterization. The purpose of assessment activities will be to project repository impacts. The role of impact monitoring will be to provide the data necessary to make the repository assessments more accurate and to identify potential site characterization effects. If the monitoring program were to identify impacts of site characterization, mitigation activities would be established. Mitigation plans would outline the process that the DOE would follow in working with the States, Indian Tribes, and local communities to minimize or mitigate adverse impacts which may be identified by the monitoring program.

There are many different effects that communities could experience from a repository project. Five types of impacts, as follow, have been identified at other large-scale facility sites:

1. Demographic impacts result from the influx of new project workers and their families. There will be a larger community population, as well as potential change in the age and family characteristics of the population.

2. Economic impacts include changes in business activity and employment in rural areas. At least temporarily, wages and costs often increase from levels existing before the project begins, and business sales and income from project-related activities increase the overall economic activity in the area.

3. Community Service impacts may also be experienced with local population growth. This growth may affect the fire protection, schools, water and sewer systems, and road maintenance.

4. Fiscal impacts may be experienced with the additional service demands and costs associated with the rapid population increases that accompany large-scale development. Offsetting possible increase in demands and costs, there may be an increase

in local tax revenues. These new revenues are often a resource for much needed service improvements, such as new schools, water and sewer systems, and service facilities.

5. Social impacts may result from the influx of large numbers of people. The informality and intimate nature of social relationships in a rural area may change. As a result, longtime residents sometimes feel that the communities become less familiar, less friendly, and less harmonious.

Assessing these socioeconomic impacts is a critical element in meeting the requirements of the "Nuclear Waste Policy Act" of 1982 (42 USC Sections 10101-10226) and the Mission Plan (DOE, 1985, Vol. I, DOE/RW-0005). The DOE has developed a modeling system that may be used in evaluating repository impacts. This model has six major components: an economic module, a demographic module, an economic-demographic interface module, a residential allocation module, a community service requirements module, and a fiscal module.

The modeling system projects demographic and economic changes. In addition, the residential allocation module distributes new residents to communities near the site. Community service and fiscal impacts are then evaluated for communities receiving new population. A social assessment methodology will be used to analyze social impacts.

For the impact assessment activities, site and area visits would be made to verify existing data and to collect additional data. The types of data to be collected and data sources are listed below

Economic

- Employment: by industrial group and occupation - Census data, Bureau of Economic Analysis, State and regional planning agencies
- Income: per capita, family - Census data, Bureau of Economic Analysis
- Economic trends and projections - Bureau of Economic Analysis, State and regional planning agencies
- Land uses: current and projections - State, regional, local planning offices, field surveys
- Sales: by industry, trade patterns - Bureau of Economic Analysis, State and regional planning agencies
- Planning regulations - State and local agencies
- Input - Output coefficients: State economic and planning agencies, research institutions.

Demographic

- Total population trends - Census data and estimates
- Age, sex, race-ethnicity of population - Census data
- Birth, death, migration trends - Census data, State health department
- Characteristics of families and households - Census data
- Nonresident, temporary population - local and regional planning agencies, State and Federal park service
- Population by type of urban center - Census data, local and regional planning agencies

- Population density - Census data and local surveys.

Fiscal

- Tax revenues: type and jurisdiction - State revenue department
- Assessed valuation: rate and jurisdiction - State revenue department, local assessor's office
- Federal and State revenue distribution - State revenue department, local and regional planning agencies, local treasurer's office
- Government expenditures: types and trends - State revenue department, local government offices
- Bonding status/capacity - local governments.

Community Service

- Housing units: type, condition, vacancy - Census of housing, State, and regional planning agencies
- Education: enrollment, school capacity - State department of education, local school districts
- Medical and mental health services - State health departments, department of human resources, National Center for Health Statistics
- Law enforcement - State police, county sheriff, and local police offices
- Fire protection - State fire marshall and local stations
- Water supply, wastewater treatment, and solid waste - Environmental Protection Agency, State health department, and community governments
- Transportation - State transportation department, community governments
- Social services - State department of human resources and local offices
- Recreation services - State recreation agency, local and regional planning agencies.

Social

- Community organizations: type and size - Community agencies
- Community leadership - Community sources
- Government organization and activity - Community leaders
- Attitudes, perceptions of community concerning repository development, economic development, community growth and change - discussion and interviews with community leaders and citizens
- Local cultural heritage - local historical society and other agencies
- Social disorganization: types and incidence of crimes - State and local crime reports.

These activities will occur during the first 2 years of site characterization. Four staff persons would be in the site areas periodically for 2 weeks at a time. Impact monitoring activities will also occur throughout site characterization. Impact monitoring involves periodic field visits to collect data and analyze key indicators of local economic and social change. Some indicators that will be analyzed in communities and counties projected to receive new residents include project information and community information.

The kind of project information that will be required during site characterization can be divided into project worker characteristics and project purchases:

- Project worker characteristics, such as family size, housing needs, number of school-age children present, marital status, changes in the scheduling of the project, and worker settlement patterns will be monitored. These factors will affect the number of persons which will be present in any community and affect the demands on community services.

- Project purchases will be monitored during site characterization. The magnitude of project purchases during site characterization will affect the local economy and be related to the number of secondary jobs created. To obtain this data, project purchase orders could be sorted out by purchase location.

Community information that may be required during site characterization can be divided into indicators of the economic, demographic, land use, community service, social, and fiscal conditions. The factors to be monitored will be keyed to impacts identified in Section 4.2.2. The staff involved in collecting impact data will also participate in the monitoring effort.

Monitoring Reports will be prepared for quarterly project reports and semiannual community reports.

If impact mitigation activities are required during site characterization, area visits will be conducted to discuss mitigation measures with project management, State and local officials, and public groups.

4.1.3.3 Land Acquisition

The land within the Richton Dome site is all privately owned. No lands owned by the DOE are located in the vicinity of the site. The DOE expects to commence land acquisition for the site characterization program, including construction of the exploratory shaft, following Presidential approval of recommended sites. The exploratory shaft site will require approximately 28 hectares (68 acres). The DOE plans to purchase the surface and subsurface rights to the land for the exploratory shaft site.

Land protection is necessary to prevent uncontrolled human activities which could affect the licensability of the proposed site as a repository. Because the DOE will not know precisely what and how much land it will need to acquire for the proposed repository site until site characterization studies are completed and data collected in those studies are evaluated, the DOE plans to protect approximately 2,222 hectares (5,489 acres) (the "protected area," see Section 5.1.1.5). Preliminary analyses indicate that a site area of this size would allow all EPA and NRC repository performance requirements to be met (See Sections 6.3 and 6.4). The DOE expects to protect this area by purchasing or leasing surface and subsurface rights or by acquiring some lesser interest that adequately protects the proposed site. This process will begin at about the same time that land for the exploratory shaft is acquired. The DOE may permit the surface owner(s) the right to continue to conduct their present activities. Some activities on the land would require prior approval of the DOE. The DOE expects to conduct site characterization field studies as described in Section 4.1.1 within portions of the protected area.

If the DOE acquires surface and subsurface rights to the protected area, then the land-use impacts would be similar to those attributable to repository development (Section 5.2.3). It is unlikely, however, that the DOE would take this action unless and until the site were selected for the first repository.

The DOE expects to conduct some site characterization activities outside the protected area. These activities may include drilling boreholes, conducting seismic surveys, and performing environmental studies (see land use requirements in Table 4-2). The DOE plans to obtain purchase, lease, or easement agreements for required parcels of land or access. Land requirements also include an access roadway and roadway right-of-way (see Section 4.1.2.1).

In the area immediately surrounding the 28-hectare (68-acre) exploratory shaft facility (ESF), designated as "repository surface facility" in Figure 4-1, the DOE will conduct intensive activities for a period of more than two years. These activities include the drilling of approximately 30 exploratory shaft monitoring wells, 400 repository foundation borings, 5 shallow aquifer hydronests, and conducting seismic surveys, in addition to ESF activities. Because of the presence in this area of large numbers of drill rigs, other equipment, and personnel, the DOE will establish a buffer area up to approximately 400 to 500 feet beyond the repository surface facility area. This area, including the ESF and repository surface facility areas, is approximately 500 to 600 acres, and has been designated as a limited-access area to ensure the safety of project personnel and the general public and to enhance the security of supplies and equipment. The DOE will acquire appropriate interests in this land. The limited-access area will be suitably marked.

Some landowners will be disrupted by site characterization activities on their land or by uncertainties regarding the future use of affected land. While there is no remedy for some of the disturbance to be caused by land acquisition, the DOE intends to minimize disturbance wherever practicable consistent with the requirements to obtain and evaluate data on the characteristics of the site, and to compensate landowners for the real property and improvements it acquires.

4.2 EXPECTED EFFECTS OF SITE CHARACTERIZATION

This section describes the environmental effects expected to result from the site characterization activities discussed in Section 4.1. These impacts have been assessed by comparing specific project activities with information on existing site and area conditions presented in Chapter 3.

This description of site characterization effects is divided into two subsections. Effects on the physical environment are presented in Section 4.2.1, and effects on the socioeconomic conditions are presented in Section 4.2.2. The discussion of effects for each discipline generally follows the order of the site characterization activities presented in Section 4.1, i.e., geotechnical field studies (Section 4.1.1), exploratory shaft development (Section 4.1.2), and other activities (Section 4.1.3). Both beneficial and adverse effects are discussed.

4.2.1 Expected Effects on the Physical Environment

This section discusses the expected effects of site characterization activities on components of the physical environment, including land and mineral resources; terrestrial and aquatic ecosystems; air quality; surface-water and ground-water quality and availability; soils; noise; aesthetic resources; archaeological, cultural, and historical resources; radiological levels; and transportation and utilities.

4.2.1.1 Effects on Land Use and Mineral Resources

The geotechnical field studies and exploratory shaft activities will occupy a total of approximately 291 hectares (718 acres). The duration of direct land disruption that will occur at any particular area ranges from one day to five years. The following land use sections examine the impact of site characterization activities on land use at Richton Dome and nearby areas.

4.2.1.1.1 Geotechnical Field Studies. Of all studies to be conducted, geotechnical field studies will affect the largest amount of land during site characterization. The field activity requiring the largest acreage will be the seismic reflection surveys. This will

require clearing of isolated parcels totaling approximately 152 hectares (380 acres) of land. Land clearing along seismic reflection lines as described in Section 4.1.1.1.9 and use of some of these lines as temporary access roads will conflict in some areas with current agriculture and forestry activities. These seismic lines will require clearing of strips of land of bush and obstacles. Access to a total of approximately 249 kilometers (155 miles) of seismic lines will be required and the activity will last 6 months. Existing access roads, trails, and rights-of-way will be used where possible to minimize land disruption. In addition, particular reflection seismic surveys and microseismic monitoring stations may be sited within portions of the De Soto National Forest. The DOE will continue to consult with the U.S. Forest Service about appropriate rights to land (Section 6.2.1.6) pursuant to the "Forest Service Organic Administration Act of 1897" and where appropriate the "Federal Land Policy and Management Act of 1976" (43 USC Section 1761). The DOE currently has a memorandum of understanding with the Forest Service that approves additional seismic testing (Finison, 1984). The remaining field studies will involve isolated parcels that will total approximately 109 additional hectares (270 acres). These activities will result in minor changes in land use and will be located to minimize conflict wherever feasible through discussion with affected landowners.

The foundation boreholes (Section 4.1.1.2.2) will also contribute to land disturbance. A truck-mounted rig will need to sample about 450 locations in the area proposed for surface facilities. These activities will create some disturbance over the entire surface facility area for a total duration of up to 20 months. Drilling will occur on nonresidential lands. Impacts on forest productivity will be minimal because little site preparation will be required and because drilling will be located primarily on land that has been clear-cut or recently reseeded. The DOE will maintain access to some well locations for the site characterization period. The well sites will be marked by the exposed casing or well head valve and a suitable protective railing (Section 4.1).

Land disturbance from trenching over a 2-month period (Section 4.1.1.1) will result from access clearing, soil mixing from excavation, and filling of the trench. Upon completion of trenching, the trench will be filled, the fill compacted, and the site restored. To minimize land disturbance, the location of trenches will be discussed with affected landowners.

Most of the land disturbance during the field studies will occur within the dome area. As discussed in Section 3.4.1, most of the dome area is covered by forested land, some of which has recently been reseeded. Although precise locations of all field study sites are not yet known, it is likely that forested land will be most affected by these activities. Even assuming that the entire area required for field activities was forested, this disturbance would represent a loss of about 0.2 percent of the forested land in Perry County. These land-use projections are a maximum estimate; the extent of actual land-use preemption and long-term impacts will be substantially smaller for three reasons: (1) some of the dome area has already been cleared; (2) marketable timber in the impact areas will be harvested for sale prior to initiation of the field studies; and (3) in general, the land will be allowed to return to its prior condition, to the extent feasible, upon completion of the field studies if the site is not chosen for a repository.

Some of the previously mentioned land areas that will be disturbed by geotechnical activities will be restored as close to their original prime condition as possible. Reclamation activities and revegetation, as described in Section 4.2.1.5, will be used to mitigate soil disruption. The DOE has filed Form AD 1006 with the Soil Conservation Service (SCS) (Prendergast, 1985) in compliance with the "Farmland Protection Policy Act" (7 USC Sections 4201-4209). Of the soils within the Richton Dome area, 2.3 percent are classified as prime farmland (Section 3.4.1). When feasible, the DOE will conduct geotechnical studies in areas not designated as prime soils in order to minimize the effect of project activities on such prime agricultural soils.

4.2.1.1.2 Exploratory Shaft Facility (ESF). Exploratory shaft facility land requirements total approximately 28 hectares (68 acres), and the access road will require 0.7 hectare (1.8 acres). All surface vegetation will be cleared and contours modified as required for construction and testing. This amount of disturbance represents less than 0.2 percent of the

forested land in Perry County. No homes or other structures will be displaced from the exploratory shaft facility site.

As discussed in Section 4.2.1.1.1, the DOE will consider locating tests on areas that are not designated as prime agricultural soils, including the ESF, pursuant to the (Federal) Farmland Protection Policy Act, 7 USC Sections 4201-4209. The DOE will comply with this Act by taking measures to minimize impacts and, as described in Section 4.1.1 and Section 4.1.2, restore the site, to the extent possible, back to its original condition. Pits will be filled and the drilling sites regraded. Stockpiled topsoil will be spread over the site and any disturbed area will be reseeded and fertilized (Section 4.2.1.5).

Camp Shelby military operations area lies approximately 16 kilometers (10 miles) south of the Richton Dome site. The only potential impacts that might occur during site characterization would be interference with access to the Camp. The Camp's operations are detailed in Section 3.4.1. The principal roads used for access to the Camp are U.S. Highways 49 and 98. Access to the Richton Dome ESF and to activities occurring near ESF facilities will not use either of these roads. Principal access will be on either Mississippi State Highway 42 or 15. Section 5.1.2.2 describes highway access in more detail. Since these routes do not interfere with each other, Camp Shelby access is not expected to be affected.

As described in Section 3.4.1, the De Soto Military Operation Area (MOA) has a portion of its airspace extending over the southern portion of the Richton Dome. Air traffic over this corridor between 152 and 3,048 meters (500-10,000 feet) above ground level is prohibited during intermittent hours of use between 9 a.m. and 4 p.m., seven days a week (BNI, 1982, ONWI-193, pp. 133, 155). The Perry County Airport (Section 3.5.3), a small, low activity, unattended airport, is located within this MOA. Since surface facilities are to be located in the northern portion of Richton Dome, exploratory shaft facility activities will not conflict with this MOA. As described in Section 4.2.1.10, any use of private or commercial aircraft to travel to the site will primarily use facilities located at the Pinebelt Regional Airport, west of Richton Dome. Any use of the Perry County Airport will be minor and travel will be scheduled to conform to the restricted hours and flight pattern over the MOA corridor.

As indicated in Section 4.1.2.4, disposal of nonhazardous solid wastes from rubbish, salt-contaminated and noncontaminated excavated materials, and waste salt, can all be accommodated by existing EPA approved landfills located near Laurel, Mississippi, and Emelle, Alabama (Sullivan, 1984, Reis, 1985a). Fluids from site runoff, if unsuitable for discharge into surface waters, will be taken to existing injection wells within 48 kilometers (30 miles) of the site (Section 4.2.1.11).

Potential effects of disposal of the material to an offsite landfill (Reis, 1985b) include (1) a decrease in the design life of that facility, (2) a potential for land-use conflicts if additional space is required, and (3) concern over long-term integrity of the landfill with respect to erosion, ground-water infiltration, subsequent leaching of salt, and potential surface-water and ground-water contamination. Although these effects could occur in a poorly sited and designed landfill, operators of the aforementioned landfills have indicated that their facilities will have sufficient capacity at the time of disposal of site characterization generated waste and the necessary permits to handle the expected kinds and amounts of solid wastes generated during this period (Sullivan, 1984; Buckley, 1984; Biggert, 1984; Reis, 1985b). Therefore, impacts potentially occurring at the disposal site or sites are not expected to be of major concern from a land use and environmental standpoint.

Transport of salt and salt-contaminated materials by truck is not expected to affect land use along the routes due to use of coverings on the vehicles (Section 4.2.1.11) as they travel on existing roads.

The Richton Dome area falls within the Rhodes, Richton, and Ovett quadrangles (USGS, 1973; 1982a,b; respectively). These mapped areas have been included in the National Wetlands Inventory conducted by the Fish and Wildlife Service (Hepner and Nault, 1984). The Fish and Wildlife service has also been consulted (Mongan, 1985) about the identification, location, and extent of any wetlands in the site vicinity that may be protected under Executive Order

11990, Protection of Wetlands, or related legislation (see Section 4.2.1.2.3 for further discussion).

4.2.1.1.3 Environmental Field Studies. Small amounts (less than 1 hectare [2.5 acres]) of land will be used for environmental studies (Section 4.1.3.1); however, these studies are expected to have insignificant effects on land use in the area. The environmental field study that will require the greatest amount of land is the air quality study, which requires a meteorological tower that will use less than 0.4 hectare (1.0 acre) of land and an access road approximately a quarter-mile long.

4.2.1.1.4 Mineral Resources. Development of any mineral resources within the controlled area will be prohibited during site characterization if such development could affect potential repository site integrity. Because of the low resource potential of Richton Dome (Section 3.2.8), however, no major adverse effects on the economy due to restricted resource development are expected. The DOE will provide compensation to owners of subsurface rights for all such rights that are required.

4.2.1.1.5 Cumulative and Long-Term Effects - Land Use. Since land disrupted for site characterization activities will be restored as close to its original conditions as feasible, no significant cumulative and long-term impacts on land use are expected. The short duration of many activities will preclude any adverse long-term build-up of impacts. Any salt deposited on soils occurring before disposal off site (if the site is not chosen for a repository) will not be significant enough to cause adverse effects on forest productivity. The DOE will closely monitor the soils around the site to detect any increases in soil salinity.

If the full 291 hectares (718 acres) of land to be disrupted by site characterization activities is to occur on forest land, this will represent only approximately 0.2 percent of the forest land in Perry County. Since some of the forest land at Richton Dome has been clear-cut, the potential disruption to county forest resources will be insignificant. However, minor future disruptions of forest practice may result from the 15 well heads that will remain on the surface of the land following deep aquifer hydronest activities.

Since only 2.3 percent of the Richton Dome site is classified as prime farmland soils, no long-term or cumulative impacts on prime soils are expected. To the extent feasible, the DOE will locate testing activities on soils not classified as prime. Reclamation and vegetation activities (Section 4.2.1.5) will be conducted following site characterization to mitigate and minimize soil and forest productivity disruptions on land at Richton Dome.

4.2.1.2 Effects on Terrestrial and Aquatic Ecosystems

Site characterization activities that could impact the resident biota (described in Section 3.4.2) in the Richton Dome area include geotechnical field studies (Section 4.1.1), exploratory shaft facility development (Section 4.1.2), and other activities (Section 4.1.3) for establishing site-specific baseline conditions. In general, the extent and magnitude of impacts will vary depending on the nature and timing of the activities and the implementation of site-specific mitigation measures.

4.2.1.2.1 Terrestrial Biota. The major impact on terrestrial biota resulting from site characterization activities will be the loss of vegetation and wildlife habitats as a result of clearing for drilling platforms, access roads, staging areas, test trenches, seismic monitoring stations, a meteorological tower, etc. The location and amount of land cleared for each of the above activities is discussed in Section 4.1.1.

Approximately 263 hectares (650 acres) will be disturbed for the geological, geophysical, and other field studies. About 28 hectares (68 acres) will be disturbed for the exploratory shaft facility and 0.7 hectare (1.8 acres) for the access road. Clearing will entail the removal of essentially all vegetation, including various softwood and hardwood tree species. Where possible, timber will be commercially harvested, and all slash will be burned or buried as permitted by local regulations. Although some vegetation will be lost, the longleaf-slash pine community present in the Richton Dome area is not unique to the area and is a common

vegetation community in the state. Due to the discontiguous nature of site characterization activities, and the recent extensive clear-cutting on project sites, impacts to vegetation and the longleaf-slash pine community in general will not be significant. During vegetation removal, some soil erosion may cause sedimentation in local drainages. Impacts of sedimentation on aquatic ecosystems are addressed in Section 4.2.1.2.2 below. Sedimentation ponds and other control measures are described in Section 4.1.1 and 4.1.2. Where required, ground clearing activities will include provisions for stockpiling topsoil to aid in later reclamation activities.

Some direct mortality may occur to small mammals and reptiles during clearing operations. All bird and most mammal species are mobile and will move to and utilize adjacent areas. Depending on the density of wildlife populations in adjoining areas, the migration could cause overcrowding, increased competition, and some mortality in wildlife. In addition to direct losses of habitat and the displacement of wildlife species residing in affected areas, there is likely to be an impact on wildlife in adjoining areas as a result of noise, lights, and increased human presence. Loss of additional wildlife may result from road kills and increased hunting and poaching activities. Although these latter impacts will not be significant on a regional basis, they can be reduced, if necessary, by educating workers, establishing awareness programs, and imposing restrictions on recreational activities near the site.

The construction of transmission lines will require the acquisition of approximately 5 hectares (13 acres) of land. Depending on the route selected, portions of the corridor will pass through forested land. Vegetation will be cleared to allow construction of the transmission line with regrowth controlled to prevent interference and allow maintenance of the system. Terrestrial wildlife utilizing the regrowth area will likely be composed of species attracted to woodland edges, shrubby areas, and the transition habitat between the two. Changes in relative abundances will be dependent on the species present. Depending on the height of the power lines (14 to 15 meters [45 to 50 feet]) relative to the surrounding forest canopy, different species of birds may be susceptible to collision. Evidence suggests that power lines that protrude just above the canopy can be dangerous to species that move swiftly above the canopy, whereas placing the structures just below the canopy would be a hazard for forest species (Thompson, 1978). However, the anticipated width of the right-of-way (15 to 19 meters [50 to 61 feet]) may be sufficiently wide to decrease impacts caused by the latter placement.

To reduce the potential for electrocution of large birds that periodically perch on tall structures, such as hawks, bald and golden eagles, and herons (species protected under the "Fish and Wildlife Coordination Act" [16 USC Sections 661-666c], the "Migratory Bird Treaty Act" [16 USC Sections 703-711], and the "Bald and Golden Eagle Protection Act" [16 USC Sections 668-668d]), it is recommended that the conductors and ground wires are separated by a distance greater than the maximum wingspan of the largest bird likely to be present in the vicinity of the powerline. In the case of the Richton Dome site, the powerline configuration shown in Section 4.1.2.2.1 (Figure 4-9) may provide adequate clearance. Because of the small area required for the transmission corridor, both in the corridor width and the total acreage, no significant adverse ecological impacts are anticipated.

The presence of a 60-meter (197-foot) meteorological tower and two 38-meter (125-foot) exploratory shaft facility (ESF) headframes may be hazardous to birds during migration or during low-visibility conditions. Collisions may be avoided by the installation of warning devices such lights or horns.

Studies of the dome area and consultation with the Fish and Wildlife Service (FWS) indicate that several threatened and endangered terrestrial species are known to occur in the general region (Section 3.4.2.3; Jordan, 1982, 1984; Eco-Inventory Studies, Inc., 1983; Rogers, 1983; Mongan 1985). However, no critical habitats have been designated anywhere in the project area, and no species protected under the Endangered Species Act of 1973 (16 USC Sections 1531-1543) are presently known to occur within the dome area itself. Habitat for the endangered red-cockaded woodpecker may be present in areas affected by site characterization studies or access roads. Should future site clearance studies conducted in consultation with the FWS reveal evidence that the red-cockaded woodpecker or other threatened or endangered

species would be adversely affected by project activities, impact avoidance measures will be implemented in cooperation with FWS. Measures could include moving a particular study site, using a phased schedule to avoid activities during the breeding season, and employing buffer zones. Consultation with the FWS regarding potential effects on these species will continue throughout the site characterization phase.

The Richton Dome site is within the range of bald and golden eagles, but no nesting habitat is known to occur there. Should preconstruction site clearance surveys reveal that eagles utilize the site, the FWS will be consulted for procedures to be followed according to the Bald and Golden Eagle Protection Act (16 USC Sections 668-668d). Detailed biological field surveys (described in Section 4.1.3.1.2) are also needed at the Richton Dome site to determine the status of migratory birds pursuant to the Migratory Bird Treaty Act (16 USC Sections 703-711). Subsequent consultations with the FWS will establish acceptable compliance requirements under the Act. In compliance with the Fish and Wildlife Coordination Act (16 USC Sections 661-666c), additional consultation with the FWS and with appropriate State agencies will be conducted to determine the need for conservation measures for fish and wildlife resources at the Richton Dome site or in the project area. This process will culminate in agreements on applicable requirements and measures to be taken by the DOE.

The potential cumulative effects of site characterization activities on terrestrial biota could include greater adverse effects upon big game populations of white-tailed deer and black bear, including local range abandonment, decreased productivity, and population decreases. Local, long-term changes in vegetation will result from site clearing activities. Depending on future land-use plans, forested areas may be replanted to pine plantations and agricultural areas returned to crop production.

While some local plant and animal populations will be adversely affected by vegetation clearing, other populations may actually benefit in the long term from the local habitat diversity created. In addition, vegetation clearing and subsequent revegetation may create ecotones (transition zones) between major habitat types (e.g., forest and field). These have generally been shown to exhibit significantly greater species richness and abundance than either of the adjacent homogeneous habitats.

Approximately 250 kilometers (155 miles) of seismic reflection survey lines and 3.2 kilometers (2.0 miles) of seismic refraction lines will be established. Truck-mounted vibrators or explosive charges will be the energy source. Both surveys will take 8 months to complete, and will be conducted along established grids, many of which can be conducted from roadways. In the process of following the grids, the large vibrator trucks will disturb habitat and wildlife. Impacts include vegetation damage and clearing of approximately 154 hectares (380 acres), soil compaction, noise, and human presence. Crossings of drainage areas may result in sedimentation and increased turbidity. Surveys conducted when drainage areas are dry will help to mitigate disturbances. No permanent aquatic habitat loss or destruction will occur.

Impacts to wildlife from the seismic surveys will occur only for the duration of the surveys, which is expected to be about three months. Truck noises will be similar to those of farm or logging machinery, to which local wildlife have become accustomed. Wildlife will also avoid the test areas while crews are present, resulting in a temporary loss of foraging habitat. Surveys will be scheduled in cooperation with the FWS to avoid the loss of migratory birds, their nests, and eggs under the Migratory Bird Treaty Act (16 USC Sections 703-711). In addition, since the trucks are not likely to cross wet areas, species present in these areas, particularly waterfowl, raptors, shorebirds, and most passerines will not be affected. Thus, the potential for adverse impacts to these species will be small.

Seismic surveys may also employ the use of explosive charges. When set off, these explosives will cause soil mounding at the shot holes and will startle nearby wildlife. The presence of field crews will also cause local wildlife to avoid the area. Habitat disturbance will be minimal, and there will be no permanent habitat loss. Although surveys conducted when sensitive species are present will cause many species (particularly waterfowl and raptors) to vacate the area, as indicated above, these surveys can be scheduled around critical times in the species' life cycle.

Impacts from environmental baseline studies are expected to be relatively insignificant to ecological resources of the site and surrounding areas. Field studies may require collection of voucher specimens of plants and animals, tissue samples for productivity and radiological critical path studies, and soil sampling. Removal of small numbers of individual organisms will not significantly affect regional populations, and none of these field studies will entail major habitat modifications.

Other environmental field studies will result in varying effects on the site ecosystem. Most disturbances will involve field crews conducting soil, noise, or land-use surveys, although it is expected that any affects will be very short term and of minor impact.

4.2.1.2.2 Aquatic Biota. Impacts on aquatic resources resulting from the site characterization activities will occur primarily in conjunction with the land clearing activities noted above. Some temporary increases in turbidity and sediment loads may occur in the intermittent streams proximal to and within the Richton Dome area. The extent of the turbidity and sediment, and their effect on the resident aquatic biota, will depend on the intensity and duration of local storm events and on the type and effectiveness of erosion control measures implemented during clearing activities. Erosion control measures proposed for geotechnical field studies include the use of sediment ponds at the various drill sites, stabilization of stockpiled soils, and site restoration upon the completion of studies (Section 4.1.1). Potential runoff from the ESF will be controlled by a series of drainage ditches on site, which will flow into the sediment detention basin. Sediments that settle out will be periodically removed to an acceptable offsite disposal facility (Section 4.1.2).

In development of the ESF, impacts will result from diversion of drainage from the site to Fox Branch and construction of various access roads and several bridges. This will result in some stream or drainage alterations and a permanent loss of some of the original habitat where rechannelization is undertaken. Some species will be adversely affected by increased sedimentation and turbidity, temporary decreases in oxygen content, and increases in temperature. Erosion and sedimentation control measures will help mitigate some of the impacts; however, loss of some aquatic organisms will be unavoidable. Such impacts will be local and not affect regional sport or commercial fisheries. The DOE will continue to consult with the FWS under the Fish and Wildlife Coordination Act (16 USC Sections 661-666c), as well as Mississippi agencies responsible for fisheries resources, to develop appropriate mitigative measures. The DOE must also obtain the necessary permits from the U.S. Army Corps of Engineers under the Rivers and Harbors Act (33 USC Sections 401-413) if fill material is put into navigable waters. Habitat alterations and development of new habitat in the diversion channel will require consultation with the FWS under the Fish and Wildlife Coordination Act (16 USC Sections 661-666c).

Contamination of local water quality and soils from windblown salt deposition from normal site characterization operations, and subsequent impacts to biota, are not expected outside of the ESF area. Based on air dispersion, soil accumulation, and water quality analyses (Section 4.2.1.11) the amounts and concentrations from windblown salt will be negligible. No significant increase in the salt concentrations of Linda Creek, Fox Branch, or any waters downstream will occur, and as a result, no impacts to resident aquatic biota are expected. Similarly, based on calculated soil accumulations of salt off site, no adverse effects to native vegetation are expected. An onsite detention basin described in Section 4.1.2 will be used to collect saline runoff from the salt storage pile. The current basin design has double liners to prevent seepage and will be sized to accommodate a 500-year, 24-hour storm event. Any runoff in the basin that does not naturally evaporate will be periodically transported off site to an acceptable disposal facility. See Section 4.2.1.11.2 for additional detail on salt effects.

Site characterization activities may also result in accidental contamination of surface waters from salt, chemicals, or construction materials. Depending upon the nature and duration of a contamination event, adverse impacts on aquatic biota could occur from the contamination of both stream waters and sediments. However, such impacts are unlikely since the water quality of adjacent systems will be protected during clearing and exploratory shaft facility development activities through the use of mitigation measures described in

Sections 4.1.1 and 4.1.2. Furthermore, the exploratory shaft facility area, where much of the heavy machinery will be operating, does not encompass any perennial streams or standing bodies of water.

Increased fishing pressure from workers may affect game fish population in streams and lakes adjacent to the Richton Dome. Although such impacts are not expected to be significant, local resource agencies could place restrictions on fishing activities, if necessary, to mitigate such impacts. No significant long-term or cumulative impacts on aquatic biota are anticipated.

Because threatened or endangered (T&E) aquatic species are not known to occur in the project area (Section 3.4.2.3; Jordan, 1982, 1984; Eco-Inventory Studies, Inc., 1983; Mongan, 1985), no adverse impacts on these resources are expected to result from site characterization activities.

4.2.1.2.3 Effects on Floodplains and Wetlands. An assessment of floodplains and wetlands (Mongan, 1985) has been prepared and is summarized below.

Description of Floodplains and Wetlands. Floodplains occur in the project area as flat bottomlands adjoining the larger drainages such as Thompson Creek and Bogue Homo Creek. These are shown as potentially wet areas on Figures 3-26 and 4-21. Some of the vegetation typical to these areas includes hardwood trees such as water oak, laurel oak, tulip tree, tupelo, sweet bay, and red bay (Section 3.4.2.1).

Wetlands also occur in the area (Goldman, 1985; Mongan, 1985) and have been classified and mapped by the FWS in their National Wetlands Inventory Maps (FWS, 1983). Figure 4-21 also depicts potentially wet areas containing wetlands. Wetlands are defined as "those areas that are inundated by surface or ground water with a frequency sufficient to support and under normal circumstances does or would support a prevalence of vegetative or aquatic life that requires saturated to seasonally saturated soil conditions for growth and reproduction (10 CFR Part 1022)."

The principal type of wetlands found in the Richton Dome area is commonly referred to as bottomland hardwood wetlands. FWS further classifies the principal wetlands of the area into the following:

- Palustrine forested wetland (PFO 1/4c): mixed broad-leaf deciduous/needle-leaf evergreen seasonally wet for extended periods of time
- Palustrine emergent wetland (PEM IA): persistent, temporary wetland, limited surface water
- Palustrine forested, intermittent riparian channels (PFO 1/4A): temporary wetland

Wetlands of these types occur throughout the project area, generally in low, poorly drained locations.

The more common forest types occurring in these wetland areas include the following:

- Bald Cypress (101)*
- Bald Cypress - Tupelo (102)
- Black Willow (95)
- Longleaf Pine (90-wet site variants)
- Longleaf Pine - Slash Pine (83-wet site variants)
- Slash Pine (84-wet site variants)

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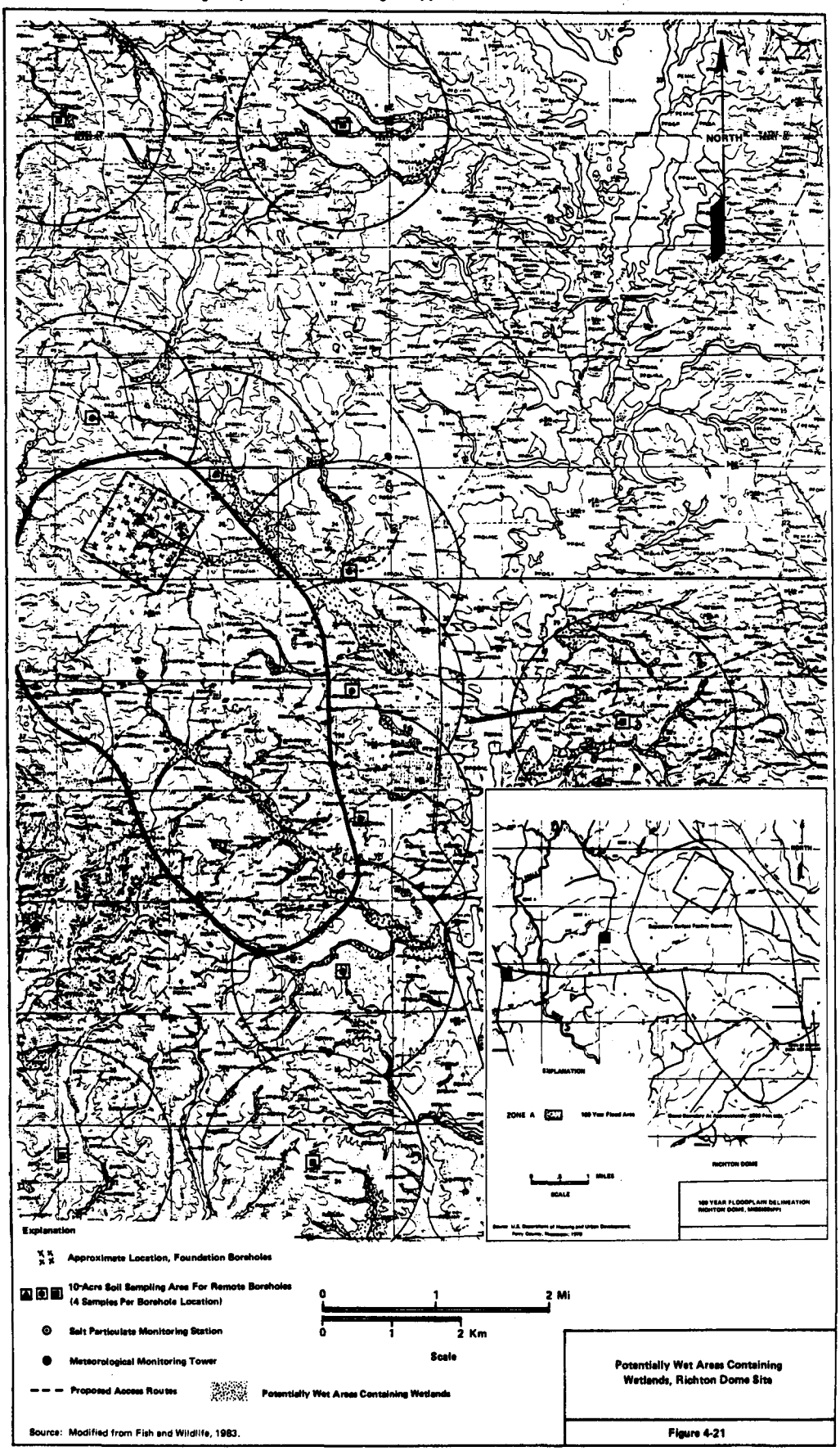
*Forest Type number, Society of American Foresters, 1980.

A larger reproduction of this figure appears at the back of this volume.



Source: Modified from Fish and Wildlife, 1983.

Potentially Wet Areas Containing Wetlands, Richton Dome Site

Figure 4-21

- Slash Pine - Hardwood (85-wet site variants)
- Sycamore - Sweetgum - American Elm (94)
- Willow Oak - Water Oak - Diamondleaf (Laurel)
- Oak (99-wet site variants)
- Loblolly Pine (81-wet site variants)
- Loblolly Pine - Hardwood (82-wet site variants)
- Swamp Chestnut Oak - Cherrybark Oak (92-wet site variant)

Description of the Proposed Action. The principal land-disturbing activities occurring during site characterization that could impact floodplains and wetlands include construction and operation of the exploratory shaft, multiple aquifer hydronests, overdome stratigraphic boreholes, dome flank stratigraphic boreholes, shallow aquifer hydronests, access roads, seismic refraction and reflection surveys, air quality/meteorological monitoring, and various foundation and other drilling efforts. Descriptions and locations of these activities appear in Section 4.1.1 and 4.1.2. The locations of some borehole and drilling sites, and their access roads, are somewhat flexible and may be moved within limits, as required.

Effects of the Proposed Actions on Floodplains and Wetlands. Flood Hazard Boundary Maps published by the U.S. Department of Housing and Urban Development (1978) delineate the estimated 100-year floodplain for unincorporated areas of Perry County. Review of these maps shows that none of the planned exploratory shaft activities or proposed drilling sites are located in a 100-year floodplain (Mongan, 1985). Some of the proposed locations under consideration for seismic refraction lines may cross floodplain areas but will have minimal impact.

On the basis on consultation with the Fish and Wildlife Service and a preliminary floodplain/wetlands assessment prepared for the DOE, it has been determined that approximately 4.0 hectares (10.5 acres) of temporary and seasonal bottomland hardwood wetland ecosystems may be affected by proposed site characterization activities (Goldman, 1985; Mongan, 1985). This would include approximately 2.0 hectares (5 acres) of palustrine forested wetland and 1.4 hectares (3.5 acres) of palustrine forested, intermittent riparian channel wetlands. The remaining 0.6 hectare (1.5 acres) are a mixture of wetland types. The specific activities that may lie in wetlands include multiple aquifer hydronest #3, flank stratigraphic boreholes #1 and #4, the shallow aquifer hydro-observation well, shallow aquifer hydronest #2, and portions of the main exploratory shaft site (refer to Sections 4.1.1 and 4.1.2).

The ecological effects of these activities on wetlands may include loss of wetland habitat during clearing operations; disturbance of adjoining wetland habitats from construction and operational noise, light and vibrations; disturbance and displacement of fish and wildlife; and possible population reductions in fish and wildlife, including migratory birds (e.g., waterfowl, raptors, and passerines) and rare or endangered species, if present (Table 3-29). Indirect ecological effects could result from interference with the hydrologic regime during access road construction, causing local vegetation losses and other associated wildlife impacts. Localized, short-term impacts to aquatic biota could result from project-related sedimentation and turbidity increases in streams (see Section 4.2.1.2.2). These impacts will be avoided or mitigated to the fullest extent possible through consultation with the FWS. Any stream alteration resulting in interference with the hydrologic regime would fall under the jurisdiction of the U.S. Army Corps of Engineers (Rivers and Harbors Act, 33 USC Sections 401-413), and a permit will be required.

The effects of site characterization on the land use and recreational values of these palustrine wetlands would include loss of commercial forest and reduced hunting and fishing opportunities in the project area. The loss of recreational opportunities during site characterization would be offset in part (assuming no repository is built there) by increased access and habitat variability provided at its completion. Larger deer herds and greater hunting opportunity may result.

Although only some 4.0 hectares (10.5 acres) of temporary and seasonal bottomland hardwood wetlands would be affected during site characterization, new access roads and well pad clearings would create minor breaks or discontinuities in the wetlands as a whole. During

seasonal or other temporary periods of innundation/saturation, minor increases in turbidity, suspended solids, and sedimentation may occur in wetlands adjoining the project site. These impacts to water quality will be temporary and primarily confined to areas along new access roads and well pad fill (see Section 4.2.1.4).

Mitigation Measures and Alternatives to the Proposed Action. Mitigation of impacts to aquatic and wetland habitats will be required by the U.S. Army Corps of Engineers. In accordance with the Federal Water Pollution Control Act, Clean Water Act of 1977 (33 USC Sections 1251-1376) impacts to wetlands and special aquatic sites should be avoided, however, if no practical alternative exists then the development activity should be conducted in the least damaging manner. Losses to wetland and aquatic habitats that still result could be offset by mitigation through the upgrading or development of new wetland or aquatic habitats. Mitigation requirements for the activities could include the following:

1. If practicable, borehole sites and access roads could be moved to alternative sites where wetlands or aquatic habitats do not occur.

2. The configuration of restricted areas, drill sites, and permanent road and railway corridors could be changed to avoid aquatic and wetland habitats, as required.

3. Application of best management practices to minimize impacts in each situation would be used.

4. Mitigation could take the form of upgrading nearby wetland and/or aquatic habitats.

4.2.1.3 Air Quality Effects

The analyses presented below are based on geotechnical and engineering data (e.g., schedules, equipment inventories, and specifications) and air source terms reported in BNI, 1985a.

Site characterization will affect air quality as a result of emissions from vehicles, drilling rigs, earthmoving equipment, and wind-blown dust. The process of determining air quality impacts includes (1) an estimate of emissions from project activities, (2) selection of an air quality model by which air quality concentrations can be estimated from emissions, (3) meteorological data, (4) "background" air quality concentrations (to which estimated air quality concentrations from proposed activities must be added), and (5) an understanding of how estimated air quality concentrations may affect human health and welfare, as established by the National Ambient Air Quality Standards (NAAQS) (see Table 3-31). Project related emissions analyzed are particulates, oxides of nitrogen (NO_x), sulfur dioxide (SO_2), and carbon monoxide (CO)(Emission rates derived from EPA documents such as "AP-42" are used; see BNI, 1985a for details). To determine compliance with the appropriate NAAQS, particulate and NO_x emissions and their impacts are examined in detail. Estimated concentrations of SO_2 and CO, based on maximum annual emissions for these pollutants, are small relative to the respective NAAQS (BNI, 1985a). Consequently, SO_2 and CO are not considered further.

4.2.1.3.1 Activities and Emissions. Site characterization activities with the potential to produce the most emissions are associated with geotechnical field studies and exploratory shaft facility (ESF) construction (see Section 4.1).

Geotechnical Field Studies. Activities during the approximately 28 months of geologic field studies include drilling of the following:

- Stratigraphic boreholes
- Shallow and deep hydrologic test wells
- Engineering design boreholes
- Shallow foundation boreholes.

Exploratory Shaft Facility. Activities during the approximate 20-month period of ESF construction include the following:

- Access-road construction
- Site clearing
- Drilling of freeze holes and freeze plant set up
- Sinking the two 12-foot diameter shafts
- Final lining* of the shafts
- Construction of surface facilities*
- Underground excavation.

The primary source of particulate emissions during geotechnical field studies and ESF construction is due to earthmoving activities. Particulate emissions from engine exhausts are included in the earthmoving fugitive dust emission rates. Other sources during ESF construction include operation of a concrete batch plant and mined materials handling. Sources of NO_x emissions include the operation of drilling rigs as wells as exhaust emissions from mobile equipment due to fuel consumption (Table 4-18).

Maximum daily particulate emissions are 728 pounds per day (Table 4-18). This maximum is expected to occur during months 6 through 8 of ESF construction. Figure 4-22 presents a plot of the mean monthly particulate emissions for that portion of the ESF construction that includes the expected maximum emissions (BNI, 1985a).

Maximum annual particulate emissions are 62 tons per year (Table 4-18). This maximum is expected to occur during months 2 through 13 of the ESF construction schedule. This period includes the emissions due to access road construction and site clearing activities, (Section 4.1.2), the activities, which cause the most particulate emissions (Figure 4-23). This figure presents a plot of the 12-month running total particulate emissions due to all sources for the ESF construction schedule. Figure 4-23 does not present individual monthly mean emission rates as in Figure 4-22. Running totals for the latter portion of the schedule are represented by a dashed line indicating particulate emissions decrease with time (BNI, 1985a).

Particulate emissions due to wind erosion from disturbed areas of the site are not included in Table 4-18 or in Figures 4-22 and 4-23, but are considered in estimating project related impacts. The determination and application of these emissions is discussed further in Section 4.2.1.3.2.

Excavation of salt does not occur during the periods of maximum daily and annual particulate emissions analyzed here. Sources of particulate salt emissions will include handling of mined salt and transferring it to the salt storage pile, maintaining the pile, and wind erosion of the active pile area. Salt deposition impacts during site characterization are discussed relative to repository impacts in Section 4.2.1.11.

Maximum annual NOx emissions are 240 tons per year (Table 4-18). This period is expected to occur during the 8th through the 19th months following the Presidential approval of a recommended salt site to undergo site characterization. This time schedule differs from that required to identify maximum periods of particulate emissions because a significant amount of the NOx emissions are due to geologic field studies which begin prior to ESF construction. Geotechnical field studies and ESF construction begins in months two and ten, respectively, following Presidential approval. Therefore, the maximum annual period includes NOx emissions due to geologic field studies (borehole drilling) and ESF construction activities (freeze hole drilling and mobile sources). Borehole and freeze hole drilling activities represent stationary sources, which account for 196 tons per year of the maximum. Mobile sources account for the remaining 44 tons per year (BNI, 1985a).

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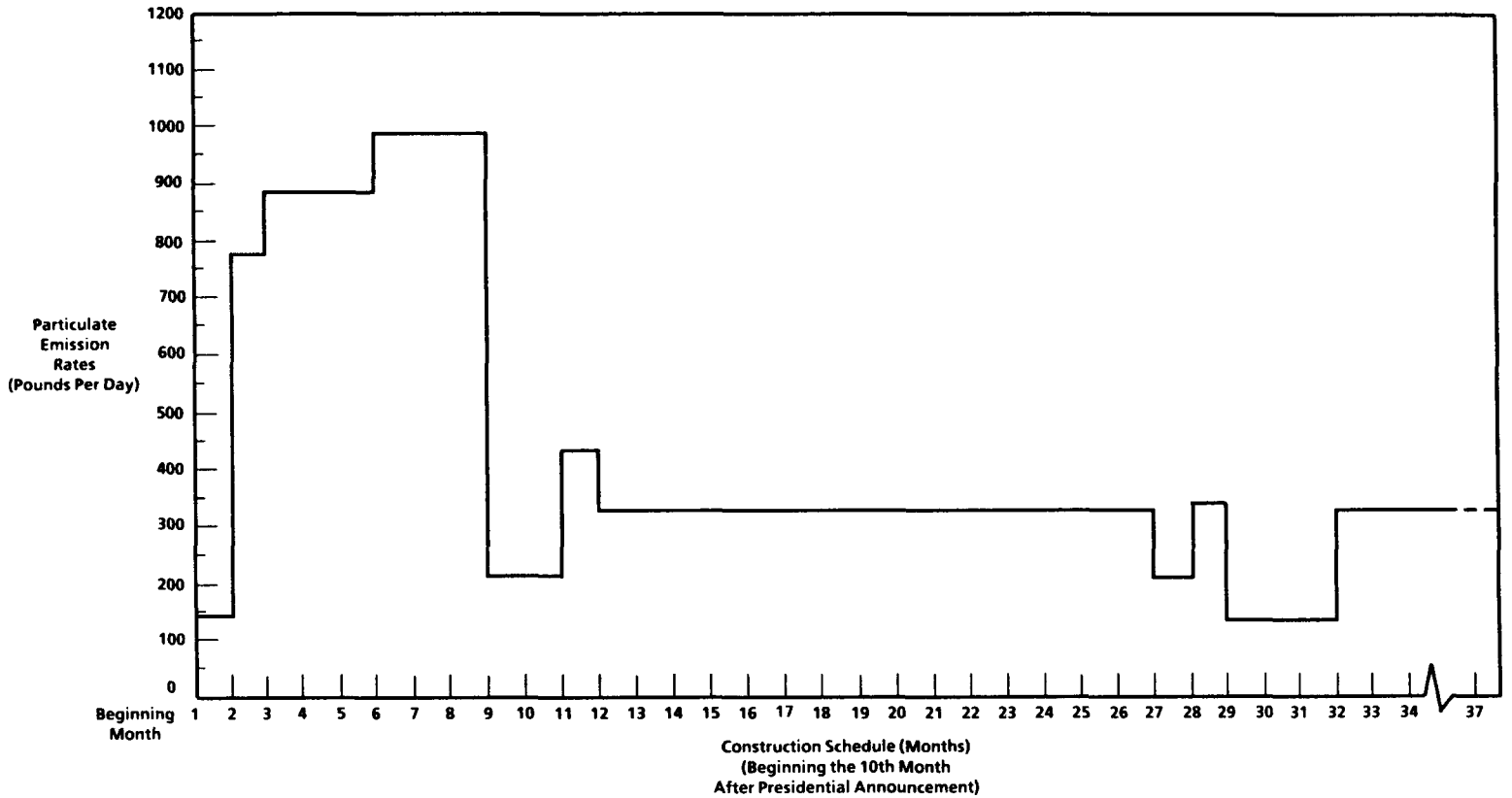
*These activities require cement mixed at an onsite batch plant.

Table 4-18. Maximum Emissions From Geotechnical Field Studies and Exploratory Shaft Facility Construction

Pollutant		Emission Rate: Maximum Daily (Pounds Per Day)	Emission Rate: Maximum Annual (Tons Per Year)
Particulates		728	62
NOx	Drilling Rigs (Borehole and Freeze Hole)	---	196
	Mobile Equipment	---	44
	Total	---	240

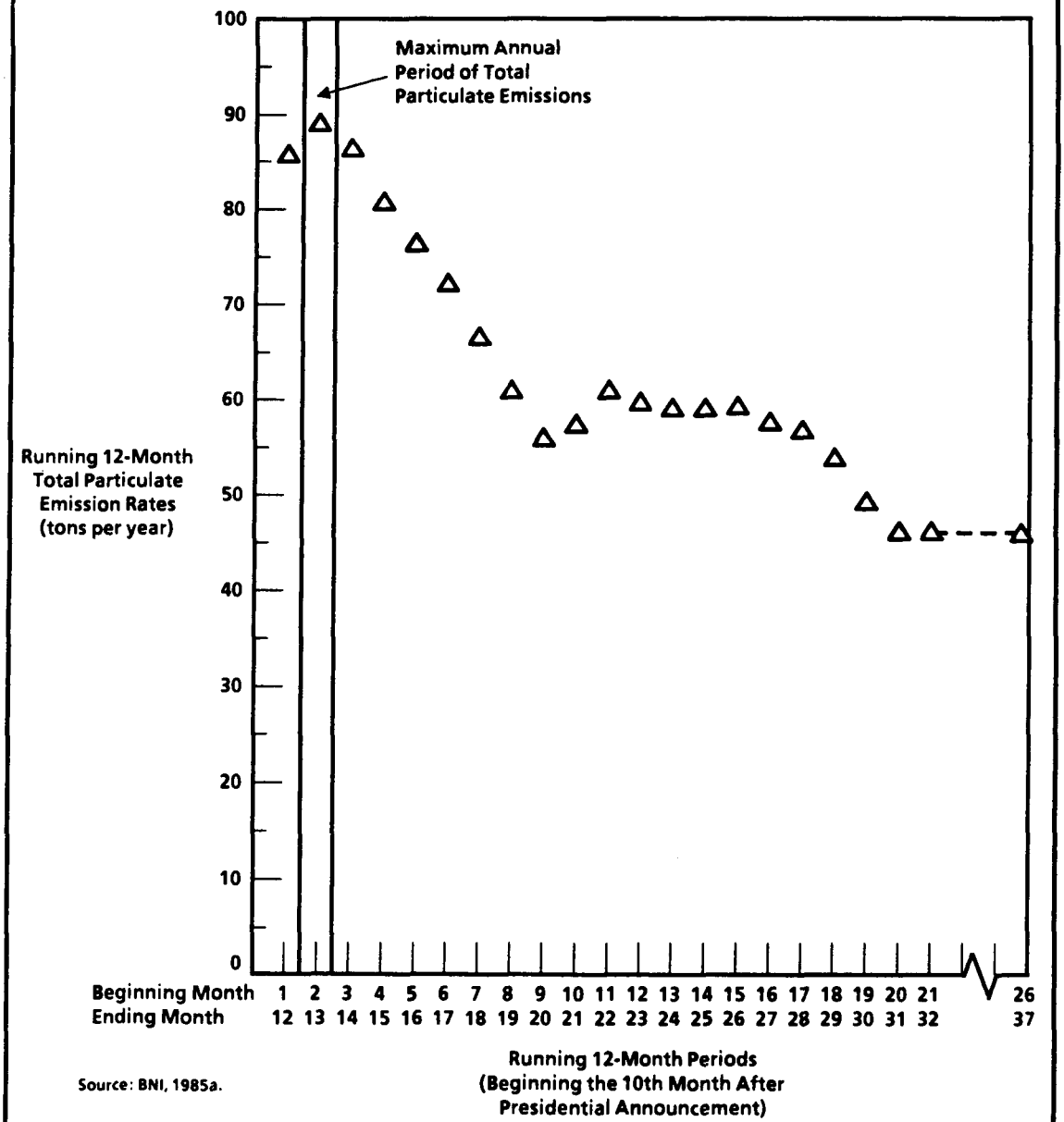
Source: ONWI, 1986.



Source: BNI, 1985a.

Monthly Particulate Emission Rates Due to ESF Construction and Underground Testing Activities at the Richton Dome Site

Figure 4-22



Source: BNI, 1985a.

Running 12-Month Total Particulate Emission Rates Due to ESF Construction and Underground Testing Activities at the Richton Dome Site

Figure 4-23

Figure 4-24 presents a plot of the 12-month running total NOx emissions due to stationary and mobile sources and to all sources combined from the initiation of geologic field studies through ESF construction. (This figure also indicates the threshold emission level for stationary sources, 227 metric tons (250 tons) per year, which would trigger Prevention of Significant Deterioration [PSD] requirements). The plot of emission values due to stationary sources indicates that site characterization activities will not be subject to PSD requirements (Section 4.2.1.3.3 contains further discussion).

Mitigation. Fugitive dust mitigation planned for the project includes the application of water and chemical suppressants to disturbed areas and haul roads in a carefully designed control program. Cuscino (1984, pp. 3-17) describes such a program to control fugitives from unpaved roads by up to 90 percent. Additional controls may be applied, such as speed controls on earthmoving vehicles and haul trucks, paving of haul roads, minimizing the size of disturbed areas, and covering storage piles.

Control efficiencies depend on three parameters: (1) application intensity, (2) application frequency, and (3) chemical dilution ratio. By adjustment of these parameters, it should be possible to obtain higher (or lower) control efficiencies than those documented in the report. The 90 percent control figure (Cuscino, 1984) is for traveled roadways. By applying the same control measures to disturbed areas and then limiting traffic access to them, control efficiencies in excess of 90 percent should be achievable. The control program for the proposed Richton Dome ESF activities has a goal of 95 percent control.

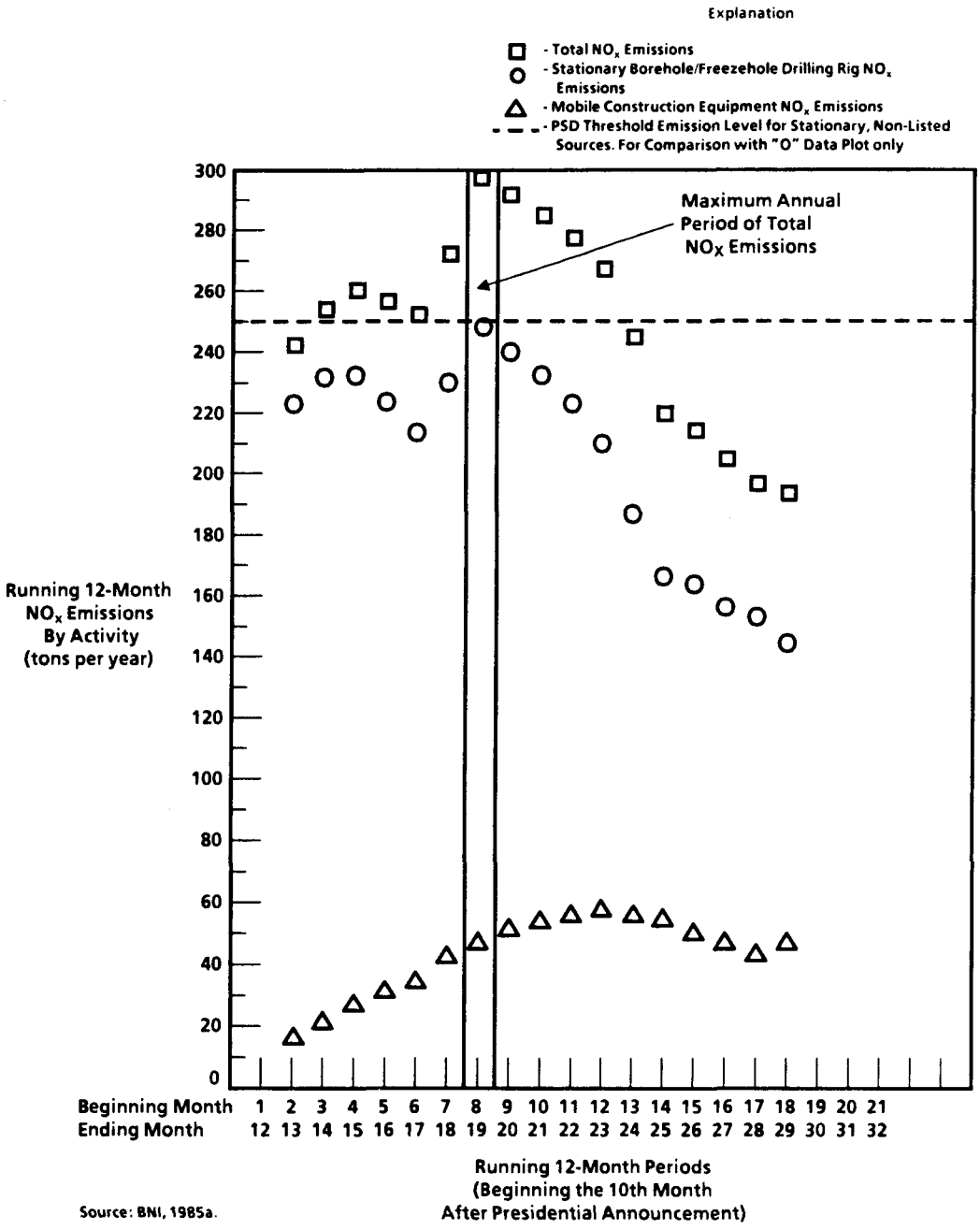
Mitigative measures are required to reduce the amount of particulate salt emissions associated with the salt storage pile. Water sprays may be used to suppress dust during salt handling activities. Wind erosion emissions from the salt pile will be reduced due to the natural crusting tendency of salt (Ver Planck, 1958). Crusting will be promoted by daily watering of the pile. Inactive areas of the salt pile will be covered (e.g., with dirt or asphalt) as it is being developed and after it is filled to capacity. Transport vehicles for hauling excess salt to offsite disposal areas will be covered.

Control of NOx emissions from diesel exhaust will be as required of manufacturers by Federal regulations. Inspection and maintenance of these controls by contractors will be a project requirement. Emissions of NOx from freeze hole drill rigs will be mitigated by using natural gas fuel and by fitting the exhaust with a catalytic reduction device. If additional reduction of NOx emissions is required to further reduce total emissions from stationary sources, then this technology could be applied to the borehole drilling rigs.

4.2.1.3.2 Methodology. The EPA Industrial Source Complex dispersion model (ISC) (Bowers et al., 1979) was used to estimate atmospheric concentrations of TSP and NO_2. ISCST (short-term) was used to estimate 24-hour average TSP concentrations. ISCLT (long-term) was used to estimate annual average TSP and NO_2 concentrations. The model is recommended by the EPA for the type of analysis needed at Richton Dome because it (1) has the ability to accommodate emissions from point and area sources, (2) allows for variable emission rates with time and with meteorological conditions (e.g., wind erosion), and (3) contains an option to consider particle deposition by gravitational settling. This latter phenomenon occurs with a significant fraction of the relatively large particle sizes found in fugitive dust emissions.

The ISC model requires a particle size distribution as input in order to use this option. The distribution used in this analysis is adopted from the results of fugitive dust measurements at western surface coal mines and is discussed in BNI (1985a).

Particulate emissions were modeled as area sources based on engineering design information discussed in BNI (1985a). Maximum 24-hour fugitive particulate emissions generated by earthmoving activities, materials handling, and vehicle movement were apportioned to one of two area sources depending on the ESF construction activity causing them. Wind erosion emissions were also apportioned to these two area sources but were assumed to occur only when the wind speed at the eroding surface exceeded the threshold of 19 kilometers (12 miles) per hour. The model requires area sources to be represented by a square. Site work activities were assumed to occur in an area 434 meters (1,424 feet) on a side (or approximately 18.8 hectares



Source: BNI, 1985a.

Running 12-Month NO_X Emissions Due to Drilling Rig Operations and Mobile Sources at the Richton Dome Site

Figure 4-24

[46.5 acres]). Surface facility construction and shaft activities were assumed to cover an adjacent area 350 meters (1,148 feet) on a side (approximately 12.3 hectares [30 acres]). On an annual basis, fugitive particulate and wind-erosion emissions were assumed to occur over a nominal 31-hectare (76.7-acre) area which is slightly larger than the 28-hectare (68-acre) ESF site area, represented by a square 557 meters (1,827 feet) on a side (BNI, 1985a).

Wind erosion emissions from disturbed areas were calculated using a predictive emission factor equation (Bohn et al., 1978). The emissions are a function of surface erodibility, soil silt content, precipitation-evaporation index, and wind speeds above the threshold value given above.

Annual NOx emissions were modeled as a combination of one area source based on engineering design information and one point source as discussed in BNI (1985a). Emissions from the freeze hole drill rigs at the service and production shafts, which last only three months, were treated conservatively as one point source centered in the ESF site area. Diesel emissions from drilling rigs associated with geologic field studies were assumed to occur at this same point. This assumption is conservative in that these drilling rigs will be located throughout the site area and will be stationary for periods of only one to six months before relocating (see Section 4.1.1). Maximum annual incremental concentrations from any one or group of these widely separated drilling rigs are much less than the concentration resulting from these modeling assumptions.

One year of sequential, hourly meteorological data (for the year 1975) and five years of meteorological data (1960-1964, STAR format) from the Jackson National Weather Service (NWS) station was used in the analysis (see Section 3.4.3.4).

In the absence of site-specific air quality data, background values of 35 micrograms per cubic meter of TSP and 20 micrograms per cubic meter of NO_2, proposed by the Mississippi Department of Natural Resources, were assumed (see Section 3.4.3.1).

4.2.1.3.3 Air Quality Impacts. This section addresses the results of the air quality modeling analyses. Additional details appear in BNI (1985a). Since the analyses were completed, updates and corrections to the equipment list have been made. Furthermore, a quality assurance check of the computation of the air quality emission levels has indicated errors in some terms, many of which have a cancelling effect with most of the others, leading to reduced impacts. Also, a review of the methodology employed in the air quality modeling revealed that the maximum 24-hour prediction (instead of the second highest) was the more appropriate value to use considering that 1 year of meterological data was used. The above changes will affect the concentrations of total suspended particulats (TSP) predicted in the air quality modeling as compared to what is presented below. A comparative evaluation has been performed of the expected changes in projected air quality impacts and is documented in "Evaluation of Air Quality and Noise Impact Assessments - Richton Dome" (ONWI, 1986). This document lists the changes in some detail and presents the results of those changes in terms of revised air quality impacts. This document concludes that small differences in expected impacts result, none of which is large enough to invalidate any of the conclusions presented herein.

Regulatory Review. The primary criterion in determining PSD applicability is whether a facility is a "major source" of criteria air pollutants. The sources of particulate and NOx emissions discussed earlier are not included in the list of 28 major stationary sources subject to an emission limitation of 91 metric tons (100 tons) per year. To be considered a major source, project-related stationary-source emissions would have to be greater than 227 metric tons (250 tons) per year (40 CFR 52.21[b][1]).

Table 4-18 indicates that the maximum annual emission level is 62 tons per year. Particulate emissions are primarily fugitive emissions. For these reasons, PSD requirements do not apply (Air Pollution Control Regulations of Mississippi [APC-S-2]; 40 CFR 52.21[b][1][iii]). NO_x emissions are due to both stationary and mobile sources. Borehole and freeze hole drilling rigs are stationary sources operating for 1-to-6-month periods at any one location. On an annual basis, the maximum total NOx emissions from these aggregate stationary sources are 196 tons per year (see Table 4-18).

For the purposes of this EA, the DOE concludes that site characterization is not subject to PSD requirements because stationary source emissions do not exceed the threshold limit of 227 metric tons (250 tons) per year.

In the interpretation of the modeling results presented below, air quality impacts are considered to be significant if the NAAQS are exceeded, i.e., those ambient concentrations which "...allowing an adequate margin of safety, are requisite to protect the public health" and those levels which "...are requisite to protect the public welfare from any known or anticipated adverse effects associated with the presence of air pollutants in the ambient air" (EPA, 1971).

Uncertainties. Prior to discussing modeling results, it is important to point out that there are uncertainties in the air quality impact analysis associated with particulate emission rates. Emission factors, particle size distributions, and control factors used to estimate particulate emission rates are drawn from the published literature. While the DOE considers that these data are the best available for use in the impact analysis, the DOE recognizes that there are uncertainties inherent in their use. For example, fugitive dust emission factors are based on limited measurements at other locations and for other types of earth-moving activities where natural soil characteristics such as silt and moisture content are different from those existing at the site. Particle size distributions from studies of western coal were used for both fugitive dust and salt emissions. Dust control efficiency values (50 percent using water application and vehicle speed limits, and 90 percent using chemical suppressant application and vehicle speed limits) can involve sizeable errors. The DOE believes the values used herein are achievable with a well designed and carefully conducted mitigation program. Uncertainties inherent in emission rate estimates have not been quantified; they could result in either higher or lower air quality impacts.

Estimated Concentrations. The highest and second-highest 24-hour TSP concentrations offsite were estimated. The second-highest offsite values are reported as "maximums" for comparison with the 24-hour NAAQS, which are not to be exceeded more than once per year. The highest annual offsite concentrations of TSP and NOx are also reported. "Offsite" refers to points at or beyond a limited access area surrounding the ESF.

Maximum offsite 24-hour TSP, and annual average TSP and NO_2 concentrations are summarized in Table 4-19. Total concentrations representing the sum of incremental concentrations plus background values identified earlier in Section 4.2.1.3.2 are presented.

The results indicate that the primary and secondary 24-hour NAAQS for TSP, and the annual NAAQS for TSP and NO_2 will be met during site characterization. On this basis, DOE concludes that site characterization activities will not have a significant impact on air quality.

Impacts due to salt deposition are discussed in Section 4.2.1.11, as mentioned earlier.

4.2.1.4 Hydrologic Effects

4.2.1.4.1 Surface Water. The following project activities may affect surface water quality during site characterization:

- Site preparation, including construction of access roads, drill sites, seismic lines, and the exploratory shaft facility
- Field data collection activities
- Brush and tree removal to provide access for foundation borehole drilling rigs and trenching activities
- Collection and disposal of exploratory shaft effluents, and stockpile runoff
- Handling and storage of excavated salt.

Table 4-19. Air Quality Impacts During Site Characterization at the Richton Dome Site

Pollutant	Averaging Time	Location	Maximum Concentration (micrograms per cubic meter)	NAAQS (micrograms per cubic meter)
TSP	24-hour	Limited Access Area Boundary	103	260/150[a]
TSP	Annual	Limited Access Area Boundary	42	75
NO2	Annual	Limited Access Area Boundary	38	100

Note: Background TSP value is 35 micrograms per cubic meter.
Background NO_2 value is 20 micrograms per cubic meter.

(a) Primary standard/Secondary standard.

Sources: BNI, 1985a; 40 CFR Part 50.

Consultation with the Department of the Interior and the State wildlife agency will continue in compliance with the Fish and Wildlife Coordination Act (16 USC Sections 661-666c), on any disturbance and modification of waterways during site characterization.

Runoff and erosion from land disturbed by site characterization field activities will result in increased suspended sediment and turbidity in Beaver Dam Creek, Fox Branch, and Linda Creek. Engineering design features of the proposed project (specifically, the planned system of sediment catchment basins and retention ponds) will minimize the total amount of sediment transported to surface receiving waters. Some offsite transport of sediment and subsequent contamination of surface waters can be expected. This impact will be temporary.

All field studies are expected to result in relatively minor, short-term deterioration of local surface water quality. Runoff and erosion of soil from these disturbed areas could affect surface water quality for the short period prior to revegetation of these areas, depending on which season of the year the survey is conducted.

Although background concentrations of suspended sediments in streams draining Richton Dome are unknown, they are likely to be high considering the extent of clear-cutting which has recently occurred there. Also, streams in this region typically carry high loads of suspended solids after major precipitation events and these streams are populated by species tolerant of such conditions. Thus, it is likely that increased suspended solids concentrations will not significantly degrade water quality in the area. Sedimentation ponds would be constructed at strategic locations (Section 4.1.2.2.1). This mitigation measure would minimize offsite transport of sediment, reducing water quality impacts on nearby streams. Site-specific studies of background water quality conditions, physical and chemical soil characteristics, and aquatic biota will be conducted prior to major land-disturbing activities during site characterization for a better assessment of site-specific mitigation measures.

Runoff from excavated material stockpiles (both salt and nonsalt) and liquids used during drilling activities may potentially contaminate nearby surface water if retention ponds overflow. Site layout and engineering design are such that stockpile runoff will be collected and directed to retention ponds. The size of the ponds will be determined based on historical rainfall data coupled with minimum evaporation rates. The salt runoff evaporation/retention pond overflow area will be designed to accommodate a storm event with a 500-year recurrence interval. No discharge from this pond to local surface waters is expected under forseeable conditions.

Based on studies performed for impact assessment of repository operations (Section 5.2.10), the potential degradation of the water quality of the nearby streams and water bodies by windblown salt would be small. The majority of the salt emitted from the ventilation shaft would be deposited within the ESF site; runoff from this area would be retained and discharged offsite only if it meets environmental discharge standards. The amount of salt deposited in the nearby water-sheds will be less than 1,800 kilograms (2 tons) per year, and will primarily affect Beaver Dam Creek, Fox Branch, and Linda Creek (see Section 3.3.1.1 and Table 3-18). Conservatively assuming that all the deposited salt will dissolve and run off with surface flows, the average annual increase in salinity in the surface runoff for these three creeks was estimated to be 0.1, 0.4, and 0.8 milligram per liter, respectively. Reported total dissolved solids concentrations for these creeks range from 32.0 to 43.0 milligrams per liter (Table 3-18). Thus, these increases in salinity would represent only minor changes in the water quality of the nearby streams.

Current plans call for the diversion of all surface water drainage from salt-contaminated areas of the exploratory shaft facilities into an evaporation/retention pond. Because precipitation exceeds evaporation, excess salt-contaminated water will have to be disposed of either by discharging to local streams or by trucking to an existing licensed brine injection well. The method of disposal depends upon salt concentration. Quantitative prediction of the salt concentration within the pond has not been possible with available data. Qualitatively, as the salt pile is initially built, rainfall may infiltrate through the salt and become salt-saturated (300,000 to 400,000 parts per million). After the salt crust forms, rainwater is expected to sluice over the surface of the crust and dissolve very little salt.

Salt runoff concentrations from salt-contaminated areas around the shafts will likely be low. Runoff from the salt pile will be collected in the retention pond. Rainfall directly in the pond will dilute its salt concentration, while evaporation will increase the concentration. The DOE plans to monitor salt concentrations within the retention pond and, if the salt concentration is below NPDES requirements, release water to surface streams. Because NPDES requirements take into account both the quality of the receiving water and the effluents, a discharge would be permitted only if it would not adversely affect water quality or downstream water uses. If salt concentrations exceed the NPDES value, the DOE may truck the salt water to an existing licensed brine injection well.

Other methods exist to mitigate salt pile runoff. The salt pile could be covered to reduce salt runoff from the pile. Only the pile runoff from uncovered areas would then require disposal, and the DOE believes that any underground injection requirements would thus be limited.

Deterioration in water quality from windblown salt deposition and subsequent runoff from salt contaminated soil is expected to be insignificant. This is because most emitted salt would be deposited within the ESF site boundary, and the runoff from this area will be retained and discharged off site only if it meets environmental discharge standards. The remaining amount of emitted salt deposited in nearby water will be small. The resulting salt concentration of the surface runoff will be low because of dilution from the high surface runoff in this area, equal to about 51 centimeters (20 inches) per year.

4.2.1.4.2 Ground Water. Site characterization activities that can potentially affect ground water quality include the following:

- Drilling 723 to 735 wells and boreholes at 700 to 800 locations to depths of up to 1,600 meters (5,200 feet) (includes 400 access and site foundation borings)
- Constructing two exploratory shafts 3.7 meters (12 feet) in diameter to a depth up to 671 meters (2,200 feet)
- Stockpiling excavated material and collection of runoff in sedimentation/evaporation ponds
- Performing pumping tests in fresh and saline aquifers
- Drilling a water supply well and withdrawing ground water.

Drilling will penetrate various water-bearing units, primarily within the Upper Aquifer geohydrologic unit (Section 3.3.2.1). Locally, ground-water quality and flow could be affected. To evaluate the potential impact of pumping tests in the Upper Aquifer geohydrologic unit on water levels in wells near Richton Dome, a calculation was performed, using the Theis Equation for non-equilibrium flow to a pumping well (Freeze and Cherry, 1979, p. 317). Hydraulic parameters used for the calculation were taken from pumping test results for a well at Richton Dome, reported by Newcome (1971, p. 36). Input parameters used were 393 square meters per day (4,000 square feet per day) for transmissivity, 32 liters per second (500 gallons per minute) for pumping rate, and 0.0002 for storativity. Because aquifer testing will typically last up to one week, with some testing lasting for longer periods, drawdowns were calculated for a test well pumped continuously for periods of 7 and 30 days.

The results indicate that a 7-day test would have a radius of influence (defined as a drawdown of less than 0.1 meter [0.3 feet]) at approximately 8 kilometers (5 miles). At a distance of 3.2 kilometers (2 miles), drawndown due to the test well would be approximately 0.7 meters (2.3 feet); at 1.6 kilometers (1 mile), drawdown would be 1.4 meters (4.6 feet). For a 30-day test, the radius of influence would be approximately 16 kilometers (10 miles), with drawdowns of 0.5 meters (1.6 feet) at 8 kilometers (5 miles); 1.0 meter (3.3 feet) at 4.8 kilometers (3 miles); 1.5 meters (4.9 feet) at 3.2 kilometers (2 miles); and 2.3 meters (7.5 feet) at 1.6 kilometers (1 mile). These drawdown values were calculated only to estimate impacts; actual values would be influenced by such factors as leakage from confining layers, concurrent aquifer tests, and local variations in hydraulic parameters.

Pumping tests of the upper aquifer unit will be performed at the six shallow hydronest and the six multiple aquifer hydronest locations. These sites are described in Section 4.1. The nearest water wells which could be affected by aquifer testing are Perry County wells B49, C15 and C40 (see Table 3-24 and Figure 3-34). These wells are all at least 1.6 kilometers (1 mile) from the nearest pumping test well, and are 99 to 224 meters (325 to 736 feet) deep. Based on the above discussion, it was concluded that water levels in production wells near the site will probably be affected by test pumping for a period of up to about 15 months, due to sequential testing. During that period, the degree of impact would be variable, depending on the distance between the water well and the well being tested. However, because of their depth, performance is not expected to be significantly affected. Once testing is complete, water levels in the area would essentially return to pre-test levels.

Drilling and testing of saline aquifers will involve production of brines which cannot be discharged to streams. Brine will be produced at an average rate of 286,000 liters per day (75,600 gallons per day) during this activity. These brines will be stored in tanks or lined pits on site, and trucked off site for disposal at a permitted facility.

The possibility also exists that the salt pile liner, retention pond liners, or the fuel tank will leak, thus affecting local ground-water quality. Possible water quality impacts of subsurface injection of brine into the deeper saline aquifers (Section 4.3.4.2) are not yet determined.

Measures proposed to avoid or minimize degradation of ground-water quality include the following:

- Using shaft construction and sealing techniques to minimize any hydraulic connection between water-bearing strata, hydrocarbon reservoirs, and salt deposits
- Avoiding onsite discharges of fluid wastes
- Collecting sludges and oily wastewater and disposing of them off site
- Lining the retention pond and any temporary or permanent salt pile storage areas with a salt-resistant double liner and including a leakage detection and recovery system
- Installing a monitoring system around the exploratory shaft and all surface facilities to detect filtration or leaching of contaminants.

As indicated in Section 4.1.2.6, solid waste generated during site characterization, and liquid wastes that cannot be discharged into the surface water system, will be disposed of at a permitted facility. Several facilities in the region have the capacity and the necessary permits to accept the expected wastes, including salt, salt-contaminated material, and brine. Because of this, impact to ground-water quality at the various disposal sites is not considered a potential problem.

Changes in ground-water quality due to infiltration of precipitation through soils contaminated by wind-blown salt are expected to be very minor. Although predictions of salt deposition from the ESF have not been made, modeling studies of repository operation show that deposition of salt will be on the order of 1 kilogram per hectare (0.9 pound per acre) per year in the repository area, diminishing to 0.1 kilogram per hectare (0.09 pound per acre) per year 1 to 2 kilometers (0.6 to 1.2 miles) away (Section 5.2.10). If all of this salt were carried to the water table and distributed in the top 3 meters (10 feet) of the saturated zone, it would represent an annual increase in salinity of about 0.01 to 0.1 milligram per liter. Over the life of the ESF, this would amount to less than a 1-milligram-per-liter increase in salinity for ground water within the immediate area. However, it is unlikely that all wind-deposited salt could reach the water table, as much of it will be transported with storm runoff to the runoff retention ponds.

4.2.1.4.3 Water Resources and Floodplain Management. Total water consumption during the construction and testing of the exploratory shaft, including site preparation and restoration, is 212 million liters (55.9 million gallons), as shown in Table 4-7. These water needs will be met with onsite wells. Although ground-water modeling to assess the impacts on local ground-water users has not been conducted, this demand is expected to have negligible impact because of the abundance of ground water available in this area (Section 3.3.3). Ground-water extraction will cause a localized depression in the potentiometric surface centered at the well field. The depression may have temporary and local effects on the existing ground-water flow regime. The potentiometric surface and ground-water flow regimes are expected to recover to essentially preconstruction conditions following the completion of site characterization and abandonment of the well field.

Because the exploratory shaft site will be located above the 100-year flood level, it will have no effect on the overall management of the floodplain in this area.

Ponding of surface runoff from the disturbed areas will reduce runoff to the adjacent streams. However, because the affected areas are small compared to total watershed areas, the overall impact on water resources is expected to be minor.

4.2.1.5 Effects on Soils, Geology, and Paleontology

This section discusses potential impacts site characterization may have on existing soils, geology, and paleontological resources of the Richton Dome area. Mitigation measures will be used to reduce potential impacts to soils. As field activities are completed, reclamation will be implemented as described below. If the site is not selected for repository development, the ESF site area will also be reclaimed. Site characterization activities are not expected to adversely affect the geology of the Richton Dome area, nor to result in a significant loss of paleontologic information.

4.2.1.5.1 Soils. Construction of drill pads and access roads, and geotechnical field activities (Section 4.1.1), will disturb a maximum total area of approximately 263 hectares (650 acres). Seismic reflection survey lines totalling approximately 154 hectares (380 acres) will be cleared, and explosives may be fired at shallow depths, which may locally disturb soil horizons. In all of these areas, the clearing of vegetation and compaction of surface soil using heavy equipment will cause increased runoff and soil erosion. In addition, the grading of drill pads will strip topsoil, mix soil horizons, and disturb local topography and drainage patterns.

The field study sites generally will be occupied for periods of 6 months or less. The borehole sites, trench sites, and seismic survey lines will be occupied at different times and will be distributed at various locations over and adjacent to the dome. Consequently, soil erosion at any one location will be minor, and much of the eroded soil will be deposited in adjacent, undisturbed areas.

As field activities conclude, reclamation will be implemented as described in Section 4.1.1. Reclamation will include regrading drill pads, access roads, and test pits to gentle contour and drainage pattern; replacing a surface layer of topsoil over stripped areas; disposing drilling fluids, cuttings, sand, and oily wastes in the offsite permitted facility; ripping and disking compacted areas to reduce surface runoff; and mulching and revegetating disturbed areas to reduce erosion. Revegetation is expected to occur rapidly and thereby decrease the erosion potential.

The drilling mud pit will be reclaimed following removal of the drilling fluids, drill cuttings, and synthetic liner. Waste drilling fluids will be separated into liquid and solid fractions to aid disposal. These materials will be disposed of off site as discussed in Section 4.1.2.4. The mud pit will be backfilled and graded to be nonimpounding, self-draining, and mechanically stable.

The principal ESF-related construction activities that will affect soils include clearing and grading a 28-hectare (68-acre) area for surface facilities, access roads, a salt storage

area, and the drilling mud and salt-pile runoff retention ponds. Preparation of the surface-facilities area will include stripping a 15-centimeter (6-inch) thick layer of topsoil. The total volume of stripped topsoil will be approximately 43,200 cubic meters (56,500 cubic yards). The topsoil will be stockpiled on site for later site restoration activities. Topsoil will be protected by seeding with suitable grasses and mulched to prevent wind and water erosion.

During the construction of the exploratory shaft facility, increased soil erosion will result from the stripping of vegetation and accelerated runoff due to paving and soil compaction. Soil erosion will be greatest during the initial months of construction but will then decrease over time. Assuming reasonably conservative conditions, the universal soil loss equation indicates that approximately 65 metric tons per hectare (29 tons per acre) per year will be lost through erosion during exploratory shaft construction. However, this estimate is not likely to be realized in practice because of both natural and human-induced conditions. The natural conditions are the hills, ridges, and other surface irregularities that tend to channelize flow, decrease surface runoff velocities, and create barriers to soil erosion. In addition, a number of mitigating measures will be implemented to reduce both the magnitude and duration of soil loss (Section 4.1.2.2). Such measures could include the following:

- Soil ridging, banking, or diking, and placement of culverts to channel surface water flow
- Construction of catchment basins on site
- Reduction of slope angles to lower runoff velocity
- Placing of material over the surface of the disturbed soils to absorb the energy or precipitation and runoff
- Replacement of topsoil followed by reseeding and mulching.

Although it is not expected, soils could be contaminated by seepage from the salt pile, the mud pit, or the retention ponds. The double-liner system with a leakage detection, monitoring, and recovery scheme (described in Sections 4.1.2 and 4.2.1.4) will be emplaced to detect seepage if a leak in the liner develops. If a leak is detected, the seepage will be pumped out and routed back to the retention pond.

Deposition of windblown salt may affect offsite soil in the vicinity of the salt storage pile. Based on deposition estimates for repository operations, the annual salt deposition rate is small: about 1 kilogram per hectare (0.9 pounds per acre). This maximum predicted rate of deposition is restricted to areas where salt is moved or stored and declines rapidly with distance from the salt handling facilities.

If it is assumed that the predicted maximum deposition rate remains in the top 0.33 meter (1 foot) of the soil strata, the annual increase in soil salinity would be less than 0.2 parts per million. Therefore, salt loading of soil is probably not significant.

Installation of a meteorological tower for environmental site investigation involves grading the tower area, constructing concrete footing, and grading an access road. These activities will increase runoff and soil erosion from clearing of vegetation and compaction of surface soil by heavy equipment. However, this will affect a small area and the site will be reclaimed when studies are complete.

Other environmental studies will have minor and localized soil impacts. Soil and archeological surveys will require scattered shallow diggings that will be backfilled. Other surveys (noise, land use, ecology) will involve several people walking or driving on the site vicinity and will have minimal soil impacts.

Site Reclamation. Grading and backfill may occur sequentially as various field activities are completed and in accordance with procedures specified by regulating agencies. In

preparation for reclamation, topsoil will be stripped from the area directly impacted by geologic, environmental, and ESF activities and stockpiled until needed for reclamation. Before stripping, the area will be inspected with a hand auger by a soil scientist to determine the depth and thickness of the soil horizons. Soil will be stockpiled as required to prevent unnecessary soil degredation. The stockpiles will be seeded with suitable grasses appropriate to the material stockpile and mulched until the grass cover is established to prevent wind and water erosion. Fertilizer needs will be determined by soil sampling and a chemical soil stablizer will be used to prevent erosion if the stockpiles cannot be mulched immediately. Clean straw or cotton gin waste at a rate of 6.7 metric tons per hectare (3 tons per acre) will be used to mulch the piles and it will be anchored using a spray-on tackifier. Seeding will be accomplished with a standard range drill or by hand if the size of piles does not warrant use of equipment.

During reclamation, regraded subsoil will be scarified, using a springtooth or diskharrow prior to topsoil redistribution, to ensure adhesion of the topsoil layer to the subsoil. Topsoil material will then be replaced over the disturbed areas to a depth corresponding to the amount removed from a given area. The replaced soil will be mulched and seeded as described for stockpile protection.

This treatment of the disturbed areas will ensure that the soils will reestablish their structure and permeability as quickly as possible and restore them to productivity for agriculture and forestry uses.

4.2.1.6 Noise Effects

The analyses presented below are based on geotechnical and engineering data (e.g., schedules, equipment inventories, and specifications) and noise source terms reported in BNI, 1985c. Since the analyses were completed updates and corrections to the equipment list have been made. Furthermore, a quality assurance check of the computation of the noise emission levels has indicated errors in some terms, many of which have a cancelling effect with most of the others, leading to reduced impacts. A comparative evaluation has been performed of the expected changes in projected noise impacts and is documented in "Evaluation of Air Quality and Noise Impact Assessments - Richton Dome" (ONWI, 1986). This document lists the changes in some detail and presents the results of those changes in terms of revised noise impacts. This document concludes that small differences in expected impacts result, none of which is large enough to invalidate any of the conclusions presented herein.

This section discusses noise criteria, noise associated with geologic field studies and exploratory shaft facility construction, modeling methodology, noise impacts, and mitigation of noise impacts. Also discussed are impulsive noise and ground vibration from blasting.

4.2.1.6.1 Noise Criteria. The EPA has not promulgated any community noise regulations pursuant to the "Noise Control Act of 1972" as amended by the Quiet Communities Act of 1978 (42 USC Sections 4901-4918) that apply site to characterization and repository construction, operation, and closure. The Noise Control Act requires Federal agencies to comply with State and local noise regulations. There are no applicable local, State or Federal standards on permissible environmental noise levels.

Two indicators of broadband environmental noise impact are used here: in terms of exceedance of certain specified energy equivalent noise levels and in terms of annoyance. First, the EPA has identified values of energy equivalent levels necessary to protect the public (EPA, 1974). The L_{dn} is the day/night energy equivalent level for the entire day; nighttime (10:00 p.m. to 7:00 a.m.) levels are weighted by 10 decibels (dB) because people are more sensitive to noise during the night. An L_{dn} of 55 A-weighted decibels (dBA) has been identified as the level sufficient to protect the public from the effects of environmental noise in normally quiet outdoor areas where people spend time. The EPA has recommended adoption of an L_{dn} less than 55 dBA as a goal in planning future programs.

The effects on humans of outdoor L_{dn} levels of 55 dBA (EPA, 1974) include the following:

1. Slight speech communication interference beyond 1 meter (3 feet) may be noted.

2. Less than 3 percent of the population may be highly annoyed, depending on attitude and other nonaccoustical factors.

Based upon EPA (1974) guidelines, offsite noise levels are considered acceptable if they are below 55 dBA and of short duration. Although no health and welfare effects are expected to occur where levels are under 55 dBA, a significant increase in noise over the existing conditions may lower the quality of the environment. As discussed in Section 3.4.4, the existing L_{dn} values are estimated to average from 35 dBA to over 45 dBA, with 35 dBA typical of remote areas and 45 dBA and higher typical of areas near farming activities, highways, residences, and communities. Since the background L_{dn} is expected to exceed 45 dBA in areas where people are likely to be, the L_{dn} 55 dBA value is adequate for estimating annoyance.

The second indicator of noise impact used here expresses the cumulative effect of activity interference due to noise in terms of annoyance. Although other factors, such as an individual's attitude towards a noise source, may influence his reaction to activity interferences, the percentage of people highly annoyed in a given environmental situation provides a useful indication of the severity of the impacts. Results of 11 surveys involving transportation noise show a remarkable consistency between measured L_{dn} levels and the subjective reaction of high annoyance (Schultz, 1978). The types of sounds from transportation involved in the 11 studies are similar to those expected from construction activities. Therefore, this correlation between the average subjective reaction of being highly annoyed and L_{dn} levels provides a perspective of the expected human response to project noise. It should be noted that the indicator of percent highly annoyed applies to a large community but may be statistically less meaningful when applied to estimating the reaction to noise of the few individuals in the rural areas near the proposed Richton Dome site whose attitudes and other nonaccoustical factors may modify this effect.

For nonimpulsive noise, the EPA (1974) has concluded that outdoor noise levels having a yearly average energy equivalent level (L_{eq}) of 70 dBA or less will protect against both hearing loss in the general population over a 40-year period and outdoor activity interference for farmland. The EPA (1974) guidelines for limiting exposure to impulsive noise, such as from blasting, are expressed in terms of peak pressure level, duration of individual pulses, and number of pulses per day. At an exposure rate of 100 impulses per day of 125 dB peak pressure, the exposed population will not experience noticeable hearing loss. Evaluation of human response to blasting noise has been studied extensively by various investigators. Correspondingly there are various metrics for assesing human response to blasting noise such as values of peak sound pressure of independent noise events, or expressions of acoustic energy averages over time. One criterion for human response to blasting that might be applied to the data expresses annoyance from impulsive sounds as a percent of listeners highly annoyed as a function of a C-weighted Day Night Sound Level (CDNL) (Committee on Hearing, Bioacoustics, and Biomechanics, 1981), as follows:

CDNL Value db	Listeners Highly Annoyed Percent
45	2
50	3
55	5
60	12
65	23
70	30

The CDNL from blasting is presented in Section 4.2.1.6.5.

Ground motion from blasting activities can result in human response. When human exposures are above established vibration thresholds, human responses can range from the vibrations being viewed as barely perceptible to intolerable. A U.S. Bureau of Mines

publication (Siskind et al., 1980) discusses various studies concerning human response to blasting. Human response to a transient ground motion such as an explosive blast is a function of the magnitude and duration of the ground motion. The threshold for a barely perceptible transient vibration is 2 millimeters (0.08 inch) per second.

The Occupational Safety and Health Administration (OSHA) regulates exposure to noise in the work place. Noise control measures will be applied as necessary to meet applicable noise standards.

4.2.1.6.2 Geotechnical Field Studies. Geological and hydrological borehole drilling activities will result in increased sound levels in the area around each location. The boreholes will be located both within and outside the ESF area (Section 4.1.1). The drilling activities will be of varying duration, depending on the type of boring. While the drilling rigs will be in the general area over a period of 28 months, the drilling at each location will last only from 1 to 6 months. Field study activities will result in some additional vehicular activity in the area of the boreholes and the site. Increases in sound levels from vehicular activity will be small, localized, and of short duration.

Short-term increases in sound levels will result from the operation of truck-mounted generators for conducting geologic resistivity surveys. These generators are small, about the size of the engine-generator on motor homes, and will only produce noticeable increases in sound levels within about 100 meters (330 feet) for short periods of time at each survey location. Explosives or truck-mounted vibrators may be used for field seismic surveys during daylight hours. Impacts on residences depend on the size of the explosive charge used, the distance to the residence, and blast-control measures.

Noise impacts from these activities are discussed in Section 4.2.1.6.5.

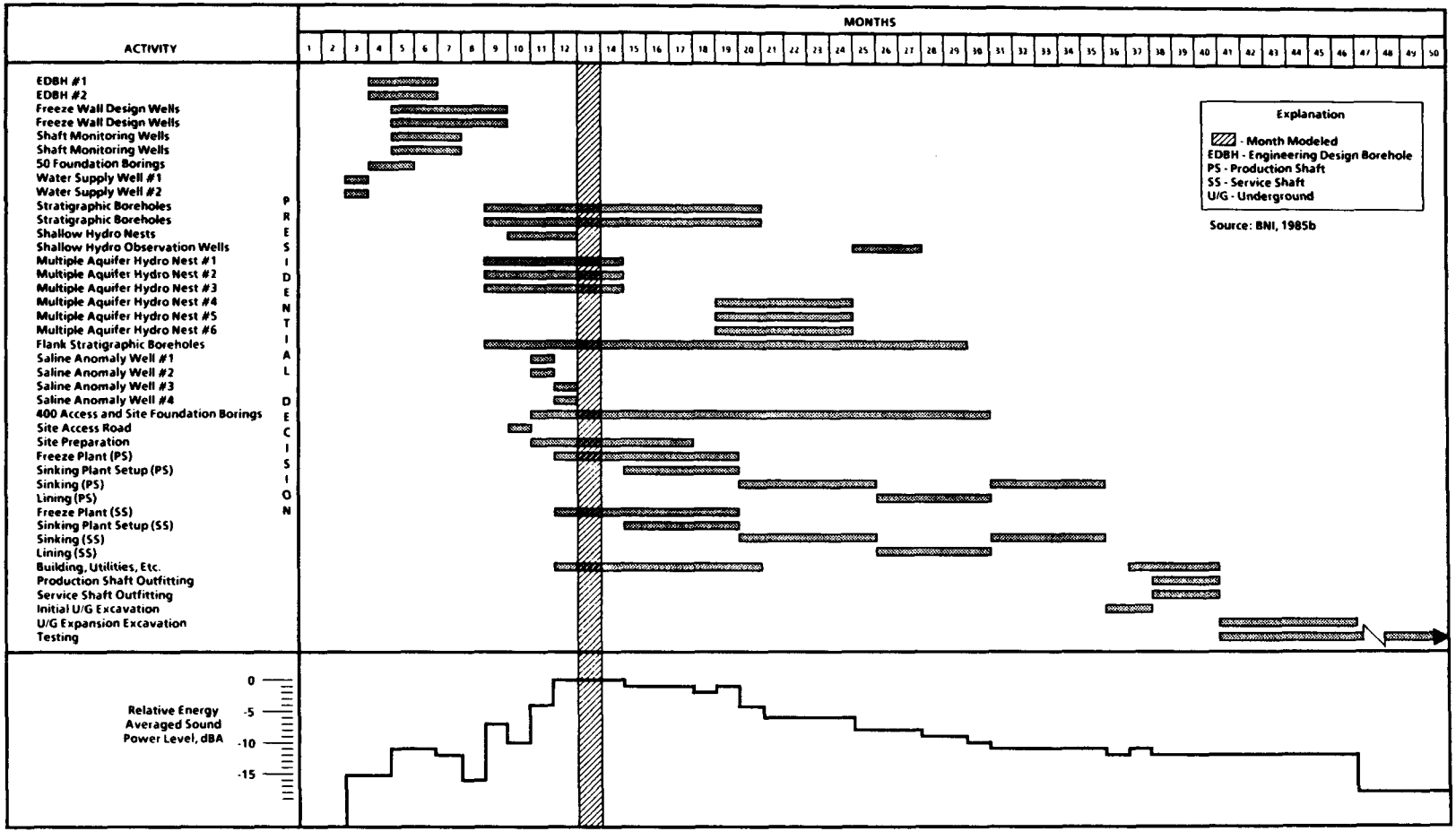
4.2.1.6.3 Exploratory Shaft Facility. Development of the exploratory shaft facility will begin with the drilling of the two engineering design boreholes (EDBH). Additional drilling activities will occur within the ESF area over a 28-month period. In addition to these activities, site preparation, shaft sinking, and facility construction activities will extend over 30 months, followed by underground excavation and testing. If this site is not chosen for the repository, the testing will be followed by decommissioning and reclamation.

Noise impacts from these activities are discussed in Section 4.2.1.6.5.

4.2.1.6.4 Methodology. Modeling of the peak activity period of site characterization was performed to estimate maximum noise impacts and to identify noise control measures necessary to mitigate these impacts. The major noise associated with site characterization will occur between months 11 and 19, of which month 13, the noisiest month (Figure 4-25), was modeled. The construction activities during the month modeled include the construction of the production and service shaft freeze plants and utilities. Various geological field studies were also considered in the modeling, including drilling of stratigraphic boreholes, multiple aquifer hydro nests, and foundation borings. Traffic along the main access route to the site was included in the modeling (BNI, 1985b). The types of equipment to be used during exploratory shaft facility development have been identified in Section 4.1.2. Using these equipment inventories, octave band sound power levels were derived assuming standard, non-quieted items using vendor furnished data or published reports (BNI, 1985b). In cases where data were incomplete or unavailable, levels were synthesized from related data, known characteristics of comparable equipment, and published standards.

The Environmental Noise Prediction Model (ENPM) was used to model project-related noise. The computer model determines the octave band level as a function of distance from each source, based on the relationship presented by Beranek (1971, pp. 164, 165). The model considers the following:

- Spatial relationships between noise sources and receptors
- Sound power level of each source



Schedule and Relative Sound Level Site Characterization

Figure 4-25

- Excess attenuation by air absorption (Acoustical Society of America, 1978)
- Anomalous excess attenuation (Edison Electric Institute, 1983, p. 5-2)
- Equipment duty cycle and loading conditions (used to estimate energy equivalent levels)
- Effects of vertical temperature and wind gradients.

The model sums the noise contributions at specified locations on a X-Y grid (BNI, 1985b). Grid intervals are 0.4 kilometer (0.25 mile) in the north and south directions. Receptors were assumed to be 1.5 meters (5 feet) above the site elevation.

Refraction of sound due to appreciable vertical temperature and wind gradients is approximated by considering a mixing layer characterized by (1) -1 C per 100 meters temperature lapse rate, (2) mean annual wind speed through the layer, and (3) an inversion at the top of the layer that serves as an oblique reflecting surface. The physical laws of refraction and reflection are also used (Eshbach and Souders, 1975, p. 1094). Refraction is assumed to be symmetrical about the sound source.

Average meteorological conditions described in Section 3.4.3 were assumed for the site. The average temperature was 65 F and the average relative humidity 78 percent. The annual mean wind speed of 5.8 kilometers per hour (3.6 miles per hour) conservatively assumed to have a direction from the sound source to the receiver. Inversion layers corresponding to the annual mean morning and afternoon mixing heights at Jackson, Mississippi, were assumed. Attenuation from low ground cover (excluding trees), distance, and air absorption were treated by the model. Accordingly, results are reasonably conservative estimates of changes in noise levels.

Noise impacts resulting from blasting were modeled separately. The audibility estimate was made using a technique described by Fidell and Horonjeff (1982). The blasting noise predictions for Richton Dome are based on empirical formulas and relationships derived from the open literature spanning the years 1965 to 1985 (BNI, 1985b). Variables and factors which are taken into account in the calculations are as follows:

- The charge weight per delay of explosive (12.7 kilograms [27.9 pounds])
- Burial depth of the explosive charge (i.e. overburden) (2.44 meters [8 feet])
- Distance from the source
- Anomalous attenuation
- Attenuation due to air absorption
- Meterological conditions.

Three wind conditions were used in the blasting model: (1) annual mean wind velocity from the source to the receiver, (2) calm conditions (wind velocity = 0), and (3) annual mean wind velocity from the receiver toward the source. Four vertical temperature gradients were used: (1) large positive, (2) small positive, (3) zero, and (4) small negative (BNI, 1985b). The modeling results are summarized in Section 4.2.1.6.5 as the extremes of the values obtained. The greatest sound propagation distances occur when there is a large positive temperature gradient and the wind direction is from the blasting site. The least blast noise occurs when there is a small negative temperature gradient and the wind direction is towards the blast site.

Although blasting activity will include parting and breaking shots for site clearing and grading, only the surface blasting associated with shaft sinking, which involves the largest explosive charges, were modeled.

4.2.1.6.5 Uncertainties. It is believed by the DOE that the noise modeling carried out in this section was based on the best available meteroological data, the latest literature on sound emission levels, and the state of the art of noise modeling techniques. However, uncertainties do exist in this modeling and are caused largely by the following:

1. Uncertainties in sound emission levels to approximately $\pm$ 5 dB

2. Consideration of wind and temperature gradient effects on noise propagation. Unfavorable gradients (when occurring) can significantly increase noise propagation toward a given receptor whereas favorable gradients can significantly reduce such impacts.

3. Pine forests, which cover a large portion of the Richton Dome area and which have not been accounted for in the modeling. They could provide over 10 dBA noise reduction (Section 4.1.1.1.7).

4.2.1.6.6 Noise Impacts. The modeling results, in the form of L_{dn} noise isopleths for site characterization with an explanation relating L_{dn} levels to percent highly annoyed, appear in Figure 4-26. The following is a summary of modeling results:

1. The L_{dn} 45 dBA contour extends approximately 2.5 kilometers (1.5 miles) from the ESF site center. Since the existing L_{dn} is expected to exceed 45 dBA, in areas where people are likely to be, no individual reaction is expected.

2. During 3 months the L_{dn} of 55 dBA will be exceeded within 1.8 kilometers (1.1 miles) of the ESF site center. Two residences, but no other noise sensitive receptors such as churches or schools, lie within this contour (USGS, 1973; 1982a,b,c). During an additional 18 months, the noise level will be slightly lower (see Figure 4-25).

3. The L_{eq} 70 dBA guideline for protecting against hearing loss and for activity interference for farmland will not be exceeded beyond the ESF site boundary.

4. The L_{dn} 55 dBA contour extends up to 0.4 kilometer (0.25 mile) from any borehole. Three borehole sites (not modeled) are within 0.4 kilometer (0.25 mile) of the town of Richton and some residents may be highly annoyed in portions of the community for approximately 9 months.

5. The L_{dn} 55 dBA contour extends less than 0.1 kilometer (0.06 mile) from the highway leading to the site. There may be isolated residents living along this highway who would be highly annoyed throughout the site characterization period.

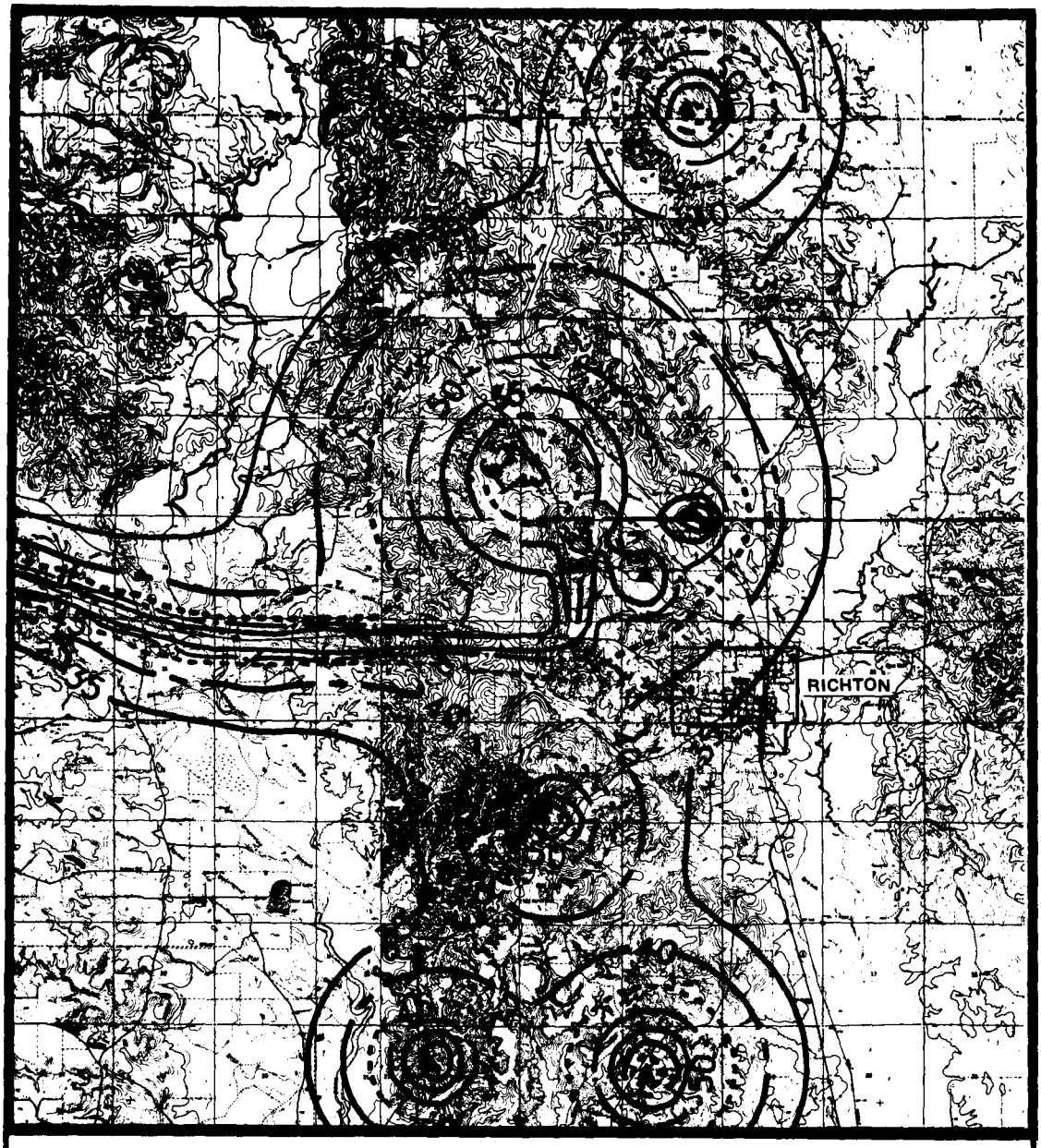
The impact of tonal noise from the equipment is more difficult to quantify. Tonal noise may be produced by any equipment, depending on the type and condition (wear) of the equipment. Although typical octave band information exists for the equipment to be used, the specific tonal components and their magnitudes depend on the manufacturer of the equipment.

Two factors aid in minimizing tonal noise impacts:

1. The broadband noise caused by equipment such as engines (mobile equipment) tends to mask the tones, reducing the likelihood that the tones would be audible in noise-sensitive areas.

2. Many of these tones (for noise sources such as welding rigs, air compressors) are at high frequencies (greater than 1,000 hertz) and are reduced by atmospheric attenuation.

A significant noise source associated with the Richton Dome site is blasting. During exploratory shaft facility construction, blasting will be employed to break rock in the shaft(s).



Note: Noise Isopleths in dBA

- Nearest Residences
- ▲ Geophysical Sites

Scale

0 ½ 1 2 Mi

0 1 2 3 4Km

Community Reaction

L_{dn}, dBA	Percent Highly Annoyed
45	0
50	0
55	3
60	8
65	15
70	24
75	37

Source: BNI, 1985b.

Site Characterization
Day/Night Sound Level
Richton Dome

Figure 4-26

It is expected that there will be no more than three blasts per day during the beginning of shaft sinking (see Figure 4-25). Each blast will consist of 10 impulses (charges) separated by 0.5 seconds. As shafts are sunk, blasting is expected to be increasingly muffled by the effects of shaft depth. After shafts have reached depths of about 27 meters (90 feet) over a period of 6 to 12 days, a sinking stage will be installed (Section 4.1.2.2) which will muffle the noise, and blasting will no longer be a significant noise source. The peak sound pressure level from blasting may be clearly audible at the edge of suburban Richton, 3.5 kilometers (2.2 miles) southeast of the blast site, where peak levels are expected to be between 50 dB and 83 dB. According to the audibility criteria of Fidell and Horonjeff (1982), it is estimated that the blast may be audible up to 17.5 kilometers (11.6 miles) from the source during conditions favorable to sound propagation. Under average meterological conditions this distance will be approximately one-half, i.e., 9 kilometers (6 miles). Less than two percent of the population will be highly annoyed when the CDNL is less than 45 dB. During meteorological conditions favorable to long-distance sound propagation, the CDNL of 45 dB will extend to 1.6 kilometer (1.0 mile), encompassing the nearest residence. During average meteorological conditions the CDNL of 45 dB will extend less than 0.6 kilometer (0.4 mile).

The highest peak sound pressure level during blasting will be below 100 dB at 1.0 kilometer (0.6 mile). This condition is well below the criteria given in Section 4.2.1.6.1 and therefore cumulative adverse health effects to the general public are not expected. Projections of ground motion caused by blasting are below the threshold of perception at the nearest residence and well below the level (13 millimeters [0.5 inch] per second) that would cause structural damage to houses (Siskind, 1980).

If explosives are used during seismic surveys, they will create occasional pulses of noise in the vicinity of the surveys. The seismic surveys will occur during daylight hours. The number of explosive charges will vary, but will probably average 70 per day. Assuming 2.3 kilogram (5-pound) charges at a 7.6 meter (25-foot) depth, and the use of electric blasting caps, there will be no impact beyond 0.1 kilometer (0.06 mile) from seismic activity (Wiss and Linehan, 1978). Section 4.1.1 contains further description of the seismic survey program.

A summary of significant noise impacts is as follows:

1. As a result of the noisiest phase of ESF and borehole drilling activities, the L_{dn} 55 dBA contour will extend 1.8 kilometers (1.1 miles) from the ESF site center, and will impact two residences for up to 16 months.

2. Drilling activities at three boreholes (not modeled) within 0.4 kilometer (0.25 mile) of the town of Richton, will produce an L_{dn} 55 dBA value in small portions of the Richton community for 1 to 6 months near each borehole location

3. Under favorable sound propagation conditions, blast noise may annoy the nearest residents during a period of 3 to 12 days.

4.2.1.6.7 Noise Impacts Mitigation. The DOE will establish a control procedure for inspection and maintenance of mufflers and other noise control devices. The noise impacts presented in Section 4.2.1.6.5 assume no special noise controls or other mitigative measures have been implemented and do not consider the noise reduction from pine forests between the source and the area impacted. Pine forest covers a large portion of the Richton Dome area. These forests can provide over 10 dBA noise reduction (Beranek, 1971, pp. 170,173) reducing the levels in Figure 4-26. During the initial period of site characterization this effect will be quantified (Section 4.1.3.1.6) and the need for additional noise controls will be determined by the DOE. If the noise reduction due to the surrounding forest is insufficient, further mitigation can be implemented. Reducing noise from most equipment is technically possible and economically feasible. For the repository construction phase, both machinery noise and noise from blasting may be reduced. Machinery noise may be mitigated by adding sound damping equipment to cooling fans and intake superchargers, and by adding more muffling to exhausts. Such practices are common in Europe, and the control technology is readily available. The effect of the damping is to reduce sound power levels 3 to 6 decibels, with concomitant reductions in predicted sound pressure levels. Noise from blasting, especially for

surface or near-surface explosions, can be mitigated by covering the blast area with sound-absorbing foam blankets. Such a mitigation technique can substantially reduce the distances at which explosions may be heard. Possible noise control measures include the following:

- Geological Field Studies
  - Enclosing diesel engines on drill rigs and installing residential-grade mufflers - up to 10 dB reduction
  - Locating boreholes at least 0.4 kilometer (0.25 mile) from the Richton community.
- Exploratory Shaft Facility
  - Implementing equipment noise controls such as sound enclosures around engines and hydraulic systems, and residential grade mufflers on equipment such as onsite drill rigs, dozers, mobile cranes, loaders - up to 10 dB reduction
  - Using adjustable backup alarms - up to 7 dBA quieter
  - Selecting equipment designed to minimize or eliminate any annoying tonal components
  - Enclosing major stationary noise sources such as the sinking plant and freeze plant
  - Leasing by the DOE of a buffer zone beyond site boundaries to control areas of unacceptable noise impact
  - Moving of residents.
- Blasting
  - Limiting blasting to daylight hours on weekdays (Section 4.2.1.6.5), to reduce any interference with sleep and leisure time
  - Limiting blasting to periods when meteorological conditions are least favorable to long-range sound propagation.

If the Richton Dome site is selected for the exploratory shaft facility, noise mitigation requirements will be established based upon identified need and discussion with appropriate agencies.

4.2.1.7 Effects on Aesthetic Resources

Introduction of large structures and associated development in a rural landscape may affect the visual character of the Richton Dome area during site characterization. Visual impacts may result from dust plumes, tall structures, sky glow from night lighting, and disturbance of surface conditions. This section discusses the impact from geologic and environmental field activities and from exploratory shaft facility development.

4.2.1.7.1 Geotechnical Field Activities. Geological field activities will involve construction of access road, land clearing and grading, erecting drill rigs, and movement of equipment. Even with dust control measures applied, minor fugitive dust emissions will result from activities such as excavation, movement of major equipment, and traffic on unpaved roads will produce dust clouds. However, these dust clouds will be local and visible only for short periods; consequently, no detectable loss of visual range from the surrounding area is expected. State-of-the-art control technology, described in Section 4.2.1.3, will be used to mitigate dust plumes.

Disturbance of surface conditions and surface construction for geologic field activity may be visible from several points in the area. However, because of relatively low topographic relief and the predominantly forested vegetative cover, visibility will generally be limited to those areas next to activity sites. Visual contrast in the area of the site due to the disturbance of surface conditions will probably be low because of recent clear-cutting. Visibility of the tallest drill rigs will be similar to that of the exploratory shaft headframes.

4.2.1.7.2 Exploratory Shaft Facility. The exploratory shaft facility (ESF) will include two 38-meter (125-foot) headframes. These shapes will be visually obvious from several points in the nearby area, altering the shape of the horizon. Although rolling terrain and existing forest cover will generally obscure the towers from public view, the towers may be visible from some cleared areas as far away as 2.4 kilometers (1.5 miles).

Preliminary visibility analyses using 1-meter-(3-foot-) diameter weather balloons suspended approximately 50 and 61 meters (165 and 200 feet) above ground level indicated that structures at these heights located at the site may be visible from an area on Mississippi State Highway 42 (approximately 2.4 kilometers [1.5 miles] south of the site), but will probably not be visible from Mississippi State Highway 15 (east and north of the site) (Scott, 1984, pp. 1-4). Portions of the head frames may therefore be visible from Mississippi State Highway 42. Visual contrast from Mississippi State Highway 42 will probably be low because tall structures are expected to be visible from only a section of the highway, and these structures would be viewed for only a short period while traveling on the roadway.

During construction of the shafts, site activities will be conducted 24 hours per day. Night lighting at the site may be visible from nearby highways and residences. Actual visibility will depend on the position of the lights, thickness of surrounding forest cover, and atmospheric conditions. Directional lighting will be used to minimize the visibility of the sky glow to the surrounding area.

New transmission lines to the ESF will cause some visual impact, appearing as dark lines on the horizon. An example of power poles used for this new line is presented in Section 4.1.2.2.1, Figure 4-9. Temporary visual impacts during erection of the new power holes will consist of an occasional observance of construction personnel and equipment. The power poles generally will be screened from view by the surrounding forest. If the site is not selected for development of a repository, and if there is no public use for it, the line will be removed and the tower and power pole sites restored.

4.2.1.7.3 Environmental Field Studies. During environmental investigations, up to 20 people will be in the field at various times to sample and collect data. These field visits will typically be short and will have no impact on the visual character of the area. The only environmental study activity that will affect the visual character is installation of a 60-meter (197-foot) meteorological tower. Impacts will be similar to those described for the exploratory shaft headframes (Section 4.2.1.7.2).

Based on the above discussions, the structures used in site characterization (headframes and meteorological tower) are expected to have visibility limited to views from some sections along local roads near the site. These impacts are not considered unusual relative to those from other industrial facilities (pulp and paper mills) in the area.

4.2.1.8 Effects on Archaeological, Cultural, and Historical Resources

Construction of access roads and drill pads, drilling operations, and excavation of test pits are examples of activities that could disturb both surface and subsurface cultural deposits. Other anticipated undertakings that could disturb cultural resource sites include land clearing procedures, grading, topsoil removal, placement of landfill, erosion control, site restoration measures, and blasting or vibrations associated with seismic surveys (Section 3.4.6.4). No sites within the dome area are listed in, have recently been nominated to, or are classified as eligible for, nomination to the National Register of Historic Places (See annual listings of NHRP properties [NPS, 1985 and previous listings]).

The DOE, the Advisory Council on Historic Preservation, and the Mississippi State Historic Preservation Officer will enter into a Programatic Memorandum of Agreement (PMOA) (DOE, 1985a). The implementation of the stipulations of the PMOA would avoid or satisfactorially mitigate the potential adverse effects of this project on historic and cultural properties. As required by the PMOA, the DOE will accomplish the following:

1. A workers awareness program for archaeological and historic resources will be initiated.

2. In consultation with the Mississippi State Historic Preservation Office, (SHPO) the DOE will develop and implement a research design to guide archaeological surveys and data recovery during site characterization.

3. The DOE will ensure completion of archaeological surveys of a unit of land prior to its disturbance. These surveys will address areas that are subject to direct and indirect project effects.

4. Every effort to design project activities to avoid damage to any historic or archaeological property will be made. If avoidance is not possible, the DOE will develop and implement a data recovery plan in consultation with the Mississippi SHPO.

Most geotechnical and other field studies will disturb small, dispersed areas and corridors. Adverse effects to cultural resource sites can be avoided by relocation of specific geotechnical study areas if cultural resources are encountered. When avoidance is not feasible, mitigation measures for National Register-eligible sites will be developed in consultation with the State Historic Preservation Office.

Because construction of the exploratory shaft facility will disturb the surface and subsurface within a defined 27-hectare (68-acre) tract, avoidance of cultural resources may not be feasible. If the exploratory shaft site is found to contain significant cultural resources, and impacts to these resources cannot be avoided, it will be necessary to apply mitigation measures to prevent the loss of important archaeological data. Such measures should include a data recovery program developed in consultation with the Mississippi SHPO and the Advisory Council on Historic Preservation.

If significant cultural resources are identified during the cultural resource surveys of the meteorological tower location and all access routes, they may be avoided by relocation of these facilities. If relocation is not possible, mitigative measures will be taken to prevent loss of archeological data.

In accordance with the PMOA, should the Richton Dome site be selected for detailed site characterization, the DOE, in consultation with the Mississippi SHPO and the Advisory Council on Historic Preservation, will plan and conduct appropriate archaeological surveys prior to any site-disturbing activities.

Any direct adverse effect on cultural resources would be limited to the period of site characterization. Indirect impacts would be more diffuse and long-term, and would include the potential loss of cultural resource sites due to induced growth and increased visitation to known cultural resources. Implementation of the PMOA would avoid or satisfactorily mitigate these potential adverse effects.

4.2.1.9 Effects on Radiological Levels

No radiological impacts are expected as a result of site characterization activities. Radioactive wastes will not be used for testing because their thermal effects can be simulated using electric heaters.

Routine releases of naturally occurring radioactivity will take place during the sinking of the exploratory shaft. This radioactivity will consist of radon and its daughter products

contained in soil and rock, and to a lesser extent, salt. However, the impact of these radioactive elements on the environment will be insignificant because of their low abundance in the overdome strata and in the salt dome itself. As discussed in Section 3.4.7, it is estimated that the background (ambient) whole body dose rate at the Richton Dome is approximately 68 millirem per year. An evaluation of the amount of radon and daughter products likely to be contained in excavated overburden and salt from exploratory shaft development conservatively indicates that up to 10 microcuries of radioactivity could be released to the environment, equivalent to a whole body dose rate of about 3.36×10^{-4} millirem per year, or about 0.0003 percent of the ambient dose rate (Waite et al., 1985, BMI/ONWI-541). Consideration of this information, plus other individual and population dose estimates given in the literature (BNW, 1979, DOE/ET-0028; DOE, 1980, DOE/EIS-0026), indicates that increases in radioactivity due to exploratory shaft development are so small as to be considered negligible.

In addition, some of the tests carried out during detailed site characterization use instrumentation procedures that involve small amounts of radioactivity. Three examples of these tests are measurement of soil density, measurement of soil moisture, and nondestructive testing of welds. Standard industry logging tools and radiography equipment will be employed, for example, in the measuring of soil and rock physical characteristics, and in the nondestructive testing of welds. All radiation sources will be licensed by the NRC and will be operated by licensed personnel, where applicable.

4.2.1.10 Effects on Transportation and Utilities

This section describes the impacts of site characterization activities on the existing transportation network and on area utilities (Figures 3-41, 3-43, and 3-44).

Site characterization begins with field activities, which include geologic, environmental, engineering, and other data acquisition activities. The start of exploratory shaft construction and ongoing field activities overlap. If Richton Dome is not selected for a repository, the site will be decommissioned, requiring the disposal of salt and salt-laden rock off site.

Section 4.2.1.10.1 discusses projected traffic volumes, traffic increases on area highways, trucking activities, possible congestion on roadways, accident increases, and disposal of excess salt off site, if the site is not selected for a repository. Section 4.2.1.10.2 discusses potential impacts on area utilities.

Short-term and long-term impacts are described in Section 4.2.1.10.3, and mitigation of these impacts is described in Section 4.2.1.10.4. Impacts from activities described in this section are increased traffic volumes and hence, increased congestion. Additional traffic accidents, and accelerated highway deterioration are also expected.

4.2.1.10.1 Transportation. The major impact on transportation facilities will result from workers traveling to and from the site and, to a lesser extent, from hauling supplies and equipment during construction of the exploratory shaft.

Access to the site will be on existing roads wherever possible. Access to the site will be via a country road off of Mississippi State Highway 42, 1.6 kilometer (1.0 mile) west of the town of Richton and a new 0.4-kilometer (0.25-mile) access road to the site from the county road. Access from Mississippi State Highway 15 will also be available from a county road approximately 1.6 kilometer (1.0 mile) north of the town of Richton.

Field activities and exploratory shaft facility construction will continue simultaneously for approximately 20 months during site characterization. The cumulative traffic resulting from these site characterization activities is shown in Figure 4-27. Figure 4-27 shows that traffic volumes peak at 734 vehicles per day. The overall project related traffic volume during site characterization will average approximately 474 vehicles per day.

The workforce distribution between cities in the area will establish commuting patterns to the site. Table 4-20 shows traffic increases on area highways.

Truck traffic increases, which are included in Table 4-20 and Figure 4-27, are also shown in Table 4-21. The largest increase during site characterization will come during the period when site preparation and shaft and surface facility construction overlap. During this period an estimated 635 truck round-trips per month (approximately 21 per day) will be required. During other phases of site characterization the number of truck round-trips will range from 2 to 13 per day. This increase should have little additional impact on the condition of area highways.

From 1981 through 1983 there were 12 accidents on Mississippi State Highway 42 in Perry County, none of which involved a fatality. During the same period there were 10 accidents (2) fatal - on Mississippi State Highway 15 in Perry County. The accident rate for the 1981-1983 period on State Highway 42 was 0.8 accidents per million vehicle miles. The accident rate on State Highway 15 was 0.6 accidents per million vehicle miles and 3.8 fatal accidents per 100 million vehicle miles. The corresponding national rates were 4.1 and 2.7 in 1983 (Table 4-22). Using the above rates and the commuting patterns previously described, accidents on local highways during the entire characterization period would increase by 18 if local rates are used, and by 90 if national rates are applied. Fatal accidents would increase by 0.3 using local rates and 0.6 using national rates.

If, at the completion of site characterization the site is not selected for a repository, it will be necessary to transport about 42,800 cubic meters (56,000 cubic yards) of excess salt, salt laden rock, from the site for disposal. This excess material will be trucked to a licensed disposal facility near Emelle, Alabama, approximately 176 kilometers (110 miles) from Richton. A total of approximately 2,700 truck loads will be transported from the site over a 12- to 18-month period.

Using regional vehicular accident rates discussed above, during the period that excess salt and is being removed from the site, accidents will increase by 0.4 and fatal accidents by 0.03. Using national rates, the increase would be 2.9 and 0.02, respectively. Impacts of salt which might escape from the truck in an accident are discussed in Section 4.2.1.11.

There will be no rail access to the site. Some supplies may be delivered to Hattiesburg or Laurel by rail for transshipment to the site by truck. This additional traffic, because of its expected small volume, should have no significant impact on existing rail facilities.

Project personnel from outside the region will probably travel by commercial airlines to the site during site characterization. Because of the limited amount of air travel expected, impacts on Pinebelt Regional Airport and other airports in the area would be minimal.

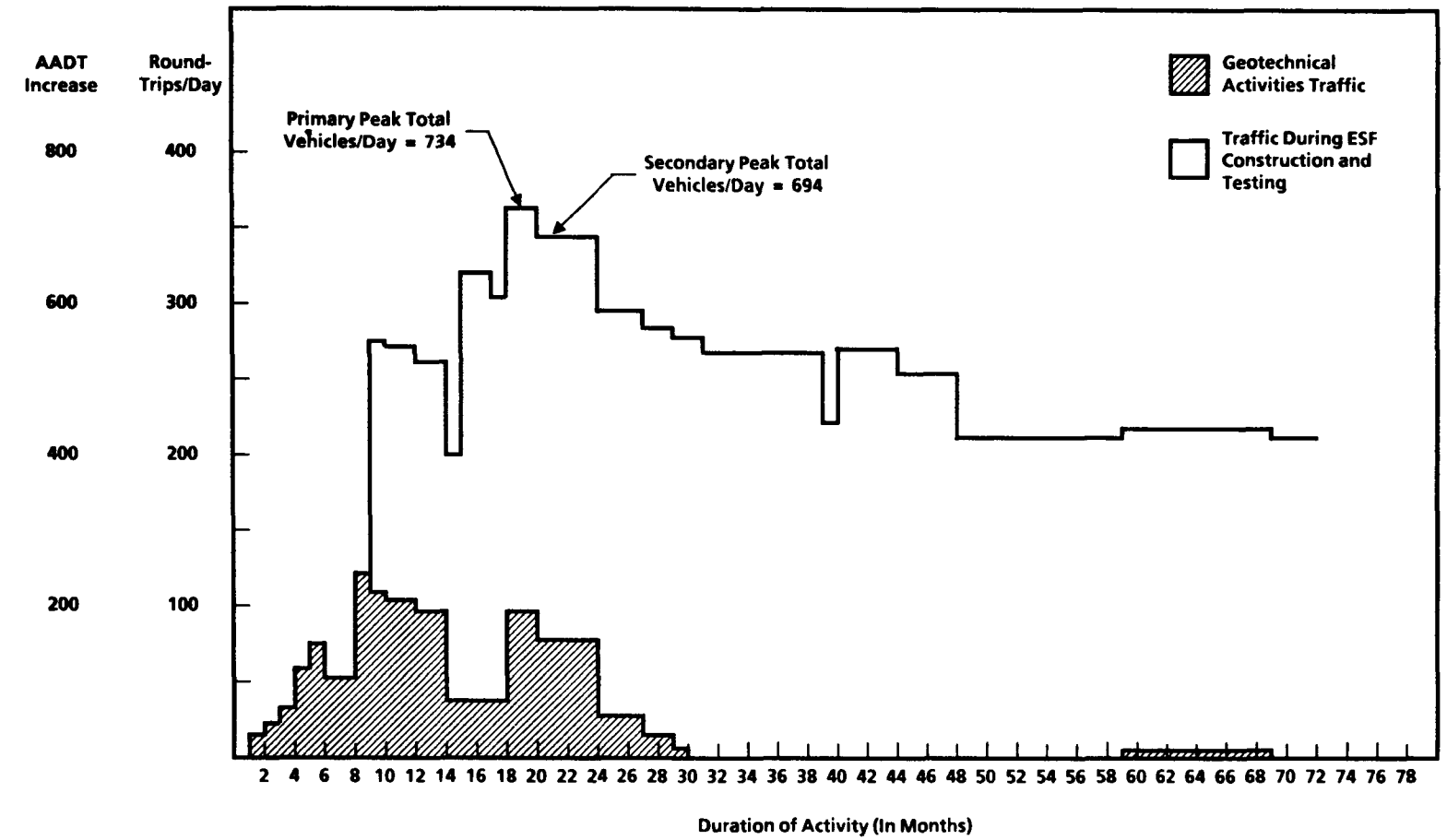
4.2.1.10.2 Utilities. Demands on utilities will be created by equipment usage at the Richton Dome exploratory shaft facility. Table 4-23 shows estimated electricity demand for the various exploratory shaft activities. It is expected that these amounts can be met using available commercial power. Projected supply and demand will be further evaluated early in site characterization (Section 4.1.3.1.11).

Estimated water consumption is shown on Table 4-23. Water use for exploratory shaft facility construction and operation will be a small fraction of current water consumption in Perry County (Table 3-23). All water will be supplied from wells and, therefore, should not have an impact on Richton's existing water system.

Sewage generated at the ESF will be treated on site and solid residue will be disposed of in a permitted disposal facility off site. Such treatment and disposal would not have a significant impact on existing sewage treatment facilities.

Solid waste will be disposed of in a sanitary landfill off site.

4.2.1.10.3 Short-Term and Long-Term Impacts. Short-term impacts include some deterioration to area highways due to increased traffic volumes, some congestion during shift changes, and a small predicted increase in area traffic accidents.



Notes:

- The numbers shown for geotechnical activities and ESF construction are combined to give the top line representing monthly peak totals
- Geotechnical traffic distribution from Table 4-2 and Figure 4-2
- ESF traffic distribution from Table 4-8 and Figure 4-7

Site Characterization
Vehicular Traffic
Richton Dome

Figure 4-27

Table 4-20. Traffic Increases On Area Highways, Richton Dome

	1983 AADT[a]	Peak Increases	Percent Increase Over 1983	Average Increase	Percent Increase Over 1983
SH-42[b] Hattiesburg/ Petal to Access Road from SH-42	1,900-7,750	434	6 to 23	280	4 to 15
SH-42 Richton to Access Road From SH-42	1,690	84	5	54	3
SH-15[b] Laurel to Access Road From SH-15	1,350-4,510	132	3 to 10	86	2 to 6
SH-15 Richton to Access Road From SH-15	7,020	84	1	54	1

(a) Annual Average Daily Traffic.
(b) Mississippi State Highway 42, 15.

Based on Figure 3-42.

Table 4-21. Traffic Increases During Shaft Construction and Testing, Richton Dome

Activity	Daily Passenger Vehicle Round-Trips	Monthly Truck Round-Trips
Site preparation	150	380
Shaft and surface facility construction	260	255
Shaft outfitting	220	95
Initial underground excavation	240	95
Expanded underground excavation	250	40
Testing	210	95
Final Disposition	90	45

Based on Table 4-8.

Note: When scheduled activities overlap (see Figure 4-7), truck traffic is additive; passenger vehicle traffic is not.

Table 4-22. National Motor Vehicle Accident and Fatality Rates, 1983

U.S. Vehicle Accidents (Reported to Police)	6,769,100
U.S. Traffic Fatalities	44,600
U.S. Total Vehicle Miles (million)	1,651,000
Accident Rate Per Million Vehicle Miles	4.1
Fatality Rate Per 100 Million Vehicle Miles	2.7

Source: National Safety Council, 1984.

Table 4-23. Estimated Electrical Energy and Water Consumption During Exploratory Shaft Work, Richton Dome

Activity	Electrical Energy Consumed, 1,000 kWh	Fresh Water Consumed, 1,000 gallons
Site preparation	--	1,800
Shaft drilling	36,000	20,000
Outfitting	2,400	1,100
Underground excavation	1,400	860
Underground expansion	3,100	1,100
Testing	32,000	16,000
Final disposition	6,000	15,000
Total consumption	80,900	55,860

Source: See Table 4-7.

There are no long-term impacts other than the benefit of roads that may be permanently upgraded in the site vicinity.

4.2.1.10.4 Mitigative Measures. Traffic congestion will be reduced by having access to the site from both Mississippi State Highways 42 and 15, thus avoiding the center of Richton. Traffic control devices and turning lanes will also help to reduce congestion and maintain traffic flows at the intersection of Mississippi State Highways 42 and 15 with the county roads leading to the site. The traffic control devices should also help control traffic flow and reduce traffic accidents.

4.2.1.11 Effects of Salt Management and Disposal

This section summarizes the potential environmental impacts associated with the management of salt and salt-laden rock during site characterization and measures for mitigating those impacts. The discussion is presented in three parts: (1) the management practices are briefly described in the context of their potential for releasing salt to the environment, (2) measures for mitigating the impacts from these sources are discussed, and the basis for assessing the impacts are described, and (3) the options for permanently disposing of the excess salt, if the site is not selected for the development of a repository, and the basis for selecting one option are presented.

4.2.1.11.1 Salt Management and Control. The exploratory shaft facility (ESF) will involve mining, handling, transport, and disposal of salt and salt-laden rock. The discrete elements of this salt management process are illustrated in Figure 4-28 along with each element's potential contribution to an overall salt emission and likely mitigation measures for each source point.

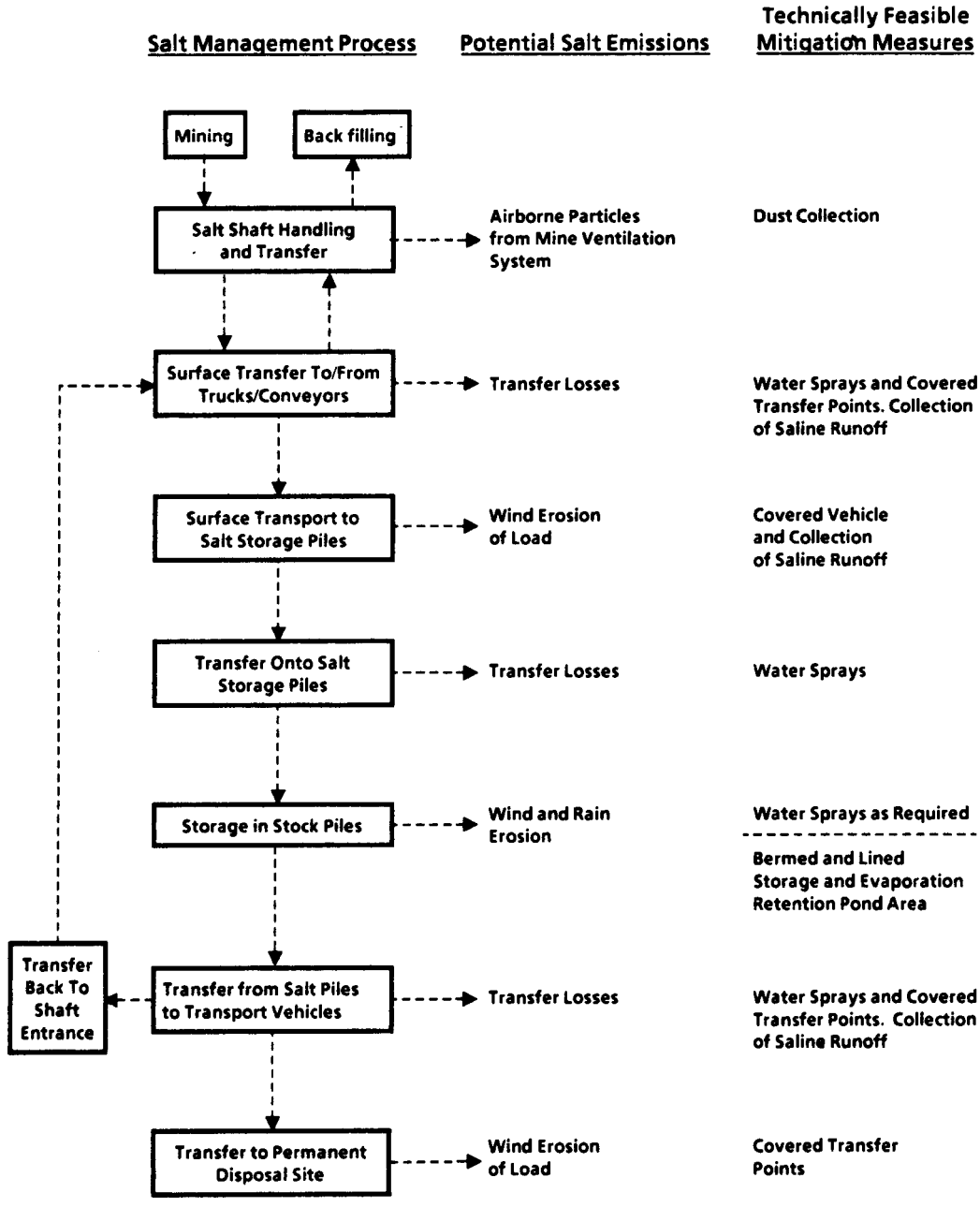
Mined salt is lifted to the surface via a skip and transferred to covered haul trucks for transfer to the salt storage pile. Emissions of salt to the atmosphere occur at the outlet of the mine ventilation system and at the point of transfer of the mined salt to the surface transport vehicle. These emissions will be minimized by the use of dust collection and suppression devices at the mine exhaust facility and a covered transfer device and water sprays at the point where underground salt is transferred to the surface haulage vehicle. Saline water, from either the salt control devices or as storm runoff, will be collected and conveyed to the evaporation/retention pond.

Although the surface haulage vehicle will be covered, small losses may occur along the haulage route. These will be collected as saline runoff and moved to the evaporation/retention pond.

According to the experience in the salt industry, stockpiled salt is not a source of windblown particles. When salt is exposed to the weather or another source of moisture, a hard surface crust, which tends to shed rainwater, forms in a few days (Ver Planck, 1958; DOE, 1983, WIPP-DOE-161). Crusting can be accelerated by wetting the pile. The salt storage pile will be kept moist, as required, to accelerate crust formation; freshly deposited material will be wetted, after spreading and compacting, to mitigate any wind effects (Section 4.1.2).

Possible leakage of brine from the evaporation/retention pond into the ground will be prevented by using double liners. These can be made of natural clays or synthetic materials (polyvinyl chloride, polyethylene, or polypropylene). A leachate collection system will be installed between the liners to monitor the integrity of the liners and to remove any effluent. The existing topsoil overburden will be stripped before emplacement of the liner and an engineered sound sub-base established. If a synthetic liner is used, an additional layer of compacted backfill material will be placed on top of the liner so that it can accommodate heavy equipment.

Saline runoff from the shaft area, haul roads and mined material stockpiles will be collected by a system of lined drainage ditches, which gravity-flow to an evaporation/retention pond. In addition, water collected in the shaft sumps will be periodically pumped to the ditch system for collection at the evaporation/retention pond. The drainage ditches will be



Salt Management Flow Diagram

Figure 4-28

designed to convey the runoff from a 500-year storm of a duration and intensity based on time of concentration of the local watershed. This will provide the capability to convey the runoff from duration storms that produce higher peak flows than a 24-hour rainfall event. The evaporation/retention pond will be designed for an operational volume equivalent to 100 percent of the rainfall volume from a 500-year, 24-hour storm falling on the areas that drain to the evaporation pond. The maximum volume of the pond will include an additional 61 centimeters (2 feet) of freeboard above the operational level (Section 4.1.2). Due to the greater volume available per unit depth in the top of the pond, the freeboard volume available will be almost equivalent to a second 500-year, 24-hour storm volume.

Project GNOME and the Waste Isolation Pilot Plant (WIPP) involved salt management practices similar to those at the ESF. Activities associated with the December 1961 Project GNOME underground nuclear test resulted in a substantial volume of sodium chloride (salt) being excavated and stored on the site. The storage facility for the salt is an area of approximately 1.2 hectares (3 acres) enclosed by a dike and fence. The salt pile is stored inside the dike and fence but is otherwise open and exposed to the elements of the environment. The project GNOME test site is located approximately 48 kilometers (30 miles) southeast of Carlsbad, New Mexico. Soil samples and ecology surveys indicate that insignificant wind erosion and dispersion is occurring at the Project GNOME salt pile, and that there is little, if any, attendant adverse impact on the immediate surrounding environment due to salt dispersion by wind (Intera, 1978).

The Waste Isolation Pilot Plant (WIPP) presently under construction approximately 40 kilometers (25 miles) east of Carlsbad, New Mexico, will test the feasibility of storing nuclear defense wastes in salt. Excavated salt has been stored in an uncovered, unlined pile holding about 150,000 tons of salt. The pile is surrounded by a bermed ditch, which collects and evaporates the precipitation that falls on the pile (average rainfall: 23 centimeters [9 inches] per year). The salt is crusted over, and rainfall does not penetrate the pile. No problems with wind dispersion of the stored salt have been experienced (Reith et al., 1985).

4.2.1.11.2 Impact of Salt Management. Soil productivity, water quality, ecosystems, and land use can be impacted by salt transported through air and water pathways. Assessment of the potential impacts requires identification and quantification of the various factors involved. For example, airborne salt can impact crop productivity through uptake by the plant roots and by deposition on the foliage. In these cases, not only must deposition rates be estimated, but irrigation rates, rainfall patterns, etc., must be taken into account. The salt deposition rates for site characterization are expected to be less than those for the repository. Repository deposition rates are predicted to be 1.0 kilogram per hectare (0.9 pounds per acre) per year at 0.8 kilometers (0.5 mile), decreasing to 0.1 kilogram per hectare (0.09 pounds per acre) between 1 and 2 kilometers (0.6 and 1.2 miles) from the salt storage pile (see Section 5.2.5.3.3). Use of these values for assessing the impact of site characterization activities is considered conservative because of the smaller quantity of salt that will be handled during site characterization. Factors are identified in the following sections for each category of impact and numerical values provided to the degree that current information allows.

Effects on Soils. In preparation for the salt pile and associated evaporation/retention pond facilities, topsoil will be removed and stored for reuse during reclamation. Proper lining and salt management activities will preclude contamination of soils under and adjacent to these facilities.

On the basis of the deposition of wind blown salt estimated for the repository operations, the annual salt deposition rate is small, less than 1 kilogram per hectare (0.9 pound per acre) per year. This deposition rate will result in an incremental increase in salt concentration of the topsoil estimated to be 0.2 part per million for soil having a density of about 1,600 kilograms per cubic meter (100 pounds per cubic foot). This is considered a conservative estimate. The potential impact of this incremental increase in salinity on soil fertility is not known, but the impact will be minimal and will decrease with increasing distance from the site. The probability of a tornado strike to the site is addressed in Section 5.2.5.3.3.

Accidental spills of salt could adversely affect soils in a limited area by altering the cation ratios, which could produce sodic conditions. This would lead to dispersion of soil aggregates and loss of soil permeability. Reclamation would consist of containing the area within a berm and flooding with water, to which amendments such as calcium chloride have been added (Hoffman and Meyer, 1982; Rhoades, 1982). The amendment would restore permeability as the water penetrated the soil, and the leachate would be collected by drains and disposed of properly.

Effects on Surface Water Quality. Runoff from the region around the salt pile and near the shafts will be collected and channeled into evaporation/retention ponds. However, in the Richton Dome area, the precipitation is higher than the evaporation, therefore, there will be excess saline water, which will be disposed of off site. If during operation it becomes evident that an acceptable evaporation rate of the water cannot be achieved due to area or depth constraints of the pond, the water would be periodically removed for transport to an acceptable, offsite disposal facility (Section 4.1.2.2.2).

On the basis of predicted salt deposition rates, potential degradation of the water quality of the adjacent streams and water bodies by windblown salt would be small. The majority of the salt emission would be deposited within the ESF boundary; runoff from this area will be retained in the evaporation/retention pond (Section 4.1.2). The amount of salt deposited in the adjacent watersheds will be less than 1,800 kilograms (2 tons) per year, primarily affecting Beaver Dam Creek, Fox Branch, and Linda Creek. Conservatively assuming that all the deposited salt will dissolve, runoff to these three creeks is estimated to be 0.1, 0.4, and 0.8 milligrams per liter, respectively (see Section 4.2.1.4.1). Reported total dissolved solids (TDS) concentrations for these creeks (as represented by downstream measurements) are 43.0 milligrams per liter in Thompson Creek and 32.0 milligrams per liter in Bogue Homo, respectively (see Section 3.3.1.1 and Table 3-18). Thus, these increases in salinity would represent only minor changes in water quality of the adjacent streams and would not impact any down stream water bodies such as the Leaf River.

Effects on Ground Water Quality. The area of the salt pile and associated evaporation/retention ponds will be lined with salt-resistant double liners to minimize impacts to ground water. Salt concentrations between the liners will be monitored at various points around the site as an early warning system for possible salt contamination. Should salt be detected, appropriate measures will be taken to (1) restore the integrity of the liners, (2) remove leaked effluents from between the liners, and (3) pump leachate back to the surface.

Changes in ground water quality due to infiltration of precipitation through soils contaminated by windblown salt will be minor. Modeling studies show that deposition of salt for the ESF will be less than 1 kilogram per hectare (0.9 pound per acre) per year in the site area, diminishing to 0.1 kilogram per hectare (0.09 pound per acre) between 1 to 2 kilometers (0.6 to 1.2 miles) away. If all of this salt were carried to the water table and distributed in the upper 3 meters (10 feet) of the saturated zone, it would represent an annual increase in salinity of 0.01 to 0.1 parts per million. Over the life of the ESF, this would amount to less than 1 part per million increase in salinity of ground water within the immediate site area. However, it is unlikely that all wind-deposited salt could reach the water table, as much of it will be transported with storm runoff to the evaporation/retention ponds.

Effects on Ecosystems. Impacts on terrestrial and aquatic biota resulting from site characterization activities were discussed in Section 4.2.1.2. The discussion below focuses on impacts from salt management.

The ions present in common salt (sodium and chloride) are universal components of plant materials. However, excessive amounts of these ions deposited on vegetation or present in the soil are harmful to plant growth. The major toxic effect is osmotic inhibition of water absorption; a common symptom is leaf-tip burn. Salinity levels (generally expressed as electrical conductivity) at which a definite productivity reduction occurs, have been reported (Wadleigh and Sherman, 1978; Bernstein and Howard, 1958).

Based on the air dispersion, water quality, and soil analyses described in previous sections, the amounts and concentrations of salt leaving the fenced surface facility by wind or water dispersion will be small. No significant increases in soil salinity are expected outside the surface facility (exploratory shaft and salt pile) and, hence, no adverse effects on vegetation are anticipated. No significant increases in the salt concentration of neighboring streams will occur and, as a result, no impacts to resident aquatic biota are expected.

Site clearing and rehabilitation will result in some loss of habitat and small numbers of mammals and reptiles will be killed. Such losses, although unavoidable, will result in small and localized impacts to the total ecosystem.

Effects on Land Use. Deposition of windblown salt from the salt stockpile will not significantly affect plant growth and, consequently, use of land for agriculture and forestry at the Richton Dome site. The impact will be minimal because predicted salt deposition rates are low. In addition, deposition decreases with increasing distance from the site, and most deposition will be confined to within the fenced surface facility area. Control measures discussed in Section 4.2.1.11.1 will minimize the potential for soil and vegetative impacts that would affect agriculture and forestry use at the Richton Dome site.

The empirical evidence for crops and trees similar to those found at the Richton Dome site indicate that deposition rates far in excess of those predicted are required for any damage to occur. Little et al. (1958) found that loblolly pines and other coniferous species along Chesapeake Bay survived brackish water flooding even though salt concentrations ranged from 2,040 to 4,340 kilograms per hectare (1,856 to 3,944 pounds per acre).

A study of the effects of the salt cooling tower at Chalk Point, Maryland, (Maryland Department of Natural Resources, 1978) reported that no significant effects on corn, soybean, or tobacco occurred at salt deposition rates below 240 kilograms per hectare (216 pounds per acre) per year.

4.2.1.11.3 Salt Disposal and Impacts. If the ESF site is not chosen for the development of a repository, 35 percent of excavated salt and salt contaminated rock equivalent to about 42,800 cubic meters (56,000 cubic yards) will require permanent disposal. This section summarizes the basis for choosing a preferred option from among the candidate options and the environmental impacts associated with that option.

Disposal Options. In addition to the preferred disposal method (offsite landfill) five alternative methods for disposal of the waste salt are available, as follows (see Section 4.3.4.2):

- Onsite landfill
- Disposal in existing, unused salt mines or flats
- Deep-well brine injection
- Offshore disposal
- Transfer, gift, or sale to Federal, State, or private parties.

For site characterization, all of the alternatives have greater potential for impacts than disposal in a landfill that is licensed, bermed, and double-lined with leak monitors. An investigation (McCutchen, 1985) identified the availability of a candidate landfill near Emelle, Alabama. The facility has the capability to handle the waste salt from site characterization (McCutchen, 1985) and will be considered for use along with other candidate landfills subsequently identified. Dust generation during transportation and disposal operations will be controlled by use of covered trucks and water sprays. Leachate collection will control leakage from the landfill.

Impacts of Disposal. Because the potential for environmental impact is negligible once the excess salt is emplaced in a licensed landfill, the only other potential impacts to be assessed are those associated with the transport of the salt from the ESF to the landfill.

The excess salt and salt-laden rock will be disposed of over a 12 to 18-month period. A total of approximately 2,700 truck loads of salt and salt laden rock will be transported off site for disposal. Each truck will contain approximately 16 cubic meters (21 cubic yards) of material. One of the possible disposal options is to transport these materials to a licensed landfill near Emelle, Alabama. The highway route would include Mississippi State Highway 15 or 42 to I-59; I-59 north to I-20; I-20 east to Alabama State Highway 17; and north on Alabama State Highway 17 to Emelle. The route from Richton Dome to Emelle, Alabama, is approximately 176 kilometers (110 miles).

Environmental impacts of salt transportation under normal conditions are expected to be negligible. Existing routes will be used and trucks will be covered to minimize potential impacts from wind dispersal of salt during transport.

In the event of an accidental spillage of salt during transport, the potential impacts will depend on the following factors:

- Location and quantities involved
- Proximity to water bodies
- Clean-up response time
- Weather conditions during that period.

Impacts resulting from accidental transportation spills on land will be localized and short-term. Spills occurring during precipitation could lead to infiltration of saline run-off. During dry conditions, a small plume of dust would be generated at the accident site, settling out within a short distance. Some vegetation that is not otherwise crushed or broken by either the vehicle or its load, may demonstrate symptoms of salt stress after prolonged exposure to salt drift or runoff in the event the site is not rapidly cleaned up. Procedures will be established to reload the salt into another vehicle, test soils for elevated salt concentrations, reclaim soil, and remove and replace soil or vegetation, as necessary.

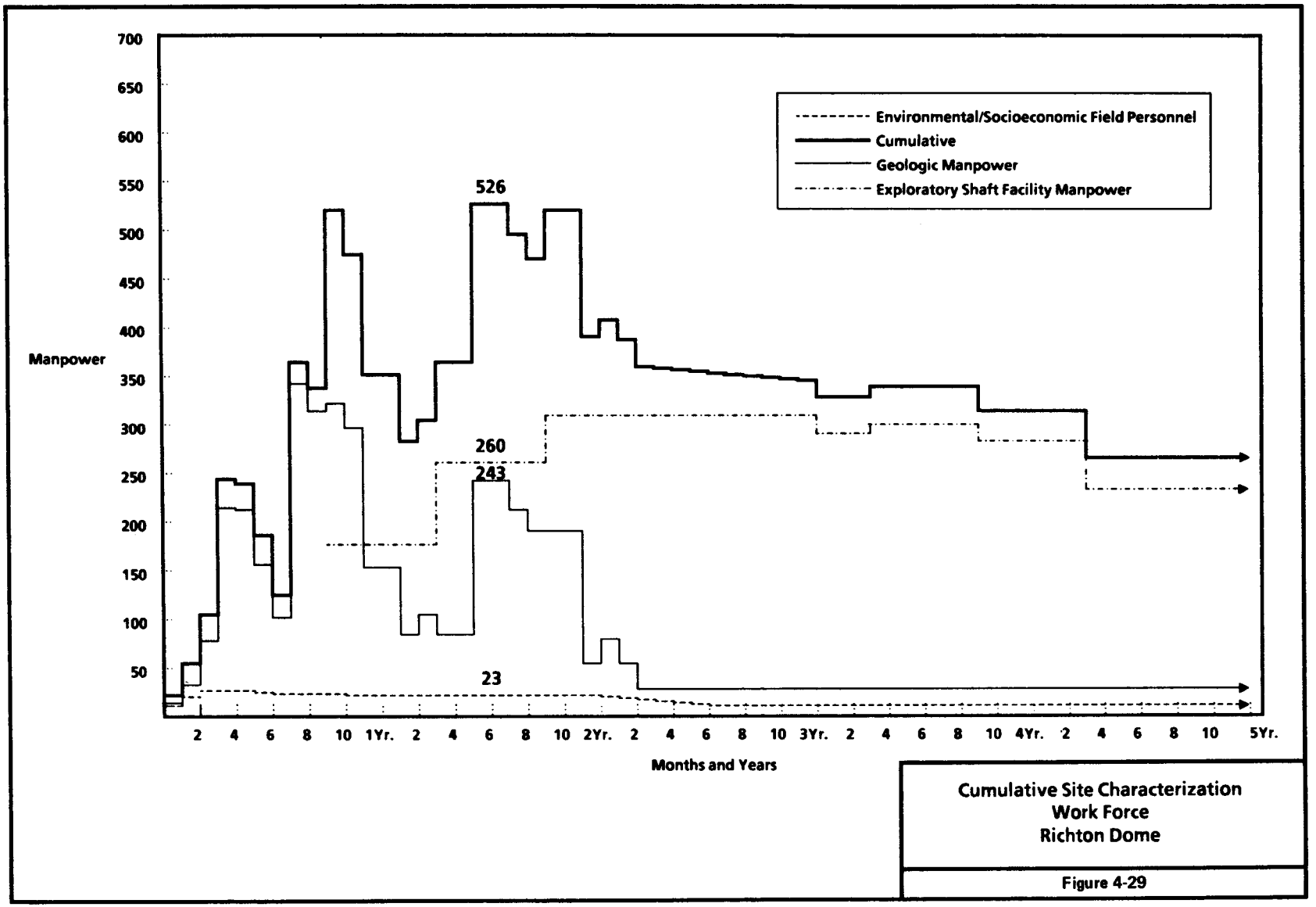
There is a lesser probability that accidental spillage into a body of water would occur. In that event, mitigation action would be more difficult and time dependent. If effective mitigation is not feasible, precautions are possible that will reduce the probability even more, e.g., route selection and vehicle speed control.

4.2.2 Expected Socioeconomic Effects

The magnitude of socioeconomic impacts that may affect surrounding communities during site characterization depends upon several major factors: work-force requirements, in-migrating workers' profiles, the location preferences of the in-migrating workers, and the number of local residents who can be employed.

Many services will be subcontracted during construction, and subcontractors will be responsible for hiring their own crews. Depending on whether local business or outside business concerns are awarded contracts, local residents who will take jobs as carpenters, welders, plumbers, electricians, miners, heavy equipment operators, and laborers would comprise at least 10 percent of the 260 shaft workers needed at the peak of construction. Based on experience with other projects of this magnitude that have numerous short-term activities, it is estimated that the minimal percentage of local hires might be as low as 10 percent of the 547 workers needed during the peak of site characterization activities. Although it is possible that a higher percentage of local workers would be employed during site characterization, the 10 percent estimate is used for the analysis because it represents the realistic, conservative case of impacts.

In addition to the shaft construction workforce, as many as 264 geologic characterization workers and 23 environmental and socioeconomic workers will be present at the peak of shaft construction activities. According to scheduling estimates, about 547 workers will be in the area during the peak period, which occurs during the nineteenth and twentieth month of the project (see Figure 4-29).



Cumulative Site Characterization
Work Force
Richton Dome

Figure 4-29

The duration of each worker's stay in the site area will vary with scheduled tasks. Some tasks will require workers to be in the area periodically for 2 weeks (such as socioeconomic data collection), while other tasks will require workers to be in the area for the entire site characterization period (such as project management activities). The various schedules of activities are presented in Section 4.1 for engineering, geologic, environmental, and socioeconomic activities. Workers associated with the shorter term tasks will occupy available temporary housing and will have few effects on community services. The peak work force number used for the following analysis is a short-term peak lasting for 2 months (see Figure 4-29) but represents a conservative case. As site activities change, specific workers used will vary, thus reducing the number of workers living in the site area for the entire site characterization period. Because many of the workers are temporary, the accompanying demand for services will cause an intensive use of services over the short duration of the peak. Peak project demand is used in this analysis, however, to identify the maximum requirements which could occur.

The ONWI Population In-Migration Model was used to project the number of people who will be in the area as a result of site characterization activities (engineering, geologic, environmental, and socioeconomic). The percentages and multiplier inputs to the model for site characterization are shown in Table 4-24. A logic diagram and a discussion of the model are contained in Section 5.4. On this basis, 492 in-migrating workers would move to the area. This would result in a total of 1,068 in-migrants, including family members.

The spouses of in-migrating site characterization workers will also be available for newly created jobs in the local economy. Demand that cannot be filled from these two sources of labor will encourage some in-migration. It is assumed that local residents and worker spouses would capture almost all of the new indirect jobs.

Based on a population location (gravity model) distribution of the in-migrants, it is anticipated that Hattiesburg (35 highway kilometers [22 highway miles] from the site; 1980 population of 40,829) would receive 40 percent of the in-migrating population. Laurel (43 highway kilometers [27 highway miles] from the site; 1980 population of 21,897) would receive 15 percent, Richton (8 highway kilometers [5 highway miles] from the site; 1980 population of 1,205) would receive 20 percent, and Petal (34 highway kilometers [21 miles] from the site; 1980 population of 8,476) would receive 10 percent of the in-migrating population during site characterization activities. The remaining 15 percent of the in-migrating population is distributed throughout the study area to small communities and rural areas. None of these small communities receives more than 2 percent of the total in-migrants.

Table 4-25 provides a description of the estimated total number of in-migrants expected, and the number of school-age children, single workers in-migrating (including married workers who do not relocate with their families) and married in-migrating workers with family members present in Hattiesburg, Laurel, Richton, and Petal under these distribution assumptions. This peak in-migration will occur in the second year of site characterization.

Baseline growth to the communities in the area at the time of peak site characterization activities is shown in Table 4-26. Both baseline growth and in-migration will be used to assess the impact on local housing and services.

The level of estimated in-migration for Hattiesburg and Laurel is about 1 percent of the projected 1987 population. For Petal, it is about 2 percent of the projected 1987 population. The estimated in-migration for Richton is about 17 percent of the town's 1987 projected population. This percent increase is greater than the town's 1984 current growth rate. It should be noted that actual worker settlement patterns may vary, based on individual desires. The effect of these changes is shown in Table 4-27. The table indicates the service needs for additional baseline population growth and the service needs for the project-related in-migrants.

Approximately 28 hectares (68.acres) of land will be required for the exploratory shaft facility site. Based on the present shaft site location , it is not expected that any residents would have to be relocated. The total displacement of economic activity in the area of (1 square mile) of forest land (see Section 4.2.1.2.1).

Table 4-24. Inputs for the Population In-Migration Model for Site Characterization, Richton Dome

Direct In-Migration	
Percent of work force in-migrating [a]	90
Percent of in-migrating workers with family members present [b]	45
Family size multiplier [c]	3.6
Percent of children of school age [d]	65
Indirect In-Migration	
Indirect employment multiplier [b]	0.4

(a) Parsons-Redpath, 1984.
(b) Murdock and Leistritz, 1979.
(c) DOE, 1978a.
(d) Bureau of the Census, 1982.

Table 4-25. Site Characterization In-Migration Distribution to Area Communities, Richton Dome

Characteristic	Estimated Peak In-Migration				Rural and Other Communities
	Hattiesburg	Laurel	Richton	Petal	
Number of total in-migrants	427	160	214	107	160
Number of in-migrating school-age children	92	35	46	23	35
Number of single in-migrating workers, includes married without family present	108	41	54	27	41
Number of married in-migrating workers with family present but not counted	89	33	44	22	33
Number of married in-migrating workers with family present and counted	319	120	159	80	120

(a) Figures rounded to nearest whole number.

Source: Hines, 1986.

Table 4-26. Baseline Projections at the Peak of In-Migration for Area Communities, Richton Dome

Characteristic	Projection of Population Figures			
	Hattiesburg	Laurel	Richton	Petal
1987 Population[a]	43,708	22,588	1,294	9,050
Additional baseline growth (1980-1987) (number of persons)	2,879	691	89	574
Number of additional households[b]	1,066	256	33	213

(a) Interpolation of 1985 and 1990 projections.
(b) An average household size of 2.7 was calculated for the above communities (BNI, 1984, ONWI-499). Figures rounded to nearest whole number.

Table 4-27. Projected Baseline and Project-Related Service Requirements, Richton Dome

	Richton		Hattiesburg		Petal		Laurel	
	1987[a] Baseline[b]	1987[a] Project-Related[b]	1987[a] Baseline[b]	1987[a] Project-Related[b]	1987[a] Baseline[b]	1987[a] Project-Related[b]	1987[a] Baseline[b]	1987[a] Project-Related[b]
Population increase	89	214	2,879	427	574	107	691	160
Total number of 1980 households (estimated)	446	--	15,122	--	3,139	--	8,110	--
Additional households	33	98	1,066	197	213	49	256	74
Housing required	33	98	1,066	197	213	49	256	74
Education								
Additional teachers required (student/teacher ratio 19:1)[1]	1	2	24	5	6	1	7	2
Protective Services								
Additional municipal police officers required/population (2:1,000)[2]	0	0	6	1	1	0	1	0
Additional fire service personnel required/dwelling units (2:1,000)[3]	volunteer	volunteer	2	0	0	0	1	0
Health								
Additional physicians required/population (1:1,000)[4]	0	0	3	0	1	0	1	0
Additional hospital beds required/population (5:1,000)[4]	0	1	9	2	3	1	3	1
Water								
Additional municipal water needs (150 GPCD[c])[5]	13,350	32,100	431,850	64,050	86,100	16,050	103,650	24,000
Sewage								
Additional effluent (100 GPCD[c])[5]	8,900 gpd	21,400 gpd	287,900	42,700	57,400	10,700	69,100	16,000
Recreation								
Additional developed acres required (1 acre/600 children-playground)[5]	0	0	1	0	0	0	0	0
(1 acre/1,000 population-neighborhood)[5]	0	0	3	0	1	0	1	0
Solid Waste								
6.2 lb/capita/day[6]	552	1,327	17,850	2,647	3,559	663	4,284	992

(a) Peak year of activities.
(b) All numbers are rounded to the nearest whole number.
(c) Gallons per capita per day.

Source: (1) National Center for Education Statistics, 1983.
(2) Federal Bureau of Investigation, 1984.
(3) Stenehjem and Metzger, 1976.
(4) National Center for Health Statistics, 1983.
(5) International City Management Association, 1979.
(6) This EPA standard appears in Reference #5.

Business in the local area would benefit from purchases related to site characterization, including personal purchases of the work force such as food, clothing, housing, and entertainment. It is estimated that the project wages and materials would total approximately $250 million (1985 dollars) for engineering activities and $225 million (1985 dollars) for the geologic activities. Approximately 70 percent of this total is for materials, and 30 percent is for wages. Some materials would be locally purchased (such as fuel, concrete, small equipment, lumber, and other building supplies). Not all wages paid as personal income would be captured in the local or regional economies. For example, the local personal consumption expenditure for those workers without families present would be lower than personal consumption expenditures for workers that relocate with their families. The same would also be true for those workers who are only at the site for relatively short periods of time.

For this assessment of impacts on community services, the additional demand created by the site characterization-related in-migration at its peak has been compared to the local supply of community services as shown in Section 3.6. This peak will last approximately 2 months. Some of the baseline needs can be met by existing capacity, especially those of workers who are in the site area for a short duration of time. These workers will use available temporary housing, which will reduce the need for additional community services. community with the greatest cumulative increase in population is Richton, with a 17-percent increase. If temporary housing is not available in Richton, these workers can find such housing in other communities in the region, such as Hattiesburg. Peak project demand does not represent average yearly demand. Peak demand can sometimes be met by a more intense use of a service over the short duration of the peak. Peak project demand is more suitable for planning purposes in that it identifies maximum requirements. Laurel, Petal, and Hattiesburg will all experience impacts during site characterization and may require additional services. All communities may require additional teachers for the school-age children who move to the area. Hattiesburg could require up to five new teachers and Laurel, two teachers. Both Laurel and Petal may require additional medical services, but Hattiesburg, which has a relatively high concentration of physicians, should be able to satisfy its own citizens as well as residents of nearby communities. Laurel would have to upgrade its sewage treatment system to accommodate any level of in-migration. Currently, the system is being utilized over its capacity. Table 4-27 summarizes project-related service impacts on the town of Richton.

The major impact of the project-related population increase in the town of Richton is the need for additional housing. Some excess housing currently is available in Richton; new housing construction will also occur. Most of this excess will be reduced by the projected baseline population increase, and up to 98 new units could be required. The types of housing desired by project-related residents will range from single-family homes to rental units to mobile homes. The duration of project work and the local housing market will be determining factors in the selection. The DOE could provide technical assistance to local government and community officials in preparing local plans, which include housing elements.

The need for up to two additional teachers is projected for the project-related increase in the number of school children. If the additional teachers are not provided, the student/teacher ratio would increase above the current 19:1 ratio. School districts in the area affected by increased Federal activities could apply for funds through the "School Assistance in Federally Affected Areas for School Construction and Operation" (Office of Management and Budget, 1983). Additional sewage treatment, water, and solid waste handling would be required for the project-related residents. Additional fire and security personnel will be provided on the project site. There is a volunteer fire department in the town of Richton and some increase may be required for the additional homes identified. No additional physician services are required for the in-migrating population, specifically; however, Perry County is currently below the national standard for physicians per 1,000 people. Forrest County, adjacent to Perry County, is above the national average and could supply the additional medical care required.

Two tennis courts and two ball fields are available in the town of Richton, and the need for additional recreation facilities is not expected.

Under Section 116(c)(3) of the Nuclear Waste Policy Act of 1982 (NWPA) (42 USC Sections 10101-10226), the DOE is authorized to make annual grant payments to states and units of general local government where a site has been approved for characterization. These payments will be made in amounts equal to the taxes that states and units of general local government would have received were they authorized to tax site characterization and repository development activities as they tax other real property and industrial activities occurring within their jurisdictions. Payments are to be made each fiscal year until activities at the site are terminated.

The major types of taxes imposed by the state of Mississippi and its units of general local government on real property and industrial activities occurring within their jurisdictions include the following:

- Real property tax
- Personal property tax
- Corporate income tax
- Franchise tax
- Severence tax
- Sales and use taxes
- Other excise taxes.

Some of these taxes might be applied to site characterization and repository development if such activities were taxed in a manner similar to the way in which other real property and industrial activities are taxed. One of the important considerations involved in calculating the annual grant-equal-to-tax payment (GETT) is establishing which taxes might be applicable. Other considerations include jurisdictional eligibility and grant administration.

The GETT payments will begin during site characterization and continue throughout repository construction and operation. The NWPA provision indicates that these funds are to be paid to states and units of general local government in which a site is located. This fund is not designated as a mitigation grant as are those payments described in Section 116(c)(2)(A) of the NWPA. Therefore, jurisdictions receiving GETT payments will not necessarily correspond to jurisdictions affected by project-related activities.

As cited above, revenue could also be available to impacted school districts through the "School Assistance in Federally Affected Areas for School Construction and Operation" program (Office of Management and Budget, 1983).

The DOE is looking at alternatives for assisting communities that require planning during site characterization. The Mission Plan (DOE, 1985, Vol. II, DOE/RW-0005, p. 88) states that "before site characterization, the DOE will review requests for impact mitigation on a case-by-case basis." However, grants will be provided to the States for specific activities under Section 116(c)(1)(B) of the NWPA. These grants will be for, among other things, (1) reviewing site characterization activities and determining socioeconomic public health and safety, and environmental impacts; (2) developing a request for repository-related impact assistance; and (3) monitoring site characterization activities.

In developing any request for repository-related impact assistance, the States and local governments will need to identify impacts and related mitigation measures. This activity will involve community planning during the site characterization phase. Funds for planning activities related to the project can also be provided through Section 116(c)(1)(B) of the NWPA.

As indicated above, the DOE could provide technical assistance to local government and community officials to help with local planning efforts. This assistance could include providing help with data analysis and plan development. The DOE technical assistance could also be used to help local governments form an impact management committee and in the development and implementation of a comprehensive community impact monitoring program. Finally, the DOE could assist in planning transportation systems, such as van pools, which would distribute workers and housing demand more widely. If site contractors hired local residents, the number of workers and families relocating to an area would be reduced. This would increase the

economic benefit to the region by increasing local employment opportunities for existing residents. In addition, wages spent outside the region are likely to be less for existing residents than for in-migrants who may be there for a shorter period of time. If contractors procure materials within the region, this would also increase the economic benefits to businesses in the area as well as raise tax revenues for communities. Such purchases will stimulate additional employment opportunities in the region.

A monitoring program will be established during site characterization so that actual impacts can be identified and appropriate mitigation measures established.

Impacts on social structure and quality of life are related largely to the population change in a community and to its existing culture. The population change for the town of Richton during the peak would be about 17 percent of its projected 1987 population. Although this population increase is considerably more than its current growth rate, the area should not be overwhelmed by the in-migrating workers and their families. However, some social disruption could occur as existing residents may feel that their social structure is threatened by the in-migration of workers and their families. As Section 3.6.4 emphasized, the towns of the study area may not easily accept the social change that the people from outside the area may bring. Nevertheless, based on evidence from case studies of rapid growth in the West, where community populations increased by 100 percent or more over a 5-year period (Gilmore and Duff, 1975; Kohrs, 1974; Little, 1977), Richton's social structure should not be significantly altered due to the relatively small number of in-migrants compared to the number of local residents and to the short time that these in-migrants would be present. As noted in Section 4.1.3.2, a monitoring program will be established during site characterization so that actual impacts can be identified and appropriate mitigation measures can be established. Also, as noted above, the DOE is looking at alternative ways to assist communities that require planning assistance during site characterization.

4.3 ALTERNATIVE SITE CHARACTERIZATION ACTIVITIES

This section discusses some alternative methods and approaches to site characterization. Some of these could be used to avoid adverse impacts; however, they may not be feasible because of unavailable technology, costs, or secondary effects.

Site characterization involves two major groups of activities:

1. Collection of geological, hydrological, and environmental data using standard, readily available procedures such as drilling of 15-centimeter (6-inch) boreholes and seismic surveys. These activities cause only local and temporary disturbances to the physical environment and can be mitigated to acceptable levels (Section 4.2). No alternative test procedures causing fewer environmental impacts are available; however, the location of these tests could, in many cases, be moved to accommodate the existence of any newly discovered archaeological or other environmentally sensitive finds.

2. Construction of an exploratory shaft facility (ESF) to permit in situ testing of thermomechanical and other properties of the host rock. This activity is required to verify site suitability and fulfill data needs for the repository, and cannot be replaced by alternate procedures. However, various aspects of the construction and operation of the ESF can be carried out using alternate procedures of varying impact; some of these alternatives are described below.

4.3.1 Alternate Exploratory Shaft Facility Locations

The ESF location was selected based on scientific, engineering, environmental, and nontechnical (such as land-use) criteria. To the extent practical, the location was also based on a conceptual repository layout for the Richton Dome (Stearns-Roger Services Inc., ONWI-283, 1981). The favorability of the site was verified through geologic mapping and geological, environmental, and engineering surveys. Alternate locations over the dome will be considered if additional investigations indicate that such changes are necessary to avoid

severe impacts on sensitive biologic communities or destruction of significant archaeological resources.

4.3.2 Single Exploratory Shaft Facility Alternative

It is physically possible to conduct the subsurface characterization activities from only one shaft. This alternative would, of course, eliminate the environmental impacts associated with constructing one of the two planned exploratory shafts. However, there are compelling reasons why this alternative is not the preferred approach. The first and foremost of these reasons is safety. A prime consideration for occupational safety is to provide at least two escapeways from any potentially hazardous work station. This principle is evidenced in the regulations of the Mine Safety and Health Administration (MSHA). Although an ESF is not a mine, in that the purpose of a mine is to extract minerals for commercial use, it does consist of shafts and underground openings constructed by mining techniques. Therefore, safety standards developed for mines are the most applicable safety standards for constructing and operating an ESF.

Section 47.11-50 of the MSHA regulations (30 CFR Part 57) states the following:

> Every mine shall have two or more separate, properly maintained escapeways to the surface from the lowest levels which are so positioned that damage to one shall not lessen the effectiveness of the others. A method of refuge shall be provided while a second opening to the surface is being developed. A second escapeway is recommended, but not required, during the exploration or development of an ore body.

The DOE policy is that meeting minimum safety standards is not adequate. According to DOE Order 5480.1A and 5480.4, Environmental Protection, Safety, and Health Protection Program for DOE Operations, the DOE has adopted as a matter of policy the California Mine Safety Orders ("Escapeways and Refuge Stations," Cal. Admin. Code, Title 8). Article 27, Section 7080 states the following:

> Every mine shall have two separate escapeways to the surface which are so positioned that damage to one shall not lessen the effectiveness of the other, or a method of refuge shall be provided when only one opening to the surface is possible.

Additionally, it is possible that personnel working in any underground opening in evaporites such as salt may encounter releases of flammable gases. MSHA regulations, 30 CFR 57.21, detail the conditions that would cause a mine to be declared a gassy mine. If a mine is declared gassy, 30 CFR 57.21-22 states the following:

> The main intake and return air currents in mines shall be in separate shafts, slopes, or drifts ....

Thus, conducting underground site characterization from two shafts would be in compliance with generally accepted safety practices as described in the MSHA and California standards quoted above.

Exploratory shaft sizes discussed herein were selected based on the project needs. Each shaft must be large enough to contain utility lines and provide necessary ventilation.

4.3.3 Alternate Water Supply

The ESF water requirements, peaking at 1,220 liters per minute (320 gallons per minute), can be satisfied from local wells or from municipal water supplies. The first alternative is preferable. Because of the small extent of this water demand, it is believed that the impacts of either supply are equivalent and minor.

4.3.4 Alternate Waste Disposal

It is believed that the procedures selected for control and disposal of liquid waste described in Section 4.1.2 represent the best available control technology, and alternate control and disposal procedures would have greater environmental impact.

Section 4.1.2.6 also describes selected disposal methods for solid refuse and excess salt; however, alternative procedures for disposal of these solid wastes have been identified and are discussed below.

4.3.4.1 Combustible Refuse

The selected disposal method for rubbish is to haul it to a permitted landfill near Laurel, Mississippi. The impacts of this method are described in Sections 4.2.1.1, Effects on Land Use and Mineral Resources; 4.2.1.3, Air Quality Effects; and 4.2.1.4, Hydrologic Effects.

Alternatives to this disposal method include (1) onsite incineration with offsite disposal of ash residue at a licensed landfill, or (2) disposal in a landfill developed on site.

A permitted disposal site is located near Laurel, Mississippi, approximately 50 kilometers (30 miles) from the Richton Dome site (Sullivan, 1984). Another permitted disposal facility is located in Emelle, Alabama, approximately 200 kilometers (125 miles) from the site.

Onsite landfill disposal requires obtaining a permit, dedication of a land area, assurance that no leachate contamination of ground water occurs, use of diesel-operated equipment for refuse spreading and compaction, and control of gaseous (methane) emissions.

4.3.4.2 Disposal of Excess Salt

Approximately 65 percent of the salt (salt and anhydrite mixed with the caprock) excavated from the exploratory shafts and subsurface test areas will be required for backfilling the shaft and subsurface if the site is not selected for a repository. The salt mixed with caprock may be used first in backfilling.

As discussed in Section 4.1.2.4.6, waste salt and residues from runoff detention ponds may be disposed of off site in a licensed landfill located near Emelle, Alabama (McCutchen, 1985). The effects of this method are discussed in Section 4.2.1.1, Effects on Land Use and Mineral Resources, and Section 4.2.1.4, Hydrologic Effects. The discussion indicates that there are one or more landfills that can accommodate the amount of waste anticipated and are licensed to do so (Biggert, 1984; Buckley, 1984). Additional facilities may also be available if required. Thus, problems including preemption of land use; shortening the design life of an existing facility; and guaranteeing the long-term integrity of the landfill with respect to erosion, leaching of salt, or contamination of ground water are not expected to be significant.

The offsite disposal option for salt and salt-contaminated materials was chosen as a result of the need to return the site to its original condition if it is not selected for a repository. The facility identified for the disposal of these materials was selected, in part, to satisfy concerns for having the salt in a caretaker-type licensed facility. The offsite alternative and the facility identified represent the most conservative case for disposal of salt and salt-contaminated materials.

Impacts resulting from transportation of the salt and salt-contaminated wastes, including greater cost and the potential for contamination along the routes, have also been discussed previously in Section 4.2.1.1.

In addition to the selected disposal method, there are five alternatives for the disposal of waste salt (Parsons-Redpath, 1984):

- Disposal in an onsite landfill
- Disposal in existing, unused salt mines
- Deep well brine injection
- Offshore disposal
- Transfer, gift, or sale of salt to Federal, State, or private parties.

All offsite alternatives require transport of excess salt. Most would also incur environmental impacts in addition to those associated with truck transportation. A qualitative environmental analysis is presented below.

Onsite Landfill. Primary issues associated with this disposal option include land-use preemption and ground-water infiltration. If the salt is buried to sufficient depth, particularly if covered with a substantial soil layer, the land above the salt may be put to beneficial use, thus minimizing land-use impacts. The use of liners above and below the salt should minimize ground-water infiltration. Long-term integrity of the landfill might become an issue, particularly if the landfill is sited in a floodplain area. The primary advantages of this option are as follows:

- Relatively low cost (Parsons-Redpath, 1984)
- Absence of transportation impacts
- Relatively slight environmental impact (primarily ground water and land use).

Disadvantages include:

- Potential long-term preemption of land use
- Problems in guaranteeing long-term integrity of the landfill with respect to erosion, subsequent leaching of salt, or subsequent water quality contamination.

Mine Disposal. Offsite disposal in existing or abandoned mines has the primary disadvantage of increased cost and environmental impacts associated with rail or truck transports. The primary advantages include the following:

- Elimination of onsite impacts
- Minimizing of offsite environmental impacts other than those associated with truck transport.

If existing or abandoned salt mines are used, there would be no alteration of the existing environment and no ground-water contamination. An additional benefit might be reduced subsidence as the mine is backfilled.

Deep Well Injection. Deep well injection would require offsite transport and the creation of an offsite brining facility, both of which would cost more than onsite land disposal. The environmental impacts associated with brining and deep well injection would be somewhat different from land disposal (NUS Corporation, 1985a). Construction of the brining facility would produce temporary impacts to land use, soils, resident biota, and air quality which are typical of any construction project. Production of brine would require substantial amounts of water, and might impact local water supply. Deep well injection of brine might impact ground-water quality.

The major advantage of deep well injection is that most environmental impacts (with the possible exception of ground water quality) are of a short-term, reversible nature. The major disadvantages compared to onsite land disposal include the following:

- Additional cost

- Additional impacts from truck transport
- Water supply requirements
- Potential deterioration of ground water quality
- Substantial but temporary environmental impacts associated with the construction and operation of a brining facility.

4.3.4.2.4 Offshore Disposal. Offshore disposal would involve transport of the excess salt to the Gulf of Mexico (NUS Corporation, 1985b). It is expected that salt would be loaded onto barges and dispersed in the ocean over a wide area. Costs (Parsons-Redpath, 1984) and environmental impacts would be expected to be low, as indicated by the performance of the DOE Strategic Petroleum Reserve Project (DOE, 1978, DOE/EIS-0029). For this project, large amounts of saturated brine (on the order of 32,000 cubic meters [200,000 barrels] per day) are being discharged in the Gulf. Findings for this project indicate negligible impacts to offshore marine biota (DOE, 1983, DOE/EP-0045/1, p. 6). This indicates that impacts from dispersion of excess salt from the exploratory shaft will also be negligible. If this method is chosen, activities will be conducted in a manner consistent with the Federal Coastal Barrier Resources System and with any approved State coastal zone management programs of the Gulf States involved (Section 3.4.1).

The primary advantage of offshore disposal is that the impacts of disposal will be, for the most part, temporary. The primary disadvantages are as follows:

- Increased cost, due primarily to transportation requirements
- Additional impacts for truck transport
- Minor adverse impacts on offshore aquatic biota.

4.3.4.2.5 Sale or Transfer of Salt. Mined salt also could be offered first to Federal agencies through sale or transfers for use in road salting and other applications. If the material is not needed or required by Federal agencies, it could be offered to interested State and local governments as a donation. If refused by these governments, it could then be offered for public sale. The feasibility of this disposal procedure has not been verified. Primary disadvantages would be the cost and impacts from truck transport of the salt.

4.4 SUMMARY OF IMPACTS OF SITE CHARACTERIZATION ACTIVITIES

The impacts of site characterization activities are summarized in Table 4-28 according to the breakdown of Geotechnical Field Studies (Section 4.1.1), and Exploratory Shaft Facility activities (Section 4.1.2), and Environmental Field Studies (Section 4.1.3.1).

The summary table identifies impacts that are projected or expected to occur and those not expected to occur. Impacts are discussed in terms of their duration, intensity, or significance. The use of mitigation measures is noted in determining the intensity of the impact. As applicable, the location of the impact is also identified.

Table 4-28. Summary of Site Characterization Activities Impacts, Richton Dome

I. Geotechnical Field Studies

1. Land Use (Section 4.2.1.1)

   - No conflict is expected with access to Camp Shelby Military Operations.
   - No significant land use impact is expected. Clearing of sites will not affect any unique lands and represents an insignificant portion of the county's forestland.
   - No impact to prime farmland is expected.
   - No impact to regional mineral resources is expected.

2. Terrestrial/Aquatic Ecosystems (Section 4.2.1.2)

   - Impacts include insignificant and temporary loss of vegetation, wildlife habitat, and aquatic biota due to land disturbance.
   - No impacts are expected to threatened and endangered (T&E) species or critical habitat as no T&E species are currently known to be present in the site.

3. Air Quality (Section 4.2.1.3)

   - No significant air quality impacts are anticipated. The expected pollutant levels are below the National Ambient Air Quality Standards (NAAQS).

4. Hydrologic Effects; Surface-Water Quality (Section 4.2.1.4)

   - There are no significant impacts to surface-water quality. Water quality impacts will be limited to local and temporary increases in sediment loads during site preparation.

5. Hydrologic Effects; Ground-Water Quality (Section 4.2.1.4)

   - No significant impact to ground-water quality is expected since drilling procedures include mitigation measures that minimize the potential for aquifer contamination.
   - Any impact on ground-water flow regime will be minor and temporary. Ground-water extraction will produce temporary drawdown effects on nearby wells.

6. Soils (Section 4.2.1.5)

   - Soil erosion from clearing of vegetation, compaction, increased runoff, stripping of topsoil, mixing of soil horizons, disturbance of local topography, and changes to drainage patterns is expected to be minor, limited in duration (6 months or less), and limited in areal extent to specific test sites.

Table 4-28. Summary of Site Characterization Activities Impacts, Richton Dome
(Page 2 of 7)

I. Geotechnical Field Studies

7. Noise (Section 4.2.1.6)

- Increases in noise levels near characterization activities will be minor and temporary. Three boreholes located within less than 0.8 kilometers (0.5 mile) of the town of Richton will produce an Ldn of 55 dBA within the town limits for a period of one to six months for each borehole.

8. Aesthetic Resources (Section 4.2.1.7)

- Impact to visual resources will be insignificant because characterization activities will be visible from only a very limited area and are of short duration. Activities are expected to produce low visual contrast.

9. Archeological, Cultural, and Historical Resources (Section 4.2.1.8)

- No significant direct or indirect impacts to resources are expected. Implementation of the stipulations of a Programmatic Memorandum of Agreement will result in the avoidance or mitigation of potentially adverse effects.

10. Radiation Levels (Section 4.2.1.9)

- No radiological impacts from site characterization are expected.

11. Transportation and Utilities (Section 4.2.1.10)

- No significant impact on transportation and utilities is expected. Geologic field studies will result in only a minor increase in traffic and little additional impact to area highways.

- Local utilities will not be affected.

12. Socioeconomics (Section 4.2.2)

The socioeconomic impacts are based on geologic, environmental, and exploratory shaft activities during site characterization.

- 473 in-migrating workers would relocate to the area during peak activities which occur in the first year. This would result in a total of 1,027 in-migrants, including family members.

- The new residents are projected to relocate in Hattiesburg (40%), Laurel (15%), Richton (20%), and Petal (10%).

- Richton will be most affected with an increase of 16 percent in the town's 1987 projected population. Additional housing may be needed beyond current projections and a potential increase of 2 teachers is projected.

Table 4-28. Summary of Site Characterization Activities Impacts, Richton Dome
(Page 3 of 7)

I. Geotechnical Field Studies

- Grants in lieu of tax payments will be made to the appropriate taxing jurisdictions.

II. Exploratory Shaft

1. Land Use (Section 4.2.1.1)

   - Site clearing does not result in any significant land use impacts since the area does not include unique lands and represents less than 0.2 percent of Perry County forestland. No permanent impact to prime farmland is expected.
   - No permanent impacts to regional mineral resources are expected.
   - No significant conflict is expected on access to Camp Shelby Military Operations.

2. Terrestrial/Aquatic Ecosystems (Section 4.2.1.2)

   - Minor and temporary loss of vegetation and wildlife habitat due to land disturbance is anticipated.
   - No impacts to threatened and endangered species or critical habitat are expected since no T&E species are known to exist on the site.
   - No significant impact on aquatic ecosystems is anticipated because of control of site runoff.

3. Air Quality (Sections 4.2.1.3)

   - No significant air quality impacts are anticipated since expected pollutant levels are below the National Ambient Air Quality Standards (NAAQS).

4. Hydrologic Effects; Surface-Water Quality (Section 4.2.1.4)

   - Water quality impacts are limited to local and temporary increases in sediment loads prior to completion of sediment ponds. These will not be significant.
   - No impact on overall management of the floodplain is expected.

Table 4-28. Summary of Site Characterization Activities Impacts, Richton Dome
(Page 4 of 7)

II. Exploratory Shaft

5. Hydrologic Effects; Ground-water Quality (Section 4.2.1.4)

- Because the control measures, detection system, and any remedial action will limit contamination to an insignificant portion of total aquifer volume, there are no significant impacts to ground water quality.
- Pumping for 30-day test wells will have a local and temporary draw down effect on some local wells. At a distance of 1.6 kilometers (1 mile), which is the nearest existing well, maximum drawdown will be 2.3 meters (7.5 feet).

6. Soils (Section 4.2.1.5)

- During construction, soil impacts will occur from stripping of topsoil and vegetation and from accelerated runoff due to paving and soil compaction. Soil erosion will be greatest during initial site clearing, but will be reduced through standard measures to control soil loss.
- Use of engineered control measures, leak detection systems, and any necessary remedial action will prevent any potential soil contamination due to seepage from the sale pile, the mud pit, or the retention ponds.
- Salt loading of soil due to windblown salt is probably not significant because the deposition rate is restricted to areas immediately adjacent to salt handling facilities.

7. Noise (Section 4.2.1.6)

- Noise impacts resulting from audibility of blasting associated with shaft construction in the town of Richton during the first 6-12 days of blasting will be minor and temporary.
- Project noise will also create a perceptible increase in noise for the 2 residences within 1.8 kilometers (1.1 miles) of the ESF site center and along access routes.

8. Aesthetic Resources (Section 4.2.1.7)

- No significant impact to visual resources is anticipated because activities and the shaft headframe will be visible from a very limited area and are expected to produce low visual contrast with the present surroundings.

Table 4-28. Summary of Site Characterization Activities Impacts, Richton Dome (page 5 of 7)

II. Exploratory Shaft

9. Archaeological, Cultural, and Historic Resources (Section 4.2.1.8)

- No significant direct impact to resources is expected. Potential for discovery of surficial cultural resources is low due to previous land disturbance. Implementation of the stipulations of a Programmatic Memorandum of Agreement will result in the avoidance or mitigation of potentially adverse effects.

10. Radiation Levels (Section 4.2.1.9)

- Insignificant radiological impacts are expected.

11. Transportation and Utilities (Section 4.2.1.10)

- Impacts will result from increased traffic on existing roadways from movement of workers, supplies, and equipment.
- The greatest impact will be on Mississippi State Highway 42, which will experience a traffic increase of 6 to 23 percent during peak periods with an average increase of 4 to 15 percent.
- Additional traffic will lead to an increase in road wear, traffic accidents, and traffic fatalities.
- No impact on utilities is expected because it is expected that project needs will be met by existing supplies.

12. Socioeconomics (Section 4.2.2)

The socioeconomic impacts are based on geologic, environmental, and exploratory shaft activities during site characterization.

- 492 in-migrating workers would relocate to the area during peak activities which occur in the first year. This would result in a total of 1,068 in-migrants, including family members.
- The new residents are projected to relocate in Hattiesburg (40%), Laurel (15%), Richton (20%), and Petal (10%).
- Richton will be most affected with an increase of 17 percent in the town's 1987 projected population. Additional housing may be needed beyond current projections and a potential increase of 2 teachers is projected.
- Grants in lieu of tax payments will be made to the appropriate taxing jurisdictions.

Table 4-28. Summary of Site Characterization Activities Impacts, Richton Dome
(Page 6 of 7)

III. Environmental Field Studies

1. Land Use (Section 4.2.1.1)

   - Environmental studies require very little land disturbance, thus, no significant impacts will occur.

2. Terrestrial/Aquatic Ecosystems (Section 4.2.1.2)

   - Environmental studies require little land disturbance, and collection of specimens is an insignificant impact.

3. Air Quality (Section 4.2.1.3)

   - No environmental study will adversely affect air quality.

4. Surface-Water Quality (Section 4.2.1.4)

   - Little or no deterioration of local surface-water quality is expected, because little land disturbance is planned.

5. Ground-Water Quality (Section 4.2.1.4)

   - No impacts on ground-water quality are expected to result from environmental studies.

6. Soils (Section 4.2.1.5)

   - Impacts due to installation of the meteorological tower will be similar in magnitude to those expected during geotechnical field studies.

   - Impacts to soils from other environmental investigations, primarily soil and archaeological surveys, will be minor and localized.

7. Noise (Section 4.2.1.6)

   - No noise impacts are expected as the result of environmental field studies.

8. Aesthetic Resources (Section 4.2.1.7)

   - The meteorological tower will be visible from a very limited area, therefore, the impact is minor.

9. Archaeological, Cultural, and Historic Resources (Section 4.2.1.8)

   - The implementation of a PMOA will satisfactorily mitigate any potentially significant impacts.

Table 4-28. Summary of Site Characterization Activities Impacts, Richton Dome (page 7 of 7)

II. Exploratory Shaft
10. Radiation Levels (Section 4.2.1.9)
• No radiological impacts are expected.
11. Transportation and Utilities (Section 4.2.1.10)
• Activities will generate an insignificant amount of additional traffic and demand for utilities.

4.5 CHAPTER 4 REFERENCES

4.5.1 References Listed by Author

Acoustical Society of America, 1978. American National Standard, Method for the Calculation of the Absorption of Sound by the Atmosphere, ANSI S1.26-1978, ASA 23-1978, American Institute of Physics, New York, NY.

Airborne Systems, Inc., 1983. Index to Photography of Richton Dome, Mississippi, aerial photograph, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Battelle's Pacific Northwest Laboratories, 1979. Technology for Commercial Radioactive Waste Management, DOE/ET-0028, 5 Vols., prepared for U.S. Department of Energy, Washington, DC.

Bechtel Group, Inc., and Law Engineering Testing Company, 1983. Site Characterization Plan: Gulf Coast Salt Domes, ONWI-293, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Bechtel National, Inc., 1982. Environmental Characterization Report for the Gulf Interior Region, Mississippi Study Area, ONWI-193, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Bechtel National, Inc., 1984. Socioeconomic Data Base Report for Mississippi, ONWI-499, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Bechtel National, Inc., 1985a. Richton Dome Air Quality Analysis, draft letter report, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Bechtel National, Inc., 1985b. Richton Dome Noise Analysis, draft letter report, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Beranek, Leo L., ed., 1971. Noise and Vibration Control, McGraw-Hill Book Company, New York, NY, pp. 34-35, 164-169, and 182-185.

Bernstein, L., and H. E. Howard, 1958. "Physiology of Salt Tolerance," Annual Review of Plant Physiology, Vol. 9, pp. 25-46.

Biggert, J., 1984. Telephone conversation between Biggert, Mississippi Department of Natural Resources, and T. Sands, Parsons Brinckerhoff/PB-KBB, about offsite salt disposal, April 10.

BNI, see Bechtel National, Inc.

BNW, see Battelle's Pacific Northwest Laboratories.

Bohn, Russel, Thomas Cuscino, Jr., and Chatten Cowherd, Jr., 1978. Fugitive Emissions from Integrated Iron and Steel Plants, EPA-600/2-78-050, prepared for U.S. Environmental Protection Agency by Midwest Research Institute, Kansas City, MO.

Bowers, J. F., J. R. Bjorklund, and C. S. Cheney, 1979. Industrial Source Complex (ISC) Dispersion Model User's Guide, Vol. 1, EPA-450/4-79-030, prepared for Source Receptor Analysis Branch, U.S. Environmental Protection Agency, Research Triangle Park, NC, by H. E. Cramer Company, Inc., University of Utah Research Park, Salt Lake City, UT.

Braun, Bernd, and William R. Nash, 1985. "Ground Freezing for Construction," Civil Engineering/ASCE, January, pp. 54-56.

Buckley, Jim, 1984. Telephone conversation between Buckley, Chemical Waste Management, Meridian, MS, and Tom Sands, Parsons Brinckerhoff/PB-KBB, about offsite salt disposal, April 11.

Bureau of the Census, 1982. 1980 Census of Population, Number of Inhabitants, Mississippi, PC80-1-A26, U.S. Department of Commerce, Washington, DC.

Committee on Hearing, Bioacoustics, and Biomechanics, 1981. Assessment of Community Response to High-Energy Impulsive Sounds, Report of Working Group 84, National Research Council, National Academy Press, Washington, DC, Figure 4.

Cuscino, Thomas, Jr., 1984. Cost Estimates for Selected Fugitive Dust Controls Applied to Unpaved and Paved Roads in Iron and Steel Plants, prepared for U.S. Environmental Protection Agency, Region V, Chicago, IL, pp. 3-16.

DOE, see U.S. Department of Energy.

Eco-Inventory Studies, Inc., 1983. Threatened and Endangered Species Survey for the Richton Salt Dome Area: Terrestrial and Aquatic Animals, Project 12354, prepared for Bechtel Group, Inc., San Francisco, CA, for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Edison Electric Institute, 1983. Electric Power Plant Environmental Noise Guide, Vol. I, 2nd Ed., prepared by Bolt Beranek and Newman Inc., New York, NY, pp. 5-1 through 5-5.

EEI, see Edison Electric Institute.

EPA, see U.S. Environmental Protection Agency.

Ertec, Inc., 1982. Generalized Drill Site Schematic, Figure 2-1, in Activity Plan, Overburden, and Salt Stock Characterization Borehole, Richton Dome, Rev. (1), Sept. 30, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Ertec, Inc., 1983. Regional Ground-Water Flow Near Richton Dome, Mississippi: Annual Status Report for Fiscal Year 1982, ONWI-456, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Eshbach, Ovid W., and Mott Souders, eds., 1975. Handbook of Engineering Fundamentals, 3rd edn., John Wiley & Sons, New York, NY.

Federal Bureau of Investigation, 1983. Crime in the United States, Uniform Crime Reports for the United States, 1982, U.S. Department of Justice, Washington, DC.

Fidell, Sanford, and Richard Horonjeff, 1982. A Graphic Method for Predicting Audibility of Noise Sources, AFWAL-TR-82-3086, prepared by Bolt Beranek and Newman Inc. for Air Force Wright Aeronautical Laboratories, Wright-Patterson Air Force Base, Dayton, OH.

Finison, B. F., 1984. Letter from Finison, Forest Service, to J. O. Neff, Salt Repository Project Office, U.S. Department of Energy, Columbus, OH, giving approval for additional access to De Soto National Forest, May 29.

Fish and Wildlife Service, 1983. National Wetlands Inventory Maps, Rhodes, Richton, Beaumont Quadrangles, Office of Biological Services, U.S. Department of the Interior, Atlanta, GA.

Freeze, R. Allen, and John A. Cherry, 1979. Groundwater, Prentice-Hall, Inc., Englewood Cliffs, NJ.

FWS, see Fish and Wildlife Service.

Gilmore, John S., and Mary K. Duff, 1975. Boom Town Growth Management: A Case Study of Rock Springs-Green River, Wyoming, Westview Press, Boulder, CO.

Golder Associates, Inc., 1985. Draft Test Plan for In Situ Testing in an Exploratory Shaft in Salt, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, in preparation.

Goldman, Larry E., 1985. Letter from Goldman, Field Supervisor, Fish and Wildlife Service, to S. E. Pomeroy, Battelle Columbus Laboratories, Columbus, OH, about existence of wetlands, July 10.

Goldsmith, Stanley, 1984. ONWI Population In-Migration Model (attachment for inclusion in salt site statutory environmental assessment documents), letter report from Goldsmith, Office of Nuclear Waste Isolation, Battelle Memorial Institute, to T. J. Taylor, Salt Repository Project Office, U.S. Department of Energy, Columbus, OH, May 30.

Hepner, J., and P. Nault, 1984. Telephone conversations between Hepner and Nault, coordinators, U.S. Fish and Wildlife Service, National Wetlands Inventory, Atlanta, GA, and K. Marcus, The Earth Technology Corporation, about wetland inventories, October 1 and 3.

Hines, Robert, 1986. Population In-Migration Model Outputs for Site Characterization and the Repository--Davis Canyon, Deaf Smith, and Richton Sites, computer output, Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Hoffman, Glenn J., and Jewell L. Meyer, 1982. "Reclamation of Salt-Affected Soils in California," Proceedings of the First Thematic Conference on Remote Sensing of Arid and Semi-Arid Lands (January, 1982, Cairo, Egypt), pp. 147, 149, 151, 153, 155, 157, and 159.

INTERA Environmental Consultants, Inc., 1978. Radiological Waste Storage Analysis, prepared for Sandia Laboratories, Albuquerque, NM.

International City Management Association, 1979. The Practice of Local Government Planning, Washington, DC.

Jessberger, Hans L., ed., 1979. Ground Freezing: Developments in Geotechnical Engineering, Vol. 26 (Proceedings of the First International Symposium on Ground Freezing, Bochum, German Federal Republic, March 8-10, 1978), Elsevier Scientific Publishing Company, New York, NY, pp. 311-327.

Jordan, Dennis B., 1982. Letter from Jordan, Field Supervisor, Fish and Wildlife Service, Jackson, MS, to J. O. Neff, Salt Repository Project Office, U.S. Department of Energy, Columbus, OH, about endangered species in Perry County, MS, and Bienville Parish, LA, November 29.

Jordan, Dennis B., 1984. Letter from Jordan, Fish and Wildlife Service, to J. O. Neff, Salt Repository Project Office, U.S. Department of Energy, Columbus, OH, about threatened or endangered species, November 7.

Kohrs, E. V., 1974. "Social Consequences of Boom Growth in Wyoming," paper presented to the Rocky Mountain American Association for the Advancement of Science, Laramie, WY.

Krynine, D. P., and W. R. Judd, 1957. Principles of Engineering Geology and Geotechnics, McGraw-Hill Book Company, New York, NY.

Law Engineering Testing Company, 1982. Gulf Coast Salt Domes Geologic Area Characterization Report, Mississippi Study Area, Vol. VI, ONWI-120, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Little, Ronald L., 1977. "Some Social Consequences of Boom Towns," North Dakota Law Review, Vol. 52, No. 3, pp. 401-425.

Little, S., J. J. Mohr, and L. L. Spicer, 1958. "Salt-Water Storm Damage to Loblolly Pine Forests," Journal of Forestry, January, pp. 27-28.

Maryland Department of Natural Resources, 1978. Power Plant Cumulative Environmental Impact Report, PPSP-CEIR-2, Maryland Power Plant Siting Program, Annapolis, MD.

McCutchen, R. S., 1985. Internal memorandum from McCutchen to A. Kashani and J. E. Gould, all of Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, about disposal facilities, August 6.

McIntosh, W. H., 1986. Telephone conversation between W. H. McIntosh, Office of Nuclear Waste Isolation (ONWI), and S. Webster, Salt Repository Project office (SRPO), U.S. Department of Energy, Columbus, OH, about SRPO acceptance of Parsons Brinckerhoff source terms, February 3.

Mississippi Air and Water Pollution Control Commission, 1983. Mississippi Air Pollution Control Regulations, Part MAPCR, APC-S-2, The Bureau of National Affairs, Inc., Washington, DC.

Mongan, Tom R., 1985. Letter from Mongan, Bechtel National, Inc., to M. R. Thomas, Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, with attachments, October 9.

Murdock, Steve H., and F. Larry Leistritz, 1979. Energy Development in the Western United States, Impact on Rural Areas, Praeger Special Studies, Praeger Scientific, New York, NY, pp. 93-100 and 109-111.

National Center for Education Statistics, 1983. Digest of Education Statistics 1983-84, U.S. Department of Education, Washington, DC.

National Center for Health Statistics, 1983. Health - United States, 1981, U.S. Department of Health and Human Services, Washington, DC.

National Park Service, 1985. "National Register of Historic Places; Annual Listing of Historic Properties; Notice of Review," Federal Register, Vol. 50, No. 43, pp. 8850, 8874-8875.

National Safety Council, 1984. Accident Facts, 1984 edn., Chicago, IL, pp. 40-79.

Newcome, Roy, Jr., compiler, 1971. Results of Aquifer Tests in Mississippi, U.S. Geological Survey Bulletin 71-2, prepared by the Water Resources Division with the Mississippi Board of Water Commissioners, Jackson, MS.

NPS, see National Park Service.

NRC, see U.S. Nuclear Regulatory Commission.

NUS Corporation, 1985a. Alternative Methods to Manage Waste Salt From Repository Excavation in the Deaf Smith County and Swisher County Locations, Texas: A Scoping Study, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, in preparation.

NUS Corporation, 1985b. Disposal Alternatives and Recommendations for Waste Salt Management for Repository Excavation in the Palo Duro Basin, Texas, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, in preparation.

Office of Management and Budget, 1983. "School Assistance in Federally Affected Areas," 1983 Catalog of Federal Domestic Assistance, Executive Office of the President, Washington, DC, pp. 816-818.

Office of Nuclear Waste Isolation, 1986. Evaluation of Air Quality and Noise Impact Assessments - Richton Dome, Battelle Memorial Institute, Columbus, OH, in preparation.

Oxley, Marvin L., Edward Minihan, and Julius M. Ridgway, 1968. "A Study of the Jurassic Sediments in Portions of Mississippi and Alabama," in T. H. Dinkins, Jr., ed., Jurassic Stratigraphy of Mississippi, Bulletin 109, Mississippi Geological, Economic and Topographical Survey, Jackson, MS, pp. 39-77.

Parsons Brinckerhoff/PB-KBB, 1983. Exploratory Shaft Facility Preliminary Designs - Gulf Interior Region Salt Domes, ONWI-497, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Parsons Brinckerhoff/PB-KBB, 1984. Support documentation regarding waste disposal, road access/ESF stream encroachment, and powerlines, BPMD-ESF-1022, letter reports from John R. Schmedeman to D. E. Miall, Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Parsons Brinckerhoff/PB-KBB, 1985. Letter from J. R. Schmedeman, to D. Miall, Office of Nuclear Waste Isolation, Battelle Project Management Division, Columbus, OH, regarding input to Environmental Assessment for Deaf Smith, Davis Canyon, and Richton Dome Sites, September 13.

Parsons Brinckerhoff/PB-KBB, 1986. Exploratory Shaft Facility EA Modeling Support, letter from R. H. Janowski, to R. Lahoti, Salt Repository Project Office, U.S. Department of Energy, Columbus, OH, February 5.

Parsons-Redpath, 1984. Preliminary Salt Control Plan, prepared for U.S. Department of Energy by Parsons-Redpath, Columbus, OH, in preparation.

PB/PB-KBB, see Parsons Brinckerhoff/PB-KBB.

Prendergast, P. J., 1985. Memorandum from Prendergast, Battelle Columbus Laboratories, to C. R. Malone, Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, about Forms AD-1006, prime farmlands at Permian and Gulf sites, August 28.

Reis, Timothy J., 1985a. Telephone conversation between Reis, Chemical Waste Management, Inc., and R. S. McCutchen, Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, about landfill capacity within 3 to 5 years at Emelle, Alabama, July 16.

Reis, Timothy J., 1985b. Telephone conversation between Reis, Chemical Waste Management, Inc., and J. D. Jackson, Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, about capacity of hazardous waste disposal sites, July 25.

Reith, Charles C., Ellen T. Louderbough, Robert J. Eastmond, and Annabelle L. Rodriguez, 1985. Ecological Monitoring Program at the Waste Isolation Pilot Plant, First Semiannual Report, WTSD-TME-058, U.S. Department of Energy, Carlsbad, NM.

Rhoades, J. D., 1982. Reclamation and Management of Salt-Affected Soils After Drainage, paper prepared for Soil and Water Management Seminar, November 29 - December 2, 1982, Lethbridge, Alberta, Canada.

Riggs, H. C., 1972. Low-Flow Investigations, Techniques of Water-Resources Investigations of the U.S. Geological Survey, TWI 4-B1, U.S. Department of the Interior, Alexandria, VA.

Riggs, H. C., 1982. Regional Analyses of Streamflow Characteristics, Techniques of Water-Resources Investigations of the United States Geologic Survey, TWI 4-B3, U.S. Department of the Interior, Washington, DC.

Roesner, Erwin K., 1980. Construction of a Watertight Deep Shaft in the Unstable and Water-Bearing Strata of the Saskatchewan Potash Field, prepared for Society of Mining Engineers of AIME Fall Meeting, October, 1980, Minneapolis, MN.

Rogers, Ken E., 1983. Tasks 1 and 2 Reports (revised), 12354-TSA-7, prepared for Bechtel Group, Inc., San Francisco, CA.

Schultz, Theodore J., 1978. "Synthesis of Social Surveys on Noise Annoyance," Journal of the Acoustical Society of America, Vol. 64, No. 2, pp. 377-405.

Scott, R., 1984. Letter from Scott, Stearns-Roger Services, Inc., to C. DaMassa, Bechtel National, Inc., San Francisco, CA, enclosing field notes and photos, March 29.

Shuster, John A., 1972. "Controlled Freezing for Temporary Ground Support," Proceedings - 1st North American Rapid Excavation and Tunneling Conference (June, 1972, Chicago, Illinois), Terrafreeze, Lorton, VA, pp. 863, 865-892, 894.

Siskind, D. E., M. S. Stagg, J. W. Kopp, and C. H. Dowding, 1980. Structure Response and Damage Produced by Ground Vibration From Surface Mine Blasting, Report of Investigations 8507, Bureau of Mines, U.S. Department of the Interior, Washington, DC.

Society of American Foresters, 1980. Forest Cover Types of the United States and Canada, F. H. Eyre, ed., Bethesda, MD.

Soil Conservation Service, 1975. Soil Taxonomy, Handbook No. 436, U.S. Department of Agriculture, Washington, DC.

Soil Survey Staff, 1951. Soil Survey Manual, U.S. Department of Agriculture Handbook No. 18, Bureau of Plant Industry, Soils and Agriculture Engineering, U.S. Department of Agriculture, Washington, DC.

Staff Industries, Inc., 1983. Impermeable Linings and Covers, Advertising Brochure, Upper Montclair, NJ.

Stearns-Roger Services Inc., 1981. Engineering Feasibility Studies for Candidate Salt Domes: National Waste Terminal Storage Repository No. 1, Special Study No. 5, ONWI-283, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Stenehjem, Erik, and James Metzger, 1976. A Framework for Projecting Employment and Population Changes Accompanying Energy Development, ANL/AA-14, Vols. I and II, prepared for U.S. Department of Energy by Argonne National Laboratory, Argonne, IL.

Sullivan, Tom, 1984. Telephone conversation between Sullivan, Bush Construction, Laurel, MS, and T. Sands, Parsons Brinckerhoff/PB-KBB, about salt disposal in Mississippi, April 18.

Thompson, L. S., 1978. "Transmission Wire Strikes: Mitigation Through Engineering Design and Habitat Modification," in M. L. Avery, ed., Impacts of Transmission Lines on Birds in Flight, Proceedings of a Workshop, FWS/OBS-78/48, Fish and Wildlife Service, U.S. Department of the Interior, Washington, DC.

U.S. Department of Energy, 1978b. Final Environmental Impact Statement: Strategic Petroleum Reserve, Texoma Group Salt Domes, Cameron and Calcasleu Parishes, Louisiana, and Jefferson County, Texas, DOE/EIS-0029, Vols. 1-5, Washington, DC.

U.S. Department of Energy, 1978a. Socioeconomic Impact Assessment: A Methodology Applied to Synthetic Fuels, HCP/L2516-01, Washington, DC, pp. 15-21.

U.S. Department of Energy, 1980. Final Environmental Impact Statement, Waste Isolation Pilot Plant, DOE/EIS-0026, Washington, DC.

U.S. Department of Energy, 1983. Strategic Petroleum Reserve Annual Report, DOE/EP-0045/1, National Technical Information Service, Springfield, VA.

U.S. Department of Energy, 1983. Summary of the Results of the Evaluation of the WIPP Site and Preliminary Design Validation Program, WIPP-DOE-161, Waste Isolation Pilot Plant, Albuquerque, NM.

U.S. Department of Energy, 1985. Mission Plan for the Civilian Radioactive Waste Management Program, Vol. I of III, DOE/RW-0005, Office of Civilian Radioactive Waste Management, Washington, DC.

U.S. Department of Energy, 1985. Record of Responses to Public Comments on the Draft Mission Plan for the Civilian Radioactive Waste Management Program, Vol. II of III, DOE/RW-0005, Office of Civilian Radioactive Waste Management, Washington, DC.

U.S. Department of Energy, 1985a. Programmatic Memorandum of Agreement Among the United States Department of Energy, the Advisory Council on Historic Preservation, and the National Conference of State Historic Preservation Officers - Richton Dome Site, Mississippi, preliminary draft.

U.S. Department of Housing and Urban Development, 1978. Flood Hazard Boundary Map, Perry County, Mississippi, Unincorporated Areas, Federal Insurance Administration, Washington, DC.

U.S. Environmental Protection Agency, 1971. "National Primary and Secondary Ambient Air Quality Standards" (42 CFR Part 410), Federal Register, Vol. 36, No. 84, pp. 8186-8201.

U.S. Environmental Protection Agency, 1973. Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents, EPA/670/4-73-001, Cincinnati, OH.

U.S. Environmental Protection Agency, 1974. Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, EPA/ONAC 550/9-74, Washington, DC.

U.S. Geological Survey, 1967. General Office and Field Procedures for Indirect Discharge Measurements, Techniques of Water-Resources Investigations of the U.S. Geological Survey, TWI 3-A1, U.S. Department of the Interior, Reston, VA.

U.S. Geological Survey, 1970. Hattiesburg, Mississippi; Alabama; Louisiana Map, 1953, revised, Scale 1:250,000, U.S. Department of the Interior, Reston, VA.

U.S. Geological Survey, 1973. Rhodes, Mississippi, Quadrangle Map, Scale 1:24,000, U.S. Department of the Interior, Reston, VA.

U.S. Geological Survey and National Ocean Survey, 1978. Mobile, Ala,; Miss.; LA, topographic-bathymetric map, Scale 1:250,000, U.S. Department of the Interior, Reston, VA.

U.S. Geological Survey, 1982b. Ovett, Miss., Quadrangle Map, N3122.5-W8900/7.5, Scale 1:24,000, U.S. Department of the Interior, Reston, VA.

U.S. Geological Survey, 1982c. Ovett SE, Mississippi, Quadrangle Map, Scale 1:24,000, U.S. Department of the Interior, Reston, VA.

U.S. Geological Survey, 1982a. Richton, Miss., Quadrangle Map, N3115-W8852.5/7.5, Scale 1:24,000, U.S. Department of the Interior, Reston, VA.

U.S. Nuclear Regulatory Commission, 1976. "Preparation of Environmental Reports for Nuclear Power Stations," NUREG-0099, Regulatory Guide 4.2, Revision 2, Washington, DC.

U.S. Nuclear Regulatory Commission, 1977. "Terrestrial Environmental Studies for Nuclear Power Stations," Regulatory Guide 4.11, Washington, DC.

U.S. Nuclear Regulatory Commission, 1980. "Meteorological Programs in Support of Nuclear Power Plants," Regulatory Guide 1.23, Proposed Revision 1, Washington, DC.

Ver Planck, William E., 1958. Salt in California, Bulletin 175, Division of Mines, California Department of Natural Resources, San Francisco, CA.

Wadleigh, Cecil H., and Mildred S. Sherman, 1978. "Sodium Chloride in Plant Nutrition," Sodium Chloride, D. W. Kaufmann, ed., ACS Monograph No. 145, American Chemical Society, Washington, DC, pp. 470-483.

Waite, David A., James J. Mayberry, and Jeffrey M. Furr, 1985. Preclosure Radiological Calculations to Support Salt Site Evaluations, BMI/ONWI-541, (Rev. 1), prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, in preparation.

Walton, Sarah, 1984. Telephone conversation between Walton, Chemical Wate Management, and T. Sands, Parsons Brinckerhoff/PB-KBB, about cost of disposal in landfill, April 18.

Wiss, John F., and Patrick W. Linehan, 1978. Control of Vibration and Blast Noise From Surface Coal Mining, Vol. 1, PB-299 877, prepared by Wiss, Janney, Elstner and Associates, Inc., for Bureau of Mines, U.S. Department of the Interior, Washington, DC.

4.5.2 Federal Regulations and Statutes, and DOE Orders

10 CFR Part 60, Disposal of High-Level Radioactive Wastes in Geologic Repositories; Technical Criteria.

10 CFR Part 960, Nuclear Waste Policy Act of 1982; General Guidelines for the Recommendation of Sites for the Nuclear Waste Repositories; Final Siting Guidelines.

10 CFR Part 1022, Floodplain/Wetlands Environmental Review Requirements.

29 CFR Part 1910, regulations under the Occupational Safety and Health Act of 1970, as amended.

29 CFR Part 1926, Safety and Health Regulations for Construction.

30 CFR Part 57, Safety and Health Standards - Metal and Non-metal Underground Mines, revised July 1, 1984.

30 CFR 57.21, Safety and Health Standards - Metal and Non-metal Underground Mines, Gassy Mines.

40 CFR Part 50, National Primary and Secondary Ambient Air Quality Standards.

40 CFR Part 52, Approval and Promulgation of Implementation Plans.

40 CFR 52.21, Prevention of Significant Deterioration of Air Quality.

Bald and Golden Eagle Protection Act, 16 USC Secs. 668-668d.

Endangered Species Act of 1973, 16 USC Secs. 1531-1543.

Farmland Protection Policy Act, 7 USC Secs. 4201-4209.

Federal Land Policy and Management Act, Rights-of-Way, 43 USC Sec. 1761(a)(6)-(7).

Federal Land Policy and Management Act of 1976, 43 USC Secs. 1701-1782.

Federal Water Pollution Control Act, Clean Water Act of 1977, 33 USC Secs. 1251-1376.

Fish and Wildlife Coordination Act, 16 USC Secs. 661-666c.

Migratory Bird Treaty Act, as amended, 16 USC Secs. 703-711.

Mine Safety and Health Act of 1977, 30 USC Secs. 801 et seq.

Noise Control Act of 1972, Quiet Communities Act of 1978, 42 USC Secs. 4901-4918.

Nuclear Waste Policy Act of 1982, 42 USC Secs. 10101-10226.

Rivers and Harbors Act, 33 USC Secs. 401-413.

Executive Order 11990, Protection of Wetlands, May 24, 1977.

DOE 5480.1A Environmental Protection, Safety, and Health Protection Program for Department of Energy.

DOE 5480.4 Environmental Protection, Safety, and Health Protection Standards

4.5.3 State of California Laws

Escapeways and Refuge Stations, California Administrative Code, Mine Safety Orders, Title 8, R. 72 (1972) Art. 27, Secs. 7080-7081.

4.5.4 State of Mississippi Laws

Air Pollution Control Regulations (identical to 40 CFR Part 52), MAPCR, APC-S-2, 1982.

Chapter 5

REGIONAL AND LOCAL EFFECTS OF LOCATING A REPOSITORY AT THE SITE

This Chapter is intended to meet the requirements of Section 112(b)(1)(E)(vi) of the "Nuclear Waste Policy Act of 1982" (NWPA) (42 USC Sections 10101-10226), which mandates that the environmental assessment (EA) include "an assessment of the regional and local impacts of locating the proposed repository at such site." This chapter meets these requirements by describing the environmental, transportation, and socioeconomic effects of locating a representative repository at the Richton Dome site.

This chapter is organized into four sections:

1. Section 5.1 describes a representative repository and those activities that occur during repository construction, operation, and decommissioning, and presents the impacts of some recent design variations.

2. Section 5.2 describes effects of representative repository activities on the physical environment.

3. Section 5.3 describes the effects of transportation and utilities access to the repository site.

4. Section 5.4 describes the socioeconomic impacts of a repository.

5.1 THE REPOSITORY

The representative repository concept described in this chapter is based on site-specific engineering feasibility studies for constructing and operating a repository at candidate salt sites (SCC, 1984a). The impact analyses presented in this chapter are based on engineering parameters developed using this feasibility study which will hereafter be referred to as the reference repository design. This concept had the most complete design information available during the time that the EA impact analyses were prepared. However, this reference design must not be construed to represent a final site-specific conceptual design. Rather, the design feasibility data generated should be treated as the first step of the design process that progresses from feasibility studies to the conceptual design phase (Site Characterization Plan Conceptual Design and Advanced Conceptual Design), and to the Title I and II design phase (License Application Design and Final Procurement and Construction Design). The site-specific conceptual design and license application design will resolve remaining uncertainties and serve as the basis for the environmental impact statement (EIS) that will be prepared before submittal of a license application. The Salt Repository Project Office (SRPO) is currently developing the Site Characterization Plan (SCP) Conceptual Design for the SCP. Development of the Advanced Conceptual Design will follow completion of SCP conceptual design. To illustrate differences which could occur in the future as the design process matures, two alternative repository design concepts are presented in Table 5-1 for comparison of design characteristics and impacts (environmental, socioeconomic and transportation). The "reference design" in the table is the design concept upon which, as mentioned previously, regional and local impacts are assessed in this EA. The reference design is a single-phase concept; that is, all surface and initial underground construction activities are completed prior to acceptance of nuclear wastes. The reference design was based on receipt of both spent fuel (SF) (36,000 metric tons of heavy metal [MTHM]) and commercial high-level waste (CHLW) (36,000 MTHM) plus approximately 3,510 MTHM of defense high-level waste (DHLW). Gassy mine conditions were not assumed in the reference design.

The second concept presented in Table 5-1 is the "Current Two-Phase Concept." This is a modification of the reference design to meet the requirements presented in the DOE final Mission Plan (DOE, 1985, DOE/RW-0005). This concept basically differs from the reference design in three areas, namely, (1) the repository is developed in two phases, (2) the repository subsurface is designed on a gassy mine basis, and (3) the waste received is 62,000 MTHM spent fuel and 8,000 MTHM DHLW and West Valley CHLW.

Table 5-1. Comparison of Alternative Repository Design Concepts - Richton Dome Site

Repository Characteristics	Reference Design	Mission Plan[a] (Current Two-Phase Concept)	Transportation Impacts	Environmental Impacts	Socioeconomic Impacts
1. Incorporation of exploratory shaft into repository[b]	Not included	Being evaluated	If one or more exploratory shafts are not incorporated into the repository, repository-related impacts are expected to be identical because the number and size of repository shafts are the same. However, if one or more exploratory shafts are incorporated into the repository and the number of shafts to be constructed during the repository phase is reduced, there would be a slight reduction in work force and supplies required during repository construction and, in turn, worker and truck traffic in the locality would be less.	If one or more exploratory shafts are not incorporated into the repository, repository-related impacts are expected to be identical because the number and size of repository shafts are the same. However, if one or more exploratory shafts are incorporated into the repository and the number of shafts to be constructed during the repository phase is reduced, there would be a minimal reduction in environmental impacts. Impact reductions would be attributable to less emissions and less resource consumption.	If one or more exploratory shafts are not incorporated into the repository, repository-related impacts are expected to be identical because the number and size of repository shafts are the same. However, if one or more exploratory shafts are incorporated into the repository and the number of shafts to be constructed during the repository phase is reduced, there would be a minimal reduction in socioeconomic impacts. Impact reduction would be attributable to reductions in the required work force.
2. Number and sizes of exploratory shafts[b] (feet, inside diameter)	Not included	Two: 12, 12	See response to Characteristic 1.	See response to Characteristic 1.	See response to Characteristic 1.
3. Number and sizes of repository shafts (feet, inside diameter)	Five - 21, 22, 23, 25, 31	Five: 21, 22, 23, 25, 31	No differences in impacts are expected because design parameters are the same.	No differences in impacts are expected because design parameters are the same.	No differences in impacts are expected because design parameters are the same.
4. Gassy conditions assumed	No	Yes	Gassy mine conditions require increased ventilation. This may require additional passageways and consequent increases in the amount of excavated salt. The transportation consequences of gassy mine conditions result from the possible increased amount of salt to be disposed of and increased work force. These potential impacts are addressed in Characteristics 7 and 18.	Gassy mine conditions require increased ventilation. This may require additional passageways and consequent increases in the amount of excavated salt. More or larger equipment to power ventilation fans will be required. Because the fans are electrically driven, no additional impact on air quality is expected. Additional or larger equipment to handle increased ventilation air flow may increase noise levels unless noise mitigation equipment is used. For the reference case, no mitigation	Gassy mine conditions require increased ventilation. This may require additional passageways and consequent increases in the amount of excavated salt. The socioeconomic consequences of gassy mine conditions result from the increased work force requirements associated with additional underground excavation. These impacts are addressed in Characteristic 18.

Table 5-1. Comparison of Alternative Repository Design Concepts - Richton Dome Site
(Page 2 of 11)

Repository Characteristics	Reference Design	Mission Plan[a] (Current Two-Phase Concept)	Transportation Impacts	Environmental Impacts	Socioeconomic Impacts
Gassy conditions assumed (Continued)				was applied to the ventilation exhaust system to reduce noise levels attributable to ventilation fans. A 50 percent increase in air flow will produce a 1.8 dB increase in emission sound levels. Reduction of 1.8 dB of the source of noise is achievable within the current state of the art through the use of baffles and muffling equipment. Thus, noise impacts for the current concepts can be held within those of the reference case through mitigation. Estimated normal use of the steam plant is 18 percent of capacity to heat buildings and supply miscellaneous needs for both the reference case and current concepts. Because the reference case modeled emissions assuming 100 percent capacity usage, the impacts modeled are conservative. Steam plant capacity is established to meet the emergency backup air conditioning requirement. Impacts from additional excavated salt are addressed under Characteristics 6, 7, and 18.	
5. Approximate repository depth (feet)	2,120	2,120	No differences in impacts are expected because design parameters are the same.	No differences in impacts are expected because design parameters are the same.	No differences in impacts are expected because design parameters are the same.
6. Salt					
Total quantity excavated (tons)	23,182,000	30,800,000	The alternative to the reference case will increase by about one-third the amount of salt to be excavated and stored on site. The increase in salt excavation and onsite	The alternative to the reference case will increase by about one-third the amount of salt to be excavated and stored on site. Airborne emissions of salt from salt	The alternative to the reference case will increase by about one-third the amount of salt to be excavated and stored on site. The increase in salt excavation is expected to
Quantity stored on site (tons)	2,965,000	3,700,000			

Table 5-1. Comparison of Alternative Repository Design Concepts - Richton Dome Site
(Page 3 of 11)

Repository Characteristics	Reference Design	Mission Plan[a] (Current Two-Phase Concept)	Transportation Impacts	Environmental Impacts	Socioeconomic Impacts
Salt (Continued)			storage is expected to result in a larger work force. The transportation impact is addressed in Characteristic 18.	handling operations are expected to increase over the life of the facility. Fugitive salt is conservatively estimated to increase up to 30 percent more than the 15 tons per year estimated for the reference case even though the salt pile will have formed a hard crust and the working face will be kept about the same size. Salt particulates from the mine exhaust will increase due to, roughly, a 50 to 60 percent increase in air flow. Repository salt deposition rates (used also for the site characterization deposition estimates) between 1 and 2 kilometers (0.6 and 1.2 miles) from the salt storage pile and exhaust ventilation shaft are projected to be 0.1 kilogram per hectare (0.09 pound per acre) per year for the reference case. This deposition rate is expected to net: • Less than a 0.2 part per million increase in the upper 0.3 meter (1 foot) of soil of assumed 100 pound per cubic foot density (Section 4.2.1.11.2) • Less than 1,800 kilograms (2 tons) of salt distributed among Beaver Dam Creek, Fox Branch, and Linda Creek. Conservatively assuming all deposited salt will run off, salt concentrations are estimated to be 0.1, 0.4, and 0.8 milligrams per liter, respectively (Section 4.2.1.4.1). These estimates compare with reported total dissolved solids	result in a significant proportion of the total work force increases associated with the two-phase repository and higher project expenditures. The impacts of these changes are addressed in Characteristic 18.

Table 5-1. Comparison of Alternative Repository Design Concepts - Richton Dome Site
(Page 4 of 11)

Repository Characteristics	Reference Design	Mission Plan[a] (Current Two-Phase Concept)	Transportation Impacts	Environmental Impacts	Socioeconomic Impacts
Salt (Continued)				for those weeks (as represented by downstream measurements) of 43.0 milligrams per liter in Thompson Creek and 32.0 milligrams per liter in Bogue Homo (Section 3.3.1.1 and Table 3-18). • Insignificant impacts on the native terrestrial ecosystems, crops, and trees. If through the life of the facility the rate of deposition or the total accumulated salt increased by 50 percent due to increased salt handling and increased exhaust ventilation shaft air flow, the values reported above for soil and runoff of streams would increase to no more than 0.3 part per million and 0.2, 0.6, and 1.2 milligrams per liter, respectively. These levels for the current concepts case are considered insignificant and would lead to insignificant impacts on native ecosystems, crops, and tree. Salt storage pile and retention pond areal dimensions do not change in the two-phase concept; the salt pile is extended higher by roughly 3 meters (10 feet) and the salt-runoff retention pond is deepened. Hence, no additional surface area is disturbed (Characteristic 8). The visual impact will be similar to that stated for the reference case. Indirect impacts of additional workers are addressed under Characteristic 18. Indirect impacts from increased traffic-induced air and noise emissions are minor and are not considered to provide significant differences in impacts.	

Table 5-1. Comparison of Alternative Repository Design Concepts - Richton Dome Site
(Page 5 of 11)

Repository Characteristics	Reference Design	Mission Plan[a] (Current Two-Phase Concept)	Transportation Impacts	Environmental Impacts	Socioeconomic Impacts
7. Nonradioactive offsite disposal requirements					
Salt (tons)	9,962,000	14,100,000	The two-phase concept will result in an increase of 42 percent in offsite salt disposal. This can be accommodated within current plans (Section 5.3.3) by increasing the number of covered hopper cars in the daily and weekly trains estimated to accommodate the reference case.	The two-phase concept will result in an increase of 42 percent in the offsite disposal requirement. Salt disposal options, especially ocean, surface (salt flat) and mine disposal, have large capacities to accept the reference or two-phase concept volumes of waste salt. For example, a Stearns Catalytic Corporation study (SCC, 1984b) cites that numerous evaporite mines were available with the capacity to accept the anticipated waste salt volumes. These options can typically accommodate more salt than is to be disposed under the two-phase concept. Transporting salt in closed hopper cars would minimize the potential for salt to be released to the environment during shipment. Because the additional salt can be disposed of with additional hopper cars on each salt train, noise and air quality impacts are expected to to be about the same.	The two-phase concept will result in an increase of 42 percent in offsite salt disposal. Because this can be accommodated within current plans, no significant differences in socioeconomic impacts are expected.
Repository-generated wastes (truck loads/year)	135	170	The increase in other repository-generated waste of 35 truck loads per year is about 1/10 truck load per day and will cause no significant transportation impacts.	Air quality impacts from NO_x, the primary emissions from diesel locomotives, are not expected to be significant because the emissions will be small. The addition of cars does not alter this conclusion. Because the Ldn 55 dBA contour is expected to remain about the same, and no sensitive receptors are expected to be within this contour, noise impacts for the two concepts are expected to be about the same.	The increase in other repository-generated waste of 35 truck loads per year (1/10 truck load per day) is not large enough to create a significant difference in the work force requirements for the repository.

Table 5-1. Comparison of Alternative Repository Design Concepts - Richton Dome Site
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Repository Characteristics	Reference Design	Mission Plan[a] (Current Two-Phase Concept)	Transportation Impacts	Environmental Impacts	Socioeconomic Impacts
Nonradioactive offsite disposal requirements (Continued)				A 26 percent increase in truck loads of repository-generated wastes exists between concepts. The estimated increase of 35 truck loads per year (1/10 truckload per day) will cause negligible changes in impacts to the noise and air quality environments and negligible increased utilization of a disposal facility.	
8. Total area required					
Surface facilities (acres)	407[c]	407[c]	Impacts of increases in underground development acreage of 34 percent affect transportation only in terms of increased salt disposal and work force. The impacts associated with these increases are addressed in Characteristics 7 and 18.	No significant difference in impacts is expected because surface land areas are the same for the two concepts and the impacts attributable to the increased underground area relate to gassy mine conditions and increased salt considerations discussed in Characteristics 4 and 6.	The increase of 34 percent in the underground development acreage will require a larger work force. The effects of additional two-phase repository work force requirements are addressed in Characteristic 18.
Underground development (acres)	2,020	2,710			
Access and utility corridors (acres)	470	470			
Land control rights (acres)	5,489	5,489			
9. Repository duration - years					
(1) Construction period (years)	6.5	4.5[d,e]	The more concentrated construction period will favorably reduce the time period over which worker-, equipment-, and supplies-traffic have to be accommodated in the local transportation infrastructure. However this is somewhat offset by the increased worker traffic volume during the shorter period. The same applies to equipment and supplies. On balance, the impacts of increased traffic volume resulting from the more concentrated construction period can be accommodated even though additional improvements and	As indicated in footnote "e," the construction period for the two-phase concept overlaps with operations and thus extends 7.5 years. The schedule influences air and noise emission rates. Major schedule differences include: 1) overlapping freeze plant and batch plant operations with site preparation and 2) delaying the start of the waste, exhaust, and service shafts by 6 months. Schedule adjustments. such as the slowing of site preparation to extend over a 2-year period, may also be implemented to mitigate impacts. Taken	The two-phase concept will require a more concentrated construction effort in the early years and therefore contributes to a higher peak work force. The estimated differences in peak work force requirements between the reference and two-phase concepts are presented and the incremental impacts are discussed in Characteristic 18.
(2) Operational period (years)	50 (26 emplacement, 24 caretaker)	50 (25 emplacement, 25 caretaker)			
(3) Decommissioning period[f]	5	5			

Table 5-1. Comparison of Alternative Repository Design Concepts - Richton Dome Site
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Repository Characteristics	Reference Design	Mission Plan[a] (Current Two-Phase Concept)	Transportation Impacts	Environmental Impacts	Socioeconomic Impacts
Repository duration - years (Continued)			traffic controls may be required on local roads as discussed in Section 5.3.3.	together, these schedule changes have the effect of achieving a more uniform distribution of emissions over the construction period for the two-phase case. Shortening the shaft construction schedule by one-half year will cause activities beyond 12 months into the schedule to be more intensive. Because NO_x emissions from shaft sinking for the reference case are projected to be below NAAQS, it is expected that this intensification will not result in exceedences of NAAQS. Emissions from increased traffic are discussed under Characteristic 6. The above factors form the basis on which the impact differences are judged not to be significant.	
10. Total repository capacity (MTHM)	36,000 SF (47.7%) 36,000 CHLW (47.7%) 3,510 DHLW (4.6%)	62,000 SF (88.6%) 8,000 HLW[g] (11.4%)	The change in waste mix and loading will result in a slight decrease in waste shipments to the repository but an increase in worker traffic and salt disposal transportation. The impacts of these increases are addressed in Characteristics 7 and 18.	Differences between concepts in impacts attributable to repository waste loading and waste mix are reflected in differing salt volumes and shipment amounts discussed in Characteristics 6, 7, and 18.	The change in waste mix and loading will contribute to increased work force requirements based on the need to expand the size of the underground area. The effects of the additional work force associated with the two-phase repository are addressed in Characteristic 18.
11. Approximate waste receipt rate planned (MTHM/year)	2,050 (initial) 3,250 (max)	400 (initial) 3,400 (max)	Although initial waste receipt rates are much lower for the two-phase concept, over the long term waste receipt rates are similar. The maximum receipt rate variation between the two concepts (approximately 5%) is less than variations already anticipated in fleet operations due to other causes. No significant impact differences are expected.	Although initial waste receipt rates are much lower for the two-phase concept, over the long term waste receipt rates are similar. Therefore, no significant differences in environmental impacts between the concepts are expected.	Although initial waste receipt rates are much lower for the two-phase concept, over the long term waste receipt rates are similar. The differences between the concepts have little effect on the total number of repository workers required. Therefore, no significant differences in impacts are projected.

Table 5-1. Comparison of Alternative Repository Design Concepts - Richton Dome Site
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	Repository Characteristics	Reference Design	Mission Plan[a] (Current Two-Phase Concept)	Transportation Impacts	Environmental Impacts	Socioeconomic Impacts
12.	Emplacement configuration	Vertical	Vertical[h]	No differences in impacts are expected because design parameters are the same.	No differences in impacts are expected because design parameters are the same.	No differences in impacts are expected because design parameters are the same.
13.	Number of waste handling buildings on site	One	Two	Two waste handling buildings will require more workers, equipment, and supplies, resulting in a slight increase in auto and truck traffic. However based on current estimates (see Section 5.3.3) the additional traffic can be accommodated by the existing network with no further improvements.	The requirement for an additional waste handling building is not expected to create any significant differences in impacts to the aesthetic values of the area due to its relatively low profile. Construction and operational impacts of the second waste handling building are part of the overall construction and operations schedules. The impact discussion of schedule differences is presented in Characteristic 9.	The requirement for two waste handling buildings in the two-phase concept results in increasing the size of the work force. The effects of the additional work force associated with the two-phase concept are addressed in Characteristic 18.
14.	Highest structure on site (by name)-feet (height)	Service shaft headframe - 265	Service shaft headframe - 265	No differences in impacts are expected because design parameters are the same.	No differences in impacts are expected because design parameters are the same.	No differences in impacts are expected because design parameters are the same.
15.	Utilities, consumption			Offsite transportation is not impacted by utility requirements.	No difference in electrical utility access is expected because the larger electrical load can be handled within the utility corridor plans of the reference case. Noise impact differences from additional or slightly larger ventilation equipment (which use more electricity) are expected to be negligible as discussed in Characteristic 4.	The design changes are not large enough to create a significant difference in socioeconomic impacts.
	Electricity, diversified load - kVA	35,900	39,100			
	Natural gas - cubic feet per day	2,400,000	2,400,000			
	Water, construction, gallons[i]	140,000,000	140,000,000			
	operation, gallons[j]	2,450,000,000	2,430,000,000			
16.	Repository wastes generated on site			An increase in the amount of underground storage needed for more onsite-generated radioactive waste containers for the two-phase concept will account for approximately 2 percent of the total increase	An increase in the amount of underground storage needed for more onsite-generated radioactive waste containers for the two-phase concept will account for approximately 2 percent of the total increase	An increase in the amount of underground storage needed for more onsite-generated radioactive waste containers for the two-phase concept will account for approximately 2 percent of the total increase
	Radioactive - canisters	2,706	4,660			
	drums	18,392	31,250			
	Non-radioactive - cubic yards per year	4,000	5,000			

Table 5-1. Comparison of Alternative Repository Design Concepts - Richton Dome Site
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Repository Characteristics	Reference Design	Mission Plan[a] (Current Two-Phase Concept)	Transportation Impacts	Environmental Impacts	Socioeconomic Impacts
Repository wastes generated on site (Continued)			in the amount of excavated salt estimated to be required for the two-phase concept. This will contribute slightly to the larger work force and greater offsite salt disposal addressed in Characteristics 18. The increase in non-radioactive waste disposal is addressed in Characteristic 7.	in the amount of excavated salt estimated to be required for the two-phase concept. These impacts are discussed in Characteristics 6, 7, and 8. No significant differences in impacts from the 25 percent increase in non-radioactive waste volume are expected because the increase can be accommodated by additional space in a licensed facility or in additional facilities.	in the amount of excavated salt estimated to be required for the two-phase concept. This will contribute slightly to the larger work force which is addressed in Characteristic 18. The increase in non-radioactive waste is not large enough to create a significant difference in the work force requirements for the repository.
17. Retention ponds, total area-acres	38.3	38.3	No differences in impacts are expected because design parameters are the same.	No differences in impacts are expected because design parameters are the same.	No differences in impacts are expected because design parameters are the same.
18. Repository personnel requirements, number of people - construction (peak)	1,511	1,949(k)	The increase in workers of 29 percent during construction and 24 percent during operations will result in proportional increases in worker auto traffic on local roads. This may require additional road improvements and traffic controls. However, based on current estimates (see Section 5.3.3) the additional traffic can be accommodated by the existing network with improvements discussed in Section 5.3.3.	Because total water use is assumed to be roughly the same, and because additional commuter vehicles will contribute only slightly to increased noise levels and air pollution along roads to the site, no significant differences in impacts are projected.	Higher work force requirements for peak construction will increase by 29 percent and will occur in a shorter time frame. This will result in an increased amount of in-migration to the region, although measures such as increased local hiring for project jobs and job training will reduce the increase in the number of in-migrating workers expected. Demands for housing and community services will increase in communities receiving new residents. Smaller communities may experience a slight increase in social problems. Consequently, government expenditures for services and planning will increase. Increases in tax revenues from property taxes, sales taxes, and user fees should help meet local govern-
operation (average)	1,000	1,240			
decommissioning (average)	820	1,060			

Table 5-1. Comparison of Alternative Repository Design Concepts - Richton Dome Site
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Repository Characteristics	Reference Design	Mission Plan[a] (Current Two-Phase Concept)	Transportation Impacts	Environmental Impacts	Socioeconomic Impacts
Repository personnel requirements, (Continued)					ment's revenue needs. In addition, project expenditures by workers and their families will increase in the region. Additional local employment opportunities will be created through the additional project jobs and indirect jobs. The Nuclear Waste Policy Act of 1982 provides for mitigation funds to the states affected by a repository development.
19. Access options, length					
Railroad - miles	26	26	No differences in impacts are expected because design parameters are the same.	No differences in impacts are expected because design parameters are the same.	No differences in impacts are expected because design parameters are the same.
Highway - miles	4	4			

(a) The repository design concept in this column assumes a requirement to meet MSHA proposed rule for gassy mines (30 CFR 57.31). The major result of this assumption is an increased underground ventilation requirement with a corresponding increase in total excavated salt, power consumption, and personnel. The Mission Plan does not specifically require that gassy mine regulations be included. Elimination of the gassy mine requirement would therefore reduce a number of parameters listed in this column. (e.g., salt quantities, power consumption, and personnel).

(b) Incorporation of exploratory shafts in the repository was not included by the design contractor during the development of the reference design concept. However, the salt project has considered exploratory shaft facility (ESF) incorporation in the past and is continuing to evaluate various ESF incorporation scenarios. No decision has been reached whether the ESF will be included or integrated into the repository.

(c) Includes Visitor Center and parking.

(d) This schedule assumes both ESF shafts, one of which is usable by the repository, are available at construction authorization.

(e) The total construction period for the phased repository is estimated to be 7½ years. Repository construction will be in two phases, which will start simultaneously. The Phase 1 construction period lasts approximately 4½ years and consists of construction, acceptance, and start-up testing of the Stage I surface facility, shafts, and underground facilities needed to accept 400 MTU per year by 1998. The Phase 2 construction continues for an additional 3 years (ending in the year 2001) and consists of the completion of all the facilities, including the Stage II waste building, needed to consolidate and accept 3,000 MTU per year. The Phase 2 construction period overlaps with the beginning of the Operations Period, which starts in 1998. The underground excavation will continue well into the Operations Period as required to accommodate waste emplacement schedules.

(f) Approximate value.

(g) Includes DHLW and West Valley CHLW.

Table 5-1. Comparison of Alternative Repository Design Concepts - Richton Dome Site
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Repository Characteristics	Reference Design	Mission Plan[a] (Current Two-Phase Concept)	Transportation Impacts	Environmental Impacts	Socioeconomic Impacts

(h) Horizontal emplacement is now being considered.

(i) Construction water requirements for both repository concepts are assumed to be the same because total construction person-hour and earthmoving requirements are assumed to be similar. Actual water consumption numbers would differ slightly because of differing schedule and personnel loadings between the two concepts.

(j) Operations water requirements are slightly less because the operating period is shortened by 1 year.

(k) Peak personnel for the current two-phase concept is assumed to occur in the fourth year of construction, which is the peak construction year for the reference case.

The current two-phase concept is designed to receive waste in two phases because the phased approach provides a mechanism for waste acceptance according to the Mission Plan schedule. The first phase is to be operational by January 1998 with an initial waste receipt rate of 400 metric tons of uranium (MTU) per year of spent fuel. Construction of the second phase will start concurrently with the first phase and will begin accepting spent fuel in 2001. The repository will begin to receive DHLW at a rate of 400-MTU-per-year equivalent beginning in the year 2003. (DHLW shipments may be by either truck or rail, but if by truck, would result in approximately three shipments per day for defense waste.)

The current two-phase concept assumes that the subsurface area of the repository be designed to MSHA's proposed rule for gassy metal and non metal mine requirements (30 CFR 57.31001 et seq.). The major impacts of this requirement compared with the reference design are the need for enhanced ventilation capability and a corresponding increase in subsurface excavation to handle the increased ventilation air. It should also be noted that MSHA's current gassy mine regulations (30 CFR 57.21000 et seq.) require crosscuts every 100 feet whereas the proposed rule is based on maintaining minimum air-flow standards which correspond to the amount of gas actually present in the mine.

Several factors are now being considered by the DOE in conducting repository engineering design activities. These factors may change the characteristics of the repository and will have the potential to increase or decrease the environmental impacts of repository construction and operation. These factors include (1) the density of the salt used as a backfill material, (2) the rate of closure of repository emplacement rooms due to lithostatic pressure, (3) the horizontal emplacement of waste packages, (4) the presence of gassy mine conditions, and (5) the age of the waste to the emplaced. A discussion follows that illustrates potential impacts of varying characteristics of each of these factors (when considered independently) on volumes of salt excavated, stored on site, and shipped off site for disposal. Impacts associated with the repository relate closely to these salt volumes. While other impacts would occur, e.g., those relating to changes in personnel and utilities requirements, they would be minor compared to impacts associated with the management of salt.

Backfill Density. The reference repository design assumes that backfill is emplaced at a density of 95 pounds per cubic foot, occupying 97 percent of the available volume. This assumed density was based on the "natural density" of crushed salt, i.e., the weight of crushed salt occupying one cubic foot of volume. The density of undisturbed salt (prior to mining) was assumed to be 135 pounds per cubic foot. Because of the gradual creep closure of the repository openings, not all of the excavated salt can be replaced in the repository. Increases in the backfill densities that can be achieved would reduce the salt quantities to be shipped off site.

Assuming that a conventional technology is used and that moderate compaction of backfill material is achieved, an estimate of the backfill density to be achieved is 115 pounds per cubit foot. This would result in 7.2 million tons of salt being disposed off site (a 2.8-million-ton or approximately 30 percent reduction), compared to 10.0 million tons in the reference case. In addition, the onsite salt storage pile would increase by approximately 600,000 tons (a 21 percent increase) to permit backfilling (repository closure) to take place with this increased density of backfill material.

Room Closure. In the reference design, it was assumed that the anticipated closure of the underground openings (other than the waste emplacement rooms) was 10 percent of the cross-sectional area in the 3 years. This value was based on structural stability limitations but would still allow the access of mining equipment. Waste emplacement rooms were assigned design dimensions that would accommodate 3 years of closure before instability and equipment access problems started to occur. In the reference design, 2 years are required to open a room, emplace waste in it, and close it; thus there is a 1-year conservative margin contained in the design.

Calculations that were utilized in the design based on commerical high level waste (CHLW) with areal thermal loading of 25 watts per square meter indicate a range from 5 percent to 16 percent volumetric closure in 3 years. These calculations, however, were performed for

CHLW alone and not for a 50/50 mix of spent fuel (SF) and CHLW, which would cause lower temperatures in the 3-year period because of the lower areal thermal loading used for SF. The reduced temperatures would cause lower room closure rates than those indicated. It is anticipated, therefore, that the 10 percent closure value in 3 years is realistic. It should be noted, however, that the repository depths used in these calculations are only approximate.

Uncertainities in the predictive capability of the exponential-time law (salt constitutive model) exist and, at present, the state-of-the-art in such model development does not allow a quantitative evaluation of the reliability of the model. Qualitatively, such reliability can only be estimated based on limited laboratory and in situ testing. Qualitatively, results to date indicate that calculations for preemplacement room closure would under-predict closure, whereas post-emplacement closure calculations for a 3-year period after emplacement would either be approximately correct or overpredicted. The degree of which overprediction or underprediction occur cannot be evaluated effectively at this time.

Results obtained from modeling of room closure at ambient preemplacement temperatures at the Waste Isolation Pilot Plant (WIPP) site indicate that the best calculations underestimate room closure by about a factor of three. If it is accepted that the predictive capability of the salt constitutive model seems to improve as the 75 to 100 C (167 to 212 F) range (approximate emplacement room maximum temperatures in the first 3 years) is approached, it may be assumed that predictions of closure would be a factor of three, or less, too low (since the maximum room temperature in the first 3 years lies in this approximate range). This therefore gives rise to a qualitative uncertainity of about 30 percent in 3 years. This discussion assumes that the WIPP constitutive model and the exponential-time law are not vastly different, which is the case.

A very approximate estimate of the amount of extra salt will need to be excavated to accommodate this uncertainty is therefore about 20 percent (the salt which is allowed for in the initial 10 percent closure has already been included in the initial excavation quantities estimate). The additional amount of salt that may need to be excavated is therefore about 4.6 millon tons.

Overall, it is difficult to make any firm statements about the amount of salt that may need to be excavated to maintain stability and access to the emplacement rooms and passageways. The numbers presented are esitimates based on limited data. It should further be recognized that a significant amount of judgement has been used to interpret these data.

Horizontal Emplacement. In the reference design the vertical mode of waste package emplacement is the assumed method of storing high-level waste in the subsurface facilities of the repository. The horizontal mode of waste package emplacement is also being considered as a method for storing the high-level waste in the subsurface facilities. The waste package, instead of being emplaced in the floor of the storage rooms, would be placed in the pillars of the storaged rooms.

This emplacement configuration changes the storage room size and provides a reduction in the cross-sectional area of the storage room by about 20 percent. The reduction in the size of the storage room results in an overall excavated tonnage reduction of 2.1 million tons, a reduction of the surface salt stock pile of 0.3 million tons, and a reduction of salt shipped off site by 0.9 million tons, compared to the reference design.

The selection of the mode of waste package emplacement will be established in subsequent design activities to manage environmental impacts. The studies will consist of cost tradeoff analysis and repository long-term stability analysis.

Gassy Mines. Gassy conditions were not assumed in the reference design, and, based on the borehole datad available, the presence of gas is not expected in any significant quantities. Recently, the DOE has directed that gassy mines be considered in future repository design efforts. Assuming that the repository subsurface is designed to gassy mine criteria (Mine Safety and Health Administration's [MSHA] proposed rule for gassy mines,

30 CFR 57.31), there are substantial changes to the number of underground openings due primarily to increased ventilation requirements. Based on the reasonable assumption that the proposed rule (30 CFR 57.31) will become effective, incorporation of gassy mine regulations to the reference case would increase the total salt quantities excavated by about 21 percent (5.0 million tons). Offsite disposal would increase by 3.1 million tons.

Waste Age/Waste Loading. Waste age for the reference repository design has been assumed to be 10 years. This is a conservatively low estimate of the expected average age of the waste, and future design activity will refine this estimate. The range of the age of spent fuel that will arrive at the repository will vary, depending on the growth of nuclear power demand, and is from 5 to about 40 years. The average age of the waste received over the life of the repository is likely to be no less than 15 years, with older waste emplaced initially, which is the current emplacement plan. Thus, 15 years average waste age is reasonable and still conservatively low. If the overall average age of the waste at emplacement is 15 years, the mass areal density at emplacement can be increased approximately 10 percent above the reference case (based on preliminary sensitivity studies). A 10 percent increase in emplacement density would lead to a total quanitity of excavated salt of about 21.2 million tons, which is 2.0 million tons or about 10 percent less than that of the reference design of 23.2 million tons. Offsite disposal would be reduced by about 0.75 million tons. Specific emplacement strategies could affect this conclusion, e.g., a strategy of emplacing oldest waste first would lead to older average ages of emplaced waste. Conversely, a strategy of minimizing handling of waste would lead to younger average ages at emplacement.

Summary. Each of the factors considered above would have impacts on the volumes of salt excavatd, stored on site, disposed off site, or backfilled into the repository compared to the reference design in Table 5-1. The presence of gassy mine conditions and accelerated room closure could cause an additional 10 million tons of salt to be excavated, whereas the use of a horizontal emplacement mode and receipt of older aged waste could cause 4 million tons less to be excavated. Changes in procedures for operation, not discussed above, would also decrease the amount of excavated salt.

The presence of gassy mine conditions and accelerated room closure could also be associated with an additional 5 million tons of salt being shipped off site for disposal, whereas the use of horizontal emplacement, receipt of older aged waste, and increased density of backfilled salt could be associated with 4.5 million tons less being shipped off site. The maximum size of the onsite salt storage pile would be affected be these considerations, with some factors causing the pile to increase by 1.5 million tons and other factors causing the pile to decrease by 0.5 million tons.

The principal environmental impact is associated with offsite disposal of salt. Taking the possible increases and decreases in offsite salt disposal together, it is therefore possible that the offsite disposal estimates could increase from 10 million tons in the reference design to 10.5 million tons, approximately a 5 percent increase over the reference design discussed in this chapter.

Of the factors considered, only the physical forces associated with room closure are beyond the capacity of the DOE to manage. Consequently, it can be concluded that with proper management, and using realistic and conservative assumptions, the impacts of future repository design concepts are approximately the same as those for the reference repository design and are contained within the impacts of the Mission Plan case discussed in Table 5-1.

Recent work by Fluor Technology, Inc. (1985) (which was a basis for the "Two-Phase Concept" presented in Table 5-26 of the draft EA) was reviewed to qualitatively reassess the impacts which may result from a repository conservatively designed in accordance with the 100-foot cross cut regulation. Because the impacts resulting from such a large repository may be significantly greater than those shown for the reference design (as discussed in the draft EA, Section 5.5) and because the 100-foot cross cut interval regulation is not in accord with the desire to minimize underground disturbance, such large repository designs are no longer being pursued by the DOE. Further, if the 100-foot cross cut regulation remains as a MSHA requirement in the future, the DOE will apply for a variance on this issue. Increasing the cross cut intervals minimize the environmental impacts and increase the underground safety.

A consideration from the 1985 Mission Plan not reflected in Table 5-1 is the impact of incorporating a Monitored Retrievable Storage (MRS) facility. The DOE is evaluating the possibility of including an MRS facility as part of the overall waste management strategy. Specifically, Section 141 of the NWPA directs the DOE to study the need for and the feasibility of an MRS facility for spent fuel and high-level waste. The DOE analyzed the provisions of the NWPA and programmatic options in the July 1985 Mission Plan (DOE, 1985, DOE/RW-0005) and is evaluating an integrated waste-management system that consists of both storage and disposal components. The primary function of the MRS is waste preparation for emplacement in a geologic repository; its role in providing temporary backup storage is secondary. Performing the waste-preparation functions (i.e., spent-fuel consolidation and packaging) in an integral MRS facility may simplify the design, construction, and operation of the repository facilities. By providing a processing and storage capacity between waste acceptance from the utilities and emplacement in a repository, the MRS would help maintain better and more consistent control over the transfer of waste from reactor to repository. An integral MRS facility would also provide a central location for the management of spent-fuel transportation, cask-fleet operations, and cask-fleet servicing. Qualitatively, the socioeconomic and environmental impacts discussed in this EA should encompass those impacts for a repository design coupled with an MRS, if Congress authorizes an MRS facility.

The NWPA directs the DOE to submit to Congress a proposal that establishes a program for the siting, construction, and operation of MRS facilities. To provide a technical basis for the congressional decision, the following documents would be included in, or would accompany, the proposal to Congress: (1) site-specific facility designs, (2) need and feasibility report, (3) program plan (funding, integration, deployment), and (4) environmental assessment. Because facilities and activities at the repository site would be less in an integrated MRS/Repository System, since waste consolidation would be accomplished at the MRS site, the nonradiological environmental impacts discussed in this EA should encompass those for a repository design coupled with the MRS, if Congress authorizes the MRS facility.

The DOE has not yet conducted studies to assess the impact of accommodating the potential amount of 5-year-old waste which might be received by a repository. Therefore Table 5-1 does not fully reflect this consideration. The "Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste" (10 CFR Part 961) establishes the contractual terms and conditions under which the DOE will make available nuclear waste disposal service to the owners and generators of spent nuclear fuel and high-level radioactive waste as provided in Section 302 of the NWPA. The contract designates spent fuel aged as little as 5 years out of the reactor as "standard spent fuel." The Standard Contract (10 CFR Part 961) and the Mission Plan (DOE, 1985, DOE/RW-0005) both specify that the DOE will accept fuel for disposal on an "oldest first" basis. Therefore, for the most of the first repository receiving and emplacement period, the average age will be greater than 10 years with an estimated 5 percent to 10 percent aged as little as 5 years. The EA reference design (SCC, 1984a) is based on receipt of 10-year-old fuel. At this point, the DOE believes that the incremental impacts of a repository designed to accommodate the requirement to accept 5-year-old fuel should be minor. Appendix A of this EA presents general background information on transportation topics and issues. Qualitatively, the environmental impacts discussed in the EA will encompass those involving transportation coupled with the MRS, if Congress authorizes an MRS facility. The MRS transportation analysis is also found in Appendix A. Appendix A of this EA presents general background information on transportation topics and issues. Qualitatively, the nonradiological environmental impacts discussed in the EA will encompass those involving transportation coupled with the MRS, if Congress authorizes an MRS facility. The MRS transportation analysis is found in Appendix A. It should be noted that the MRS impacts are not addressed in Table 5-1.

Table 5-1, in presenting a comparison of the current two-phase concept with the Chapter 5 reference repository and with the limitations noted above, provides a reasonable representation of the range of impacts expected from repository designs in salt. Table 5-1, however, was not intended to provide a limiting analysis for design and impacts.

In summary, the DOE believes that the environmental, socioeconomics, and transportation impacts for the reference design concept are within reasonable limits or are mitigable.

Similarly, the current two-phase concept also has impacts that are comparable to the reference case and are mitigable. The DOE believes, therefore, that the conclusions reached on the guideline findings in EA Chapter 6 would not change due to variations in the repository design concepts analyzed.

5.1.1 General Description

An operating nuclear waste repository consists of surface and subsurface facilities licensed by the U.S. Nuclear Regulatory Commission (NRC) for the permanent, deep geologic disposal of nuclear waste. The repository is to be a fully integrated facility for the receipt and long-term geologic disposal of nuclear waste, designed to handle, package, and dispose of spent fuel (SF), commercial high-level waste (CHLW) from reprocessing of spent fuel, transuranic (TRU) waste, defense high-level waste (DHLW), and low-level wastes generated on the repository site. The reference repository facility concept is depicted in Figure 5-1; major project characteristics are listed in Table 5-1. The current estimate of personnel requirements per year is listed in Table 5-2. The DOE intends to seek and obtain all applicable Federal, State, and local permits and approvals necessary for the construction and operation of the repository. A license from the Nuclear Regulatory Commission is also required.

5.1.1.1 Repository Site Layout

Repository surface facilities will comprise four major components:

- Waste-handling building
- Mine support facilities (head frames, salt storage pile, ventilation exhaust, and supply buildings
- Administration and support buildings
- Utilities and utility support facilities (steam plant and tank farms).

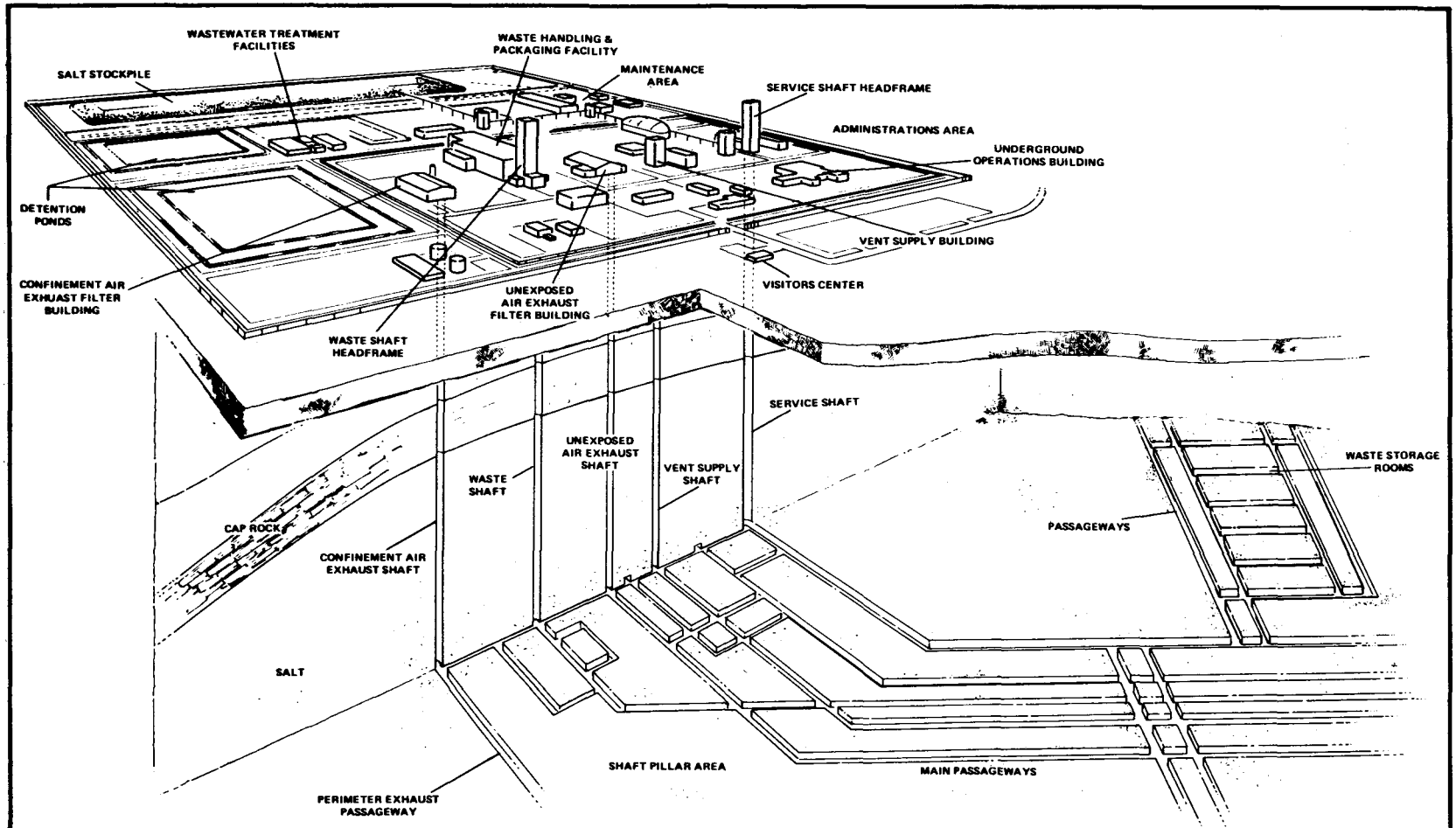
These surface components will be located on approximately 165 hectares (407 acres) of land, exclusive of corridors (i.e., road, rail, and utilities) discussed in Section 5.3.2. The underground facilities will extend beyond the surface facility; therefore, a controlled area will be established. Future subsurface activities such as drilling or mining may be prohibited within this area, but various controlled surface uses will be permitted.

The controlled area will be determined explicitly during site characterization; definition of its extent will be based on ability to comply with 10 CFR Part 60, 40 CFR Part 191, and 10 CFR Part 960. The minimum controlled area for Richton Dome site was determined by adding a buffer zone around the area required for the underground repository. The buffer zone extends out to the controlled area perimeter and allows for protection from radionuclide release. Figure 5-2 presents the controlled area for the Richton Dome site.

Road and rail access to the site will be designed and constructed to support the expected shipments of personnel, material, and waste. Acquired offsite utilities, such as electrical and natural gas, will run to tie-in points to service the repository.

During construction, topsoil will be removed and used for onsite landscaping or stockpiled for future restoration. During construction and operation, excavated salt will be stockpiled in a designated storage area designed to minimize runoff.

Estimated surface drainage and wind conditions were also considered in the layout of the surface facilities, including the wastewater ponds. Nonradioactive liquid wastes will be shunted to a treated wastewater storage pond. A salt runoff pond sized for a greater than 100-year, 24-hour precipitation event will collect runoff from the salt pile. Storm-water detention ponds will have sufficient capacity to hold rainfall runoff. All these ponds will be designed to minimize water seepage into the ground. Also, all wastewater will be recycled to the maximum extent possible.



Nuclear Waste Repository Facility Concept

Source: Adapted from SCC, 1984a.

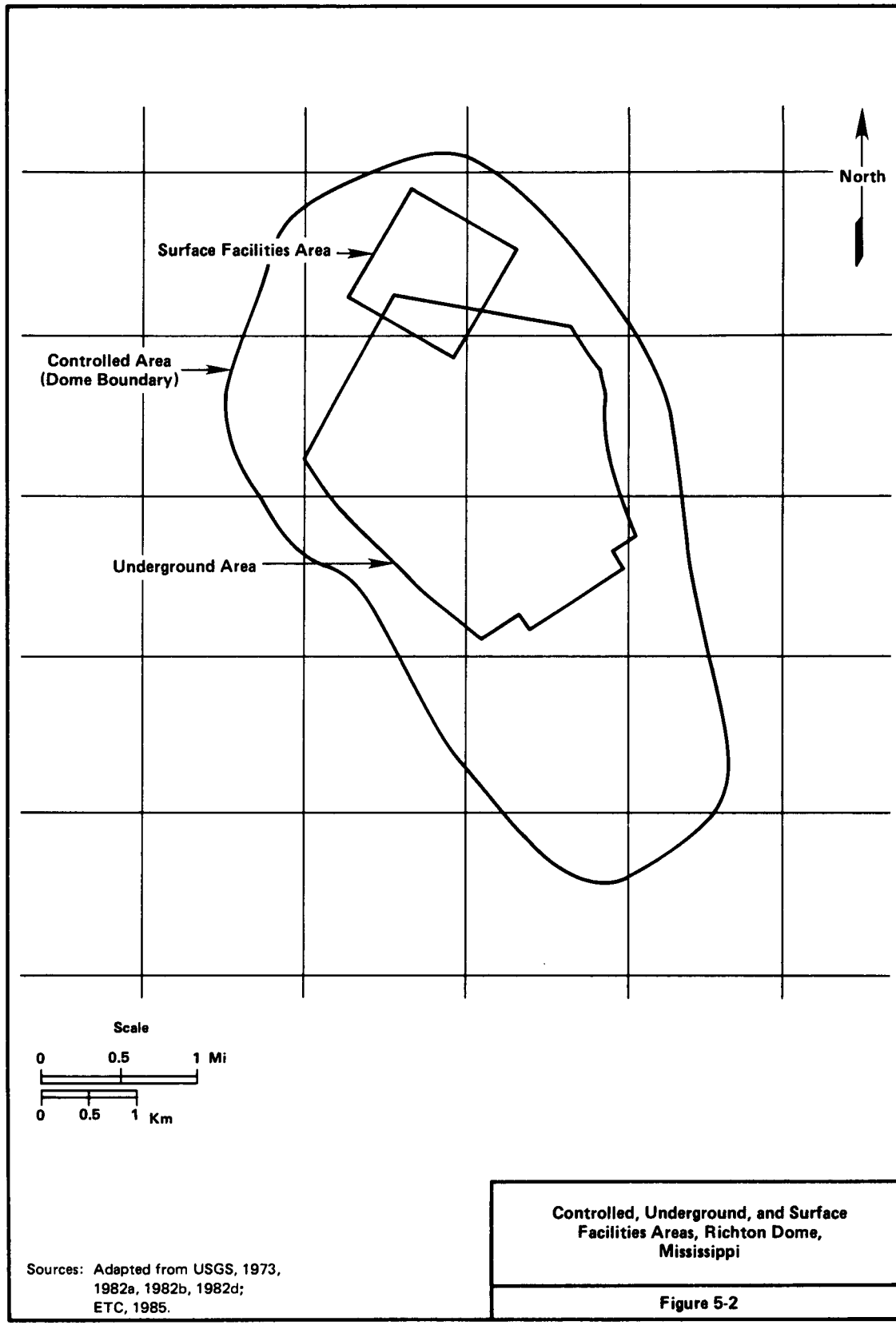
Figure 5-1

Table 5-2. Repository Personnel Requirements[a], Richton Dome

Years Into Project	Construction	Operation	Caretaker	Decommissioning
1	589			
2	977			
3	1130			
4	1428[b]			
5	1357			
6	1308			
7	617			
7-32		1000		
32-56			230	
56-61				820

(a) SCC, 1984a; Eschen, 1985.

(b) The peak of 1,511 personnel is expected to be reached in this year.



Sources: Adapted from USGS, 1973, 1982a, 1982b, 1982d; ETC, 1985.

Controlled, Underground, and Surface Facilities Areas, Richton Dome, Mississippi

Figure 5-2

All disturbed areas not paved, graveled, or otherwise covered will be landscaped. Buildings and other structures will be painted to minimize their contrast with the surrounding environment.

A perimeter fence will enclose the entire surface facility with the exception of the visitor center and parking lot. An inner security fence will surround the radiological operations area including the shafts, receiving and packaging facility, and other waste-related support facilities.

5.1.1.2 Waste Receiving, Handling, and Packaging Facilities

The repository surface-waste receiving, handling, and packaging facilities are designed to receive, handle, and package nuclear waste arriving at the repository and to transfer the packaged waste to the repository subsurface.

The waste handling and packaging facility (WHPF) (see Figure 5-3) is the largest building on the repository site. The building will be located adjacent to the waste shaft headframe and will be accessible by both road and rail.

The WHPF (Figures 5-3 and 5-4) provides for washing down contaminated shipping casks if required, unloading the cask from the transport vehicle, removing the waste from the shipping casks, inspecting and recording identification of waste forms, temporary storing of waste forms and waste packages, packaging of the waste forms, closure welding of the waste packages, inspecting of the completed waste packages, and transferring the waste packages in a transfer cask to the waste shaft.

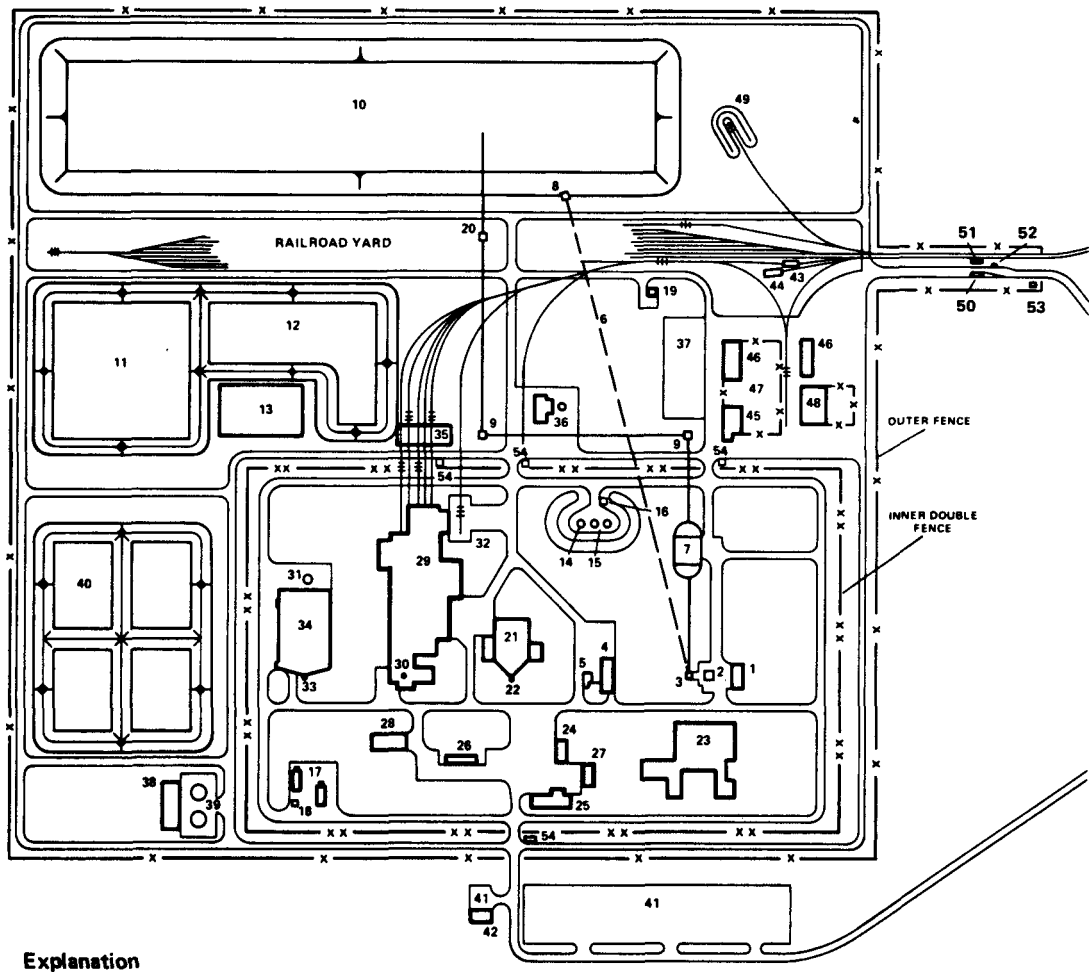
The functions required to receive the shipping casks from the transport vehicles (i.e., rail and truck), and to prepare the waste form for underground emplacement, up to and including the transfer to the waste shaft hoist, will be performed within the confines of the WHPF. The overall functional-flow schematic diagram for the WHPF is shown in Figure 5-5.

Waste handling activities will begin with the receipt of the transport vehicle from the cask contamination survey station. As necessary, the casks will be reinspected and contaminated casks will be washed down in a separate decontamination wash bay. Casks will then be unloaded from the transport vehicle and positioned for removing their radioactive waste forms.

With the exception of contact-handled TRU, all waste forms will be removed from the shipping casks into the hot cell portion of the facility, where the waste forms will be inspected, sorted, and temporarily stored. Contact-handled TRU is not highly radioactive and will be handled outside the hot cells. It will be unloaded, inspected, and placed on pallets before being transferred to the waste hoist.

The functions performed within the hot cell depend upon the waste type. Spent fuel assemblies will be disassembled and spent fuel pins repackaged. These packages and canisters of CHLW and DHLW will be placed in containers. Typically, remote-handled TRU will be inspected and passed through the hot cell without repackaging. However, if any remote handled TRU canisters are found to be externally contaminated, they will be cleaned or enclosed in containers to provide a contamination-free exterior. These waste packages will be passed out of the hot cell area via transfer casks used to move the waste packages to and down the waste hoist and through the underground workings to the emplacement area.

The WHPF will have several support areas not directly involved in the handling of radioactive waste. Most significant of these in size and importance will be the heating, ventilating, and air conditioning (HVAC) systems constituting the major engineered safety feature system for the containment of the radioactive materials. The largest system is the hot cell HVAC "once-through" system, which will move air through the hot cells and then through



Explanation

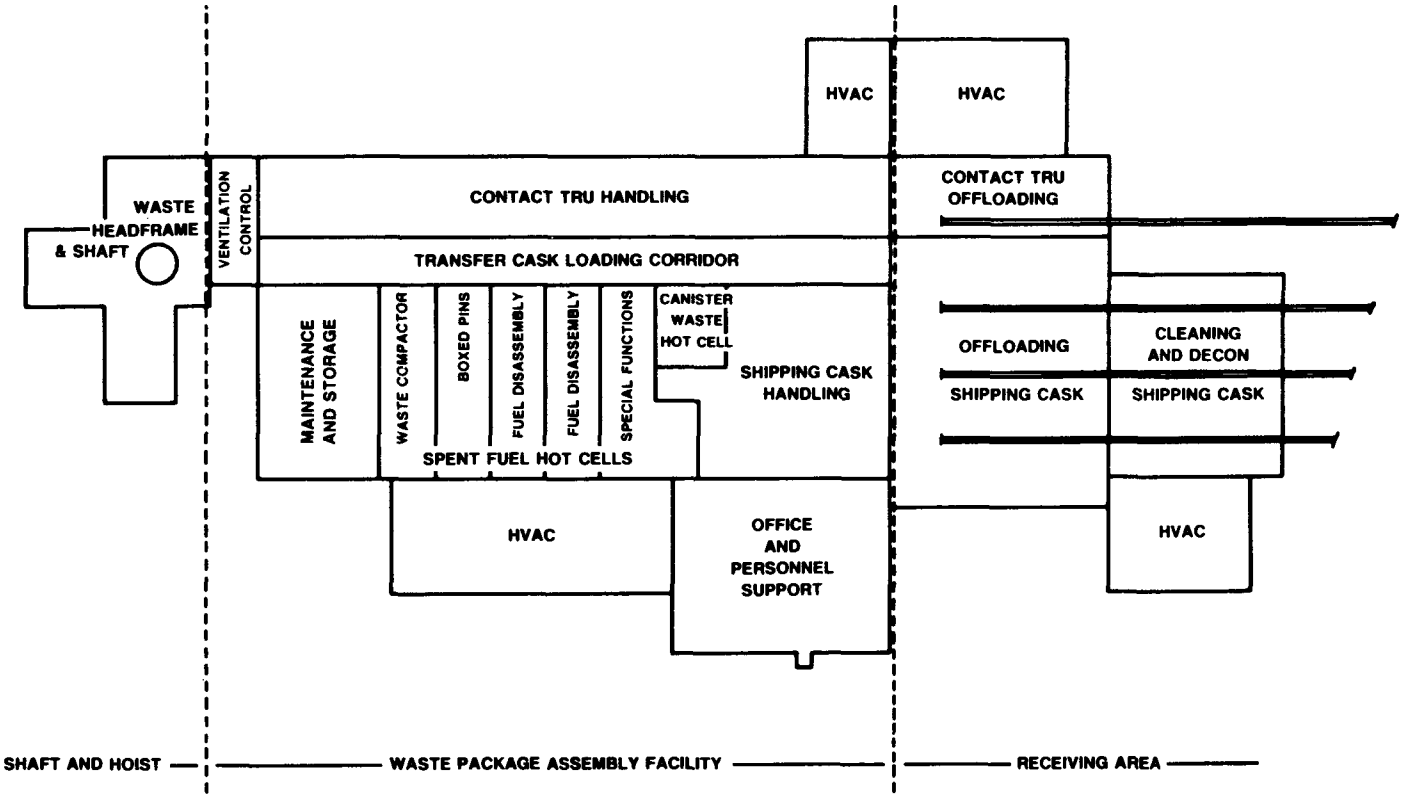
1 Service sheft filter building
2 Service shaft
3 Transfer tower
4 Ventilation supply filter building
5 Ventilation supply shaft
6 Reclaim tunnel
7 Live storage & surge building
8 Reclaim hopper
9 Salt transfer tower
10 Salt stockpile
11 Salt runoff pond
12 Treated wastewater holding pond
13 Wastewater treatment facilities
14 Potable water tank
15 Fire water storage tanks
16 Fire/potable water pumphouse
17 Cooling towers
18 Chemical feed building
19 Railroad control tower
20 Salt loadout structure
21 Unexposed air exhaust filter building
22 Unexposed air exhaust shaft
23 Underground operations building
24 Firehouse, security & medical treatment center
25 Administration & operation control center
26 Electric power building
27 Environmental & instrument laboratory
28 Compressor chiller building
29 Waste handling & packaging facility
30 Waste shaft
31 Confinement exhaust stack
32 Storage yard
33 Confinement air exhaust shaft
34 Confinement air exhaust filter building
35 Noncontaminated railcar/truck washdown area
36 Steam plant
37 Abandoned material & equipment storage yard
38 Raw-water treatment
39 Raw-water storage tanks
40 Storm-water detention ponds
41 Parking lot
42 Visitors center
43 Railroad inspection pit
44 Railroad maintenance building
45 Maintenance building
46 Storage shed
47 Storage yard
48 Warehouse
49 Suspect railcar/truck storage area
50 Truck inspection pit
51 Railcar inspection pit
52 Monitoring station
53 Guardhouse

Scale
0 500 1000 Feet
0 150 300 Meters

Repository Site Layout Plan
Richton Dome

Source: Adapted from SCC, 1984a.

Figure 5-3



Scale

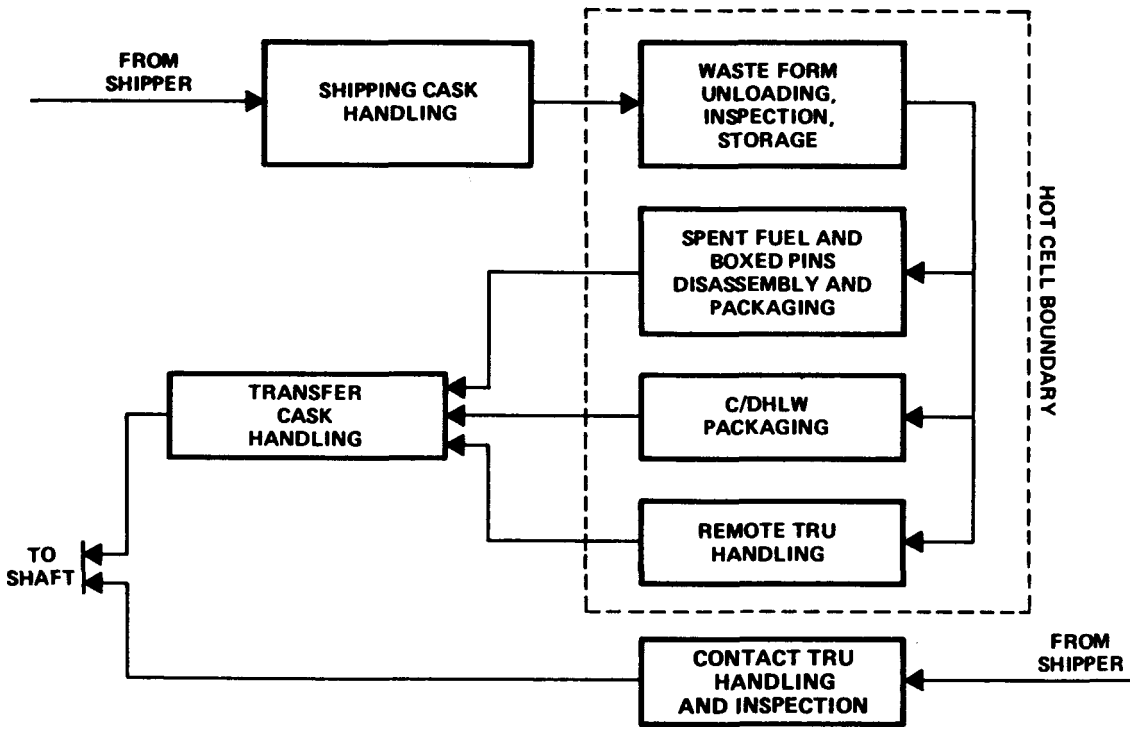
0 40 80 120 Feet

0 10 20 30 Meters

Waste Handling and Packaging
Facility Layout
Richton Dome

Figure 5-4

Source: Adapted from SCC, 1984a.



Waste Handling and Packaging Facility Overall Functional Schematic Richton Dome

Source: SCC, 1984a.

Figure 5-5

60-percent and 90-percent prefilters and double high-efficiency particulate air (HEPA) filters in series, and charcoal absorbers. The system will have 100-percent flow and filtering redundancy. Separate ventilation systems similar to the hot cell HVAC system will be provided for other major functional areas such as the shipping cask handling area, the personnel area, and the contact-TRU handling area.

5.1.1.3 Repository Shafts

Repository shafts will provide the means of ingress and egress of personnel, transport of materials and nuclear waste packages, and ventilation of the underground workings of the repository. The reference design in Table 5-1 (SCC, 1984a) proposes five shafts which will serve the requirements of the repository:

- Waste shaft - transport of waste containers from surface to subsurface
- Service shaft - transport of personnel, equipment, material, salt, supply air, and utility lines
- Ventilation supply shaft - supply air, utility lines, and emergency egress
- Unexposed air exhaust shaft - exhaust air from the subsurface development area, utility access
- Confinement air exhaust shaft - Exhaust air from the waste emplacement area.

All shafts will be circular in cross section and range in size from 6.4 to 9.4 meters (21 feet to 31 feet) finished inside diameter. The depths of the shafts into the repository horizon will vary from the repository level to some distance below the repository to accommodate the excavated salt hoist skips in a loading position, salt spillage storage area, and hoist equipment. The service shaft headframe will be 80.7 meters (265 feet) high. The DOE will comply with regulation 14 CFR Part 77, "Objects Affecting Navigable Airspace," which requires notifying the Federal Aviation Administration of plans to construct structures of 61 meters (200 feet) or greater in height.

The shaft pillar, which encompasses all five shafts, is an area containing little excavation and no emplaced nuclear waste. It will be offset or placed to one side of the underground facilities. This shaft pillar offset will isolate the shafts and main surface facilities from any potential effects of subsidence or uplift over the storage room panels.

The shaft liner designs and installation will take into account the site-specific stratigraphy and major aquifers, with seals installed to isolate the aquifers from the waste storage level and from each other. The design and construction of the shafts and liners will take into account the eventual decommissioning of the repository.

The waste shaft, service shaft, and ventilation supply shaft will be equipped with hoisting systems. The ventilation exhaust shafts will not have hoisting facilities.

The repository ventilation system will use the shafts to provide ventilation air to the underground facility. The ventilation system will provide air flow throughout the repository to service the two underground functions of mine development and waste emplacement operations. Exhaust ventilation air from the mine development operations will be kept separate from air exhausting from waste emplacement activities.

5.1.1.4 Repository Subsurface Facilities

The repository subsurface will consist of the excavated rooms for waste emplacement, branch and main passageways for transporting the mined salt and waste packages, and corridors for ventilation. Additional areas will be excavated for equipment maintenance, parts and materials storage, operations control and monitoring, first-aid and emergency systems, and other miscellaneous facilities normally associated with underground operations.

Figure 5-6 is a simplified layout of the repository subsurface area showing a completed repository development at the end of operations. There will be five horizontal main passageways driven down the approximate centerline of the repository storage room area:

- A path for fresh air to both the development areas and emplacement areas
- An exhaust air path from the development areas
- A corridor for waste transport
- An access to both development areas and emplacement areas for personnel and equipment
- A corridor for mined salt transport.

The cross section of the passageways will be rectangular with major dimensions of approximately 9 meters wide by 5 meters high (30 feet wide by 15 feet high). There will be a total of 13,500 meters (44,300 feet) of drifts in the main passageways and 5,580 meters (18,300 feet) of drifts in the shaft pillar zone.

The waste storage areas of the repository will consist of branch passageways, exhaust branch passageways, and 28 panels of storage rooms. The branch passageways will provide access to the individual storage rooms and will be interconnected by cross cuts. During the excavation of storage rooms, the passageways will provide a path for intake and exhaust air. During emplacement operations, the branch passageways will be used to transport waste to the individual rooms and provide fresh air. The exhaust passageways will be connected to the exhaust end of the storage rooms and to the perimeter exhaust passageways. These passageways in conjunction with the perimeter exhaust passageways will provide a completely isolated path for confining of exhaust air.

According to the reference repository design (SCC, 1984a) each waste type would be located in separate panels of the repository. The storage room quantities and related parameters are shown in Table 5-3.

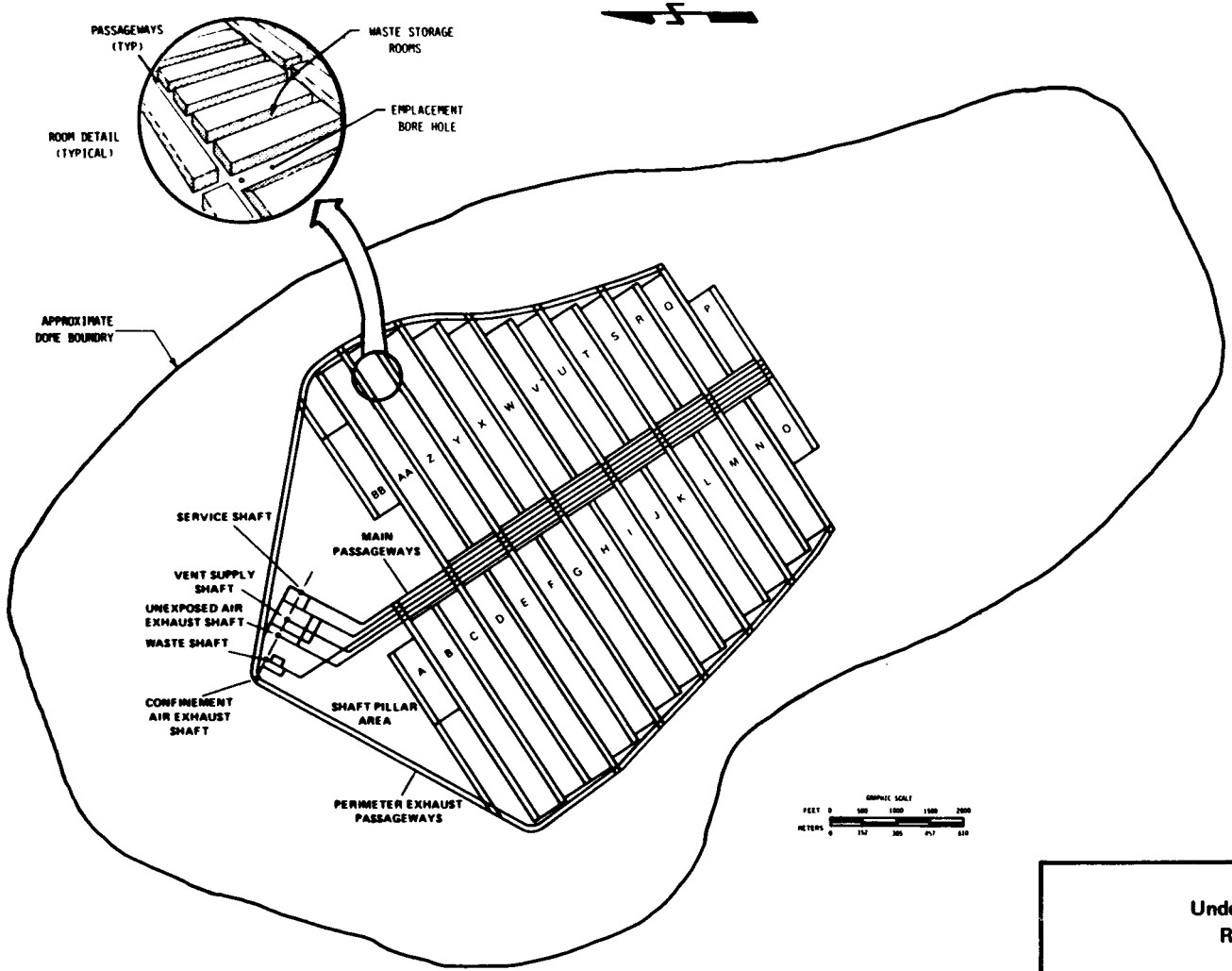
The waste package concepts for defense and commercial high-level waste and spent fuel consist of the canisterized waste form, surrounded by a steel waste package container, and, after emplacement, a packing and cover of crushed salt. This concept is described in Section 6.4.2.2.1 and as the Alternate II concept in Westinghouse Electric Corporation (1983, ONWI-438).

The defense and commercial high-level waste forms consist of high-level waste melted into borosilicate glass that is poured into thin-walled stainless steel canisters by the waste form producer. They are then shipped to the repository for assembly into the waste package container.

The spent fuel waste form consists of spent fuel rods which have been removed from several fuel assemblies and consolidated into a close-packed bundle. The bundle of spent fuel rods is surrounded by a thin-walled canister of low-carbon steel.

The waste package container is a thick-walled low-carbon steel vessel surrounding the waste form. It is designed to provide containment for the desired period when exposed to the external geologic pressure and corrosive environment.

Waste package concepts for TRU wastes are in the very early stages of development. At this time, it is anticipated that the disposal containers for both contact- and remote-handled TRU wastes will be either standard 0.24-cubic-meter (55-gallon) drums or other mild steel containers.



PANEL TABLE		
PANEL	WASTE	NO ROOMS
A	TRU	24
B	TRU	69
C	DHLW/CHLW	26/39
D	CHLW	54
E	CHLW	52
F	SF	66
G	SF	63
H	SF	62
I	SF	60
J	SF	58
K	SF	55
L	SF	53
M	SF	49
N	SF	47
O	SF	23
P	SF	24
Q	SF	37
R	SF	39
S	SF	42
T	SF	44
U	SF	48
V	SF	51
W	SF	57
X	CHLW	48
Y	CHLW	52
Z	DHLW/CHLW	25/38
AA	TRU	67
BB	TRU	26

NOTES: ALL ROOMS ARE NOT SHOWN; SEE ROOM DETAIL

Source: Sneed, 1985.

Underground Layout
Richton Dome

Figure 5-6

Table 5-3. Approximate Waste Storage Room Quantities

Waste Type	Waste Package Characteristics			
	Rows Per Room	Pitch, feet[a]	Number per Room	Total Number
Spent Fuel	1	60	9	7,899
CHLW	1	40	13	3,673
DHLW	2	7 square	138	7,020
Remote TRU	3	7 triangular	200	37,050
Contact TRU	3	N/A	480	18,406 (pallets)

(a) "Pitch" is the center-to-center spacing between adjacent waste packages.

5.1.1.5 Repository Land Acquisition

The requirements for ownership and control of interests in land for a repository are established in "Disposal of High-Level Radioactive Waste in Geologic Repositories," 10 CFR 60.121, which states:

> (a) Ownership of land. (1) Both the geologic repository operations area and the controlled area shall be located in and on lands that are either acquired lands under the jurisdiction and control of DOE, or lands permanently withdrawn and reserved for its use. (2) These lands shall be held free and clear of all encumbrances, if significant, such as: (i) rights arising under the general mining laws; (ii) easements for right-of-way; and (iii) all other rights arising under lease, right of entry, deed, patent, mortgage, appropriation, prescription, or otherwise.

The DOE is also required to exercise any jurisdiction and control over surface and subsurface estates outside of the controlled area, to prevent adverse human actions that could significantly reduce the geologic repository's ability to achieve isolation (10 CFR 60.121[b]).

The DOE currently estimates that a repository site at Richton Dome would consist of (1) a fenced area of about 165 hectares (407 acres) for support buildings and repository surface facilities, (2) the geologic repository underground operations area of about 817 hectares (2,020 acres), and (3) a controlled area extending outward from the edge of the underground facility. The total site area could be a maximum of approximately 2,221 hectares (5,489 acres). See Figure 5-2 for a schematic drawing of the controlled area. The total site land-control requirements have been estimated by conservative technical analysis (Chen and Raines, 1985). Preliminary analyses indicate that a site area of 2,221 hectares (5,489 acres) would allow all EPA and NRC repository performance requirements to be met (see Sections 6.3 and 6.4). The exact size of the controlled area will depend on the rate of ground-water flow and other site characteristics and will be established in accordance with EPA standards and NRC regulations.

For the Richton Dome site, the DOE will purchase surface and subsurface rights to the required land.

5.1.2 Repository Construction Activities

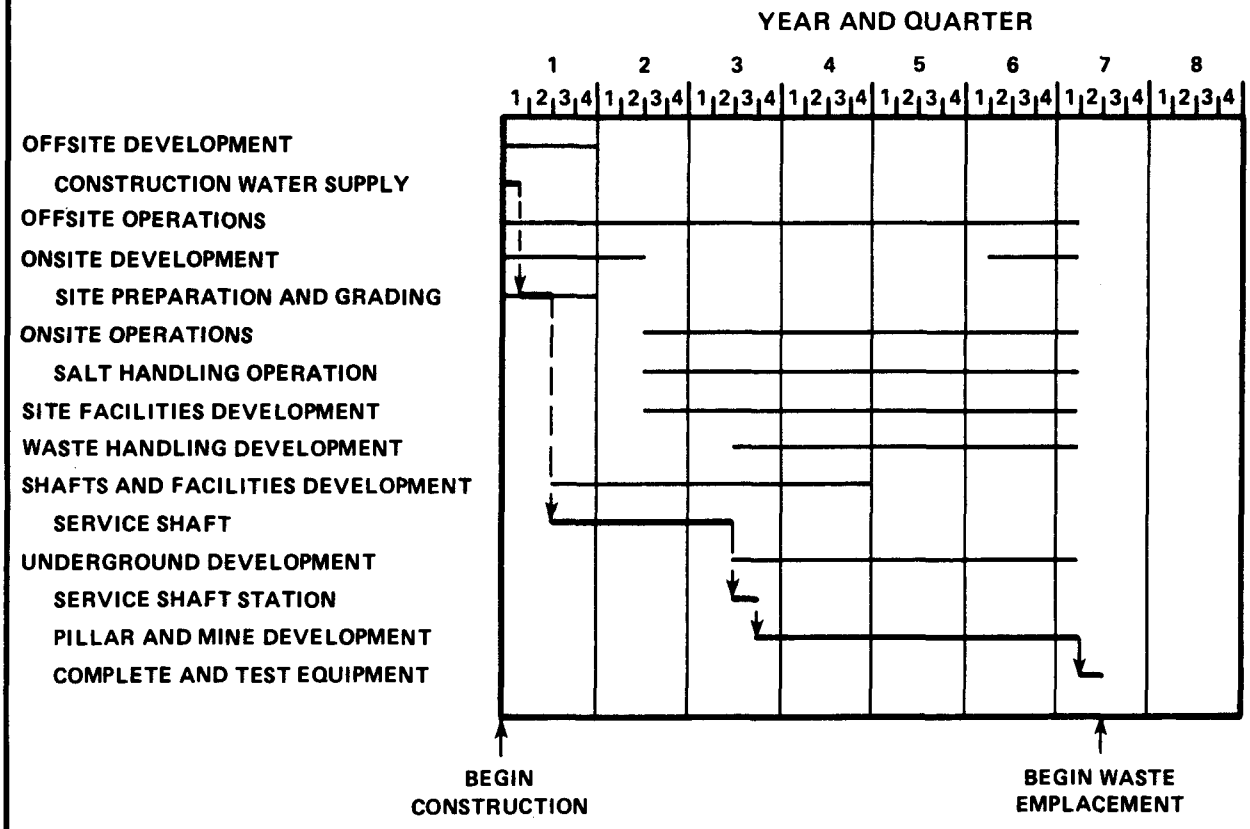
5.1.2.1 Construction Schedule and Personnel

The sequence and duration of repository construction activities are depicted in Figure 5-7. The total time estimated for construction is approximately 6.5 years, including 3 months for equipment tests. The following subsections describe the activities in detail.

The construction of the repository will begin with the development of offsite utilities and transportation access corridors and the establishment of the permanent water supply. Site preparation and grading can begin immediately, using the water supply constructed during the site characterization program. These activities will be completed in the service shaft vicinity before shaft sinking starts. The critical path phase of the development of the construction water supply, site preparation, and grading activities is estimated to require approximately 6 months.

The next critical phase will involve sinking, lining, and equipping the service shaft and stations, and will be completed before at-depth excavation begins. The shaft and shaft station construction activities are estimated to require approximately 42 months, of which 27 months are on the critical path.

Before waste emplacement operations begin, the shaft pillar and mine development will be completed to a point at which 1 year's waste receipt could be emplaced. This activity is estimated to require approximately 42 months, and is on the critical path.



Explanation

SUMMARY LEVEL CRITICAL ACTIVITY

LOGIC

ACTIVITY DURATION

CRITICAL ACTIVITY DURATION

Schedule Summary Bar Chart
Richton Dome

Source: SCC, 1984a.

Figure 5-7

Preoperations testing of emplacement equipment and ventilation systems will be completed before actual waste emplacement activities begin. This testing is estimated to require approximately 3 months.

Estimated construction personnel requirements per year are listed in Table 5-2 and Figure 5-8. The construction estimate (Table 5-2) includes personnel for the DOE, the NRC, architect-engineer, construction managers, and others.

Over 50 percent of the water projected to be required for construction at the repository site is associated with earthwork. For the purpose of estimating this water requirement, it has been assumed that all of the voids in the soil must be filled with water to achieve proper compaction. This provides a rather conservative estimate of water required and does not attempt to take credit for probable water conservation practices employed. Water required for dust suppression is considered to also be covered by this estimate. The remaining portion of water use is associated with concrete production, consumption by personnel, and minor miscellaneous uses. The scheduling of these water demands will be linked to the schedule for concrete production and to the approximate distribution of personnel at the site over time.

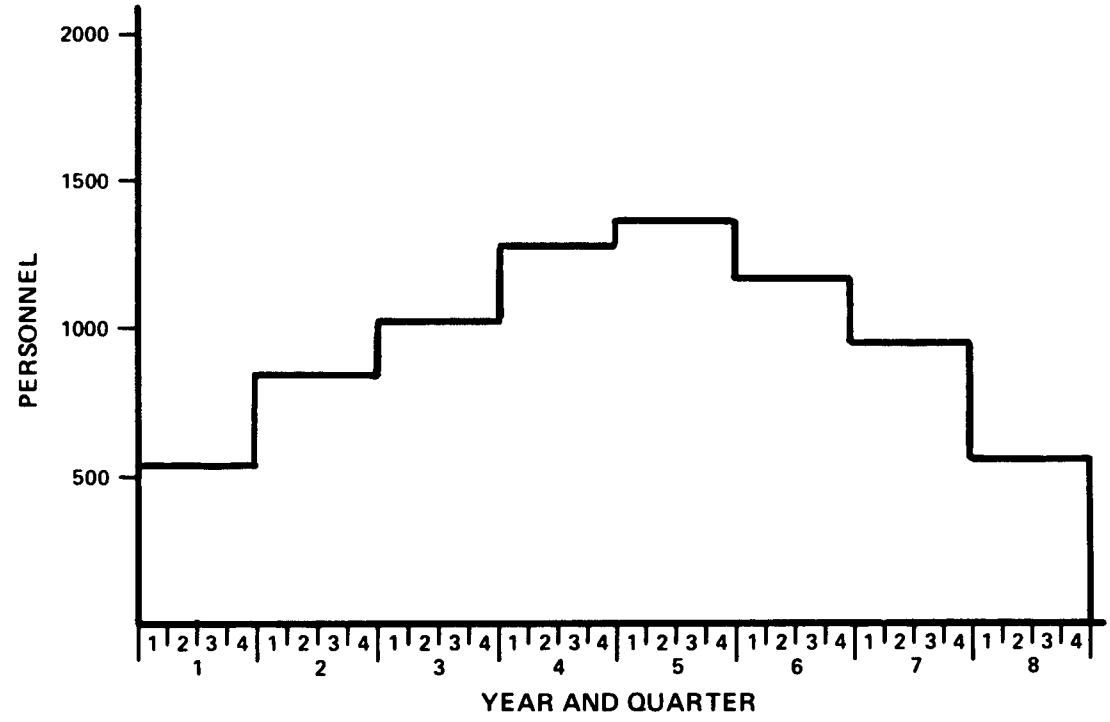
5.1.2.2 Offsite Development

Offsite development activities consist of constructing the transportation access corridors and utility supply lines from the public and commercial domain (Section 3.5) to the repository site. The selection of preferred transportation routes to the site will occur later in the siting process and will use the results of detailed investigations conducted during site characterization (Section 4.1.3.1.10). For the purposes of this environmental assessment and to fulfill the siting guideline requirements, the approach taken has been to identify alternative routes as described below. It is assumed that impacts of construction and operation of these routes will be similar to the impacts of the routes that will be finally selected as preferred. The selection process will include participation of State and local officials and the public as well as further economic and environmental impact analyses.

Based on U.S. Department of Transportation regulations, highway transport of nuclear waste must use the interstate highway system unless a state specifies a preferred alternative route. Highway access to Richton Dome could be provided by three possible routes which have been considered between I-59 and the site. These routes used one or the other of the two regional highways that pass within a few miles of the proposed repository site. One is Mississippi State Highway 42 from Hattiesburg to Richton. The other is Mississippi State Highway 15 from Laurel to Beaumont.

Because most of the waste is generated or stored north and east of the site, it is expected that most of the waste will approach the site vicinity traveling southwestward on I-59. Leaving I-59 at the Mississippi State Highway 15 interchange in Laurel and traveling southward to the vicinity of the site is one alternative. The second alternative is to continue on I-59, with a connection to Mississippi State Highway 42 to the site. The third alternative is to continue on I-59, past Hattiesburg to the U.S. 98 interchange. U.S. 98 is then taken to Beaumont and the junction with Mississippi State Highway 15. This latter highway is taken northward to Richton and the site vicinity. Of the three routes, the first was selected for the purposes of this environmental assessment because it is the most direct and it minimizes travel through Hattiesburg, the major regional population center.

At Laurel, the first kilometer (0.6 mile) of Mississippi State Highway 15 passes through a residential area. Past this area, new highway and bridge construction is in progress west of Mississippi State Highway 15. There is no evidence that new road construction will continue for more than a reasonable tie-in distance from the south end of the new bridge to existing State Highway 15. The existing road sections consist of two 3-meter (10-foot) wide



Explanation

TOTAL PROJECT

Note: Values were taken from Table 5-2.

Construction Personnel Requirements
Richton Dome

Figure 5-8

paved driving lanes and two unpaved shoulders varying in width from 1 to 2 meters (2-6 feet) centered in a 33-meter (100-foot)-wide (approximate) right-of-way. There are numerous driveways (approximately 10 per mile) along the route. The terrain is heavily vegetated and gently rolling and has isolated swampy areas. The existing highways and bridges will be upgraded as required. The new access road from Mississippi State Highway 15 will traverse heavily vegetated, gently rolling terrain. A new bridge structure will be required at Beaver Dam Creek.

To minimize traffic impacts on the town of Richton, highway access to Richton Dome will be provided from Mississippi State Highway 15 north of Richton and from Mississippi State Highway 42 west of Richton. Approximately 6 kilometers (4 miles) north of Richton, and 35 kilometers (22 miles) south of Laurel, a new 6.4-kilometer (4-mile)-long access highway will be constructed from Mississippi State Highway 15 westward to the candidate site. An existing county road, approximately 1.6 kilometers (1 mile) west of Richton, will provide access northward from Mississippi State Highway 42. Two kilometers (1.2 miles) of this road will be upgraded as required. The existing county road may also have to be relocated. The studies described in Section 4.1.3.1.10 will determine the extent of improvements that may also be required on portions of Mississippi State Highways 15 and 42. Preliminary estimates of new access route construction costs are approximately $3 million and upgrading costs in the vicinity of the repository will be approximately $5.7 million (SCC, 1984b), not including land acquisition costs.

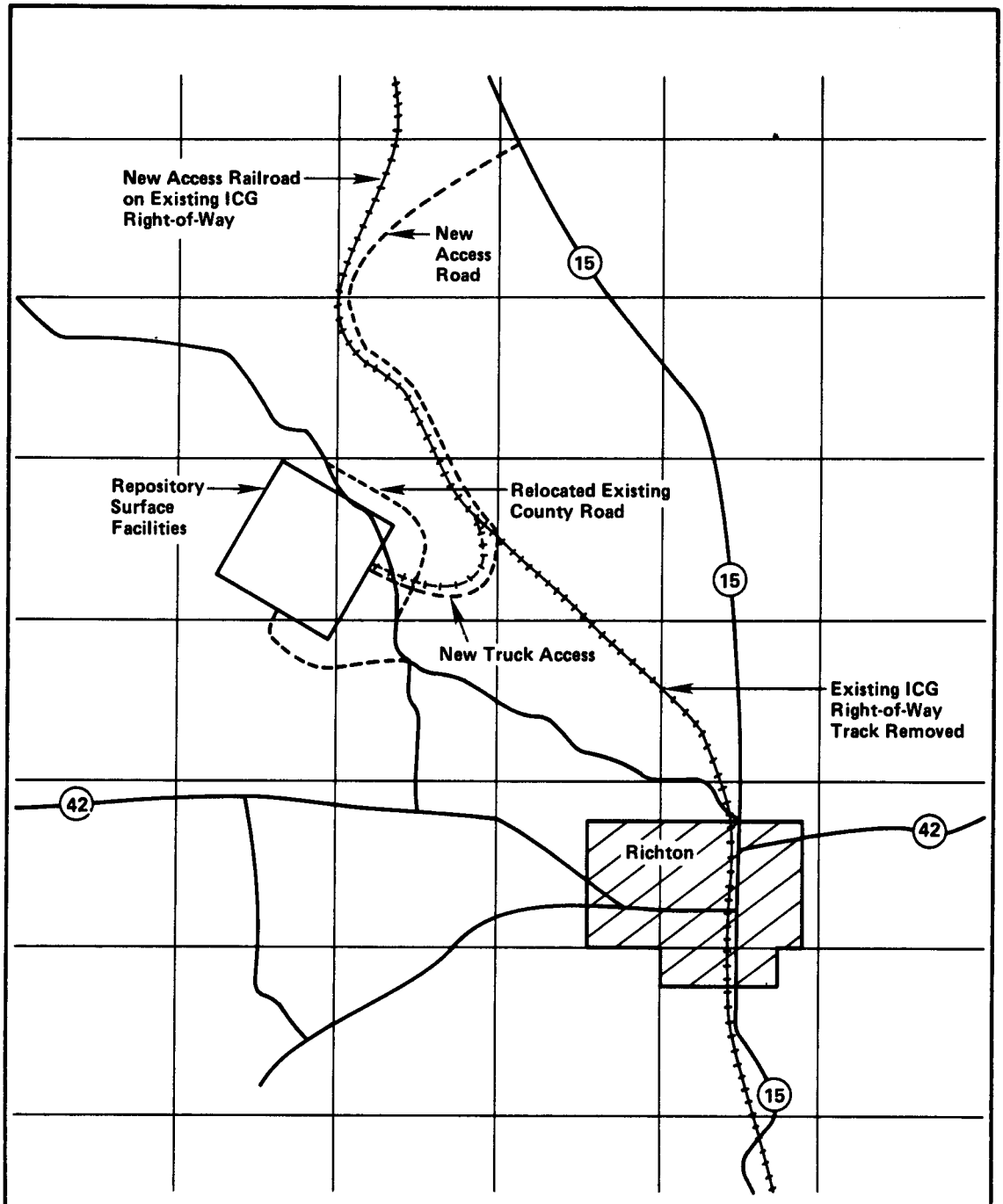
Rail access to Richton Dome includes the study of three rail corridors: (1) the abandoned Illinois Central Gulf line (ICG) right-of-way southward from Laurel to the site vicinity, (2) the abandoned ICG right-of-way northward from Beaumont through Richton, and (3) a reconstructed line for the entire distance from Laurel to Beaumont. Of the three alternatives, the line from Beaumont through Richton represents the shortest access route; reconstructing the entire line results in the greatest impact. Using the abandoned line from Laurel is intermediate to the two. Constructing a rail line from the Hattiesburg-Petal area was not considered because of environmental and economic impacts.

Accordingly, for the purposes of this environmental assessment, the former right-of-way of the ICG, which extends southerly from Laurel a distance of 40 kilometers (25 miles), is used. A new 1.6-kilometer (1-mile)-long right-of-way will be constructed between this right-of-way and the Richton Dome site (Figure 5-9). The northernmost part of this route travels through 1 kilometer (0.6 mile) of the corporate limits of Laurel. Numerous bridges, grade crossings and new railroad construction will be required for the entire route. The preliminary cost estimate for reconstructing the railroad over the abandoned right-of-way and constructing the additional 1.6-kilometer (1-mile) connection to the site is approximately $16 million not including land aquisition costs (SCC, 1984b).

Should the decision be made to transport nuclear waste by barge (see Appendix A) to a Gulf Coast port or should ocean disposal of salt be selected, consideration might then be given to constructing trackage on the existing right-of-way extending south to Beaumont. This would provide a more direct access route to the Gulf. This may be further studied as described in Section 4.1.3.1.10.

The electrical power for normal repository operations at the Richton Dome will be supplied from a new substation located at Beaumont. This substation will be tied into the east-west 115 kV transmission line of the Mississippi Power Company. A new 22-kilometer (14-mile)-long power line will be constructed from the substation to the repository site (Figure 5-10).

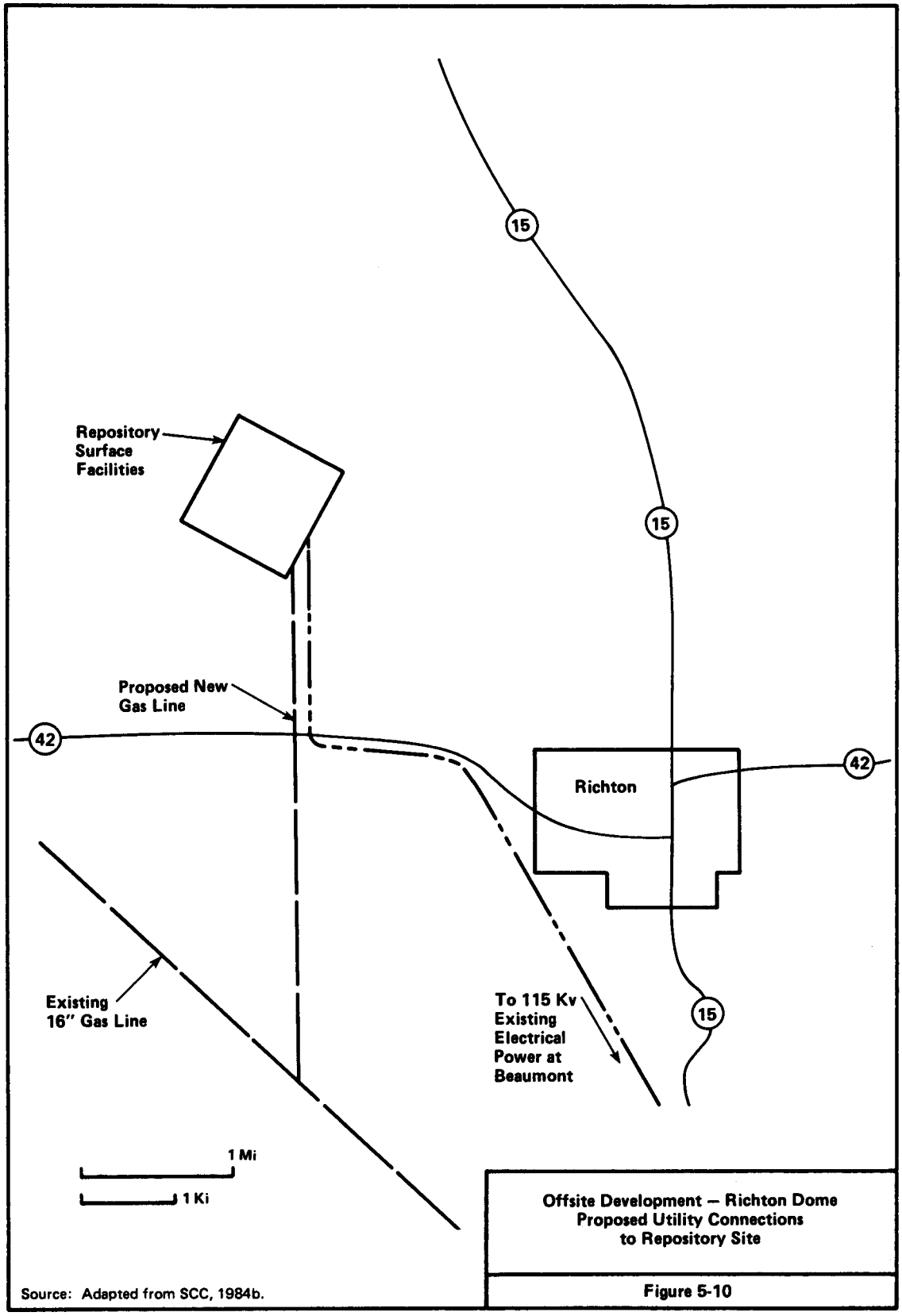
Natural gas for the repository will be obtained by tapping a 40.6-centimeter (16-inch) pipeline of the United Gas Pipeline Company. This gas main runs east-west about 1.3 kilometers (0.8 miles) south of Richton and carries gas at about 2 megapascals (315 pounds per square inch). A 20.3-centimeter (8-inch) branch line about 4 kilometers (2.5 miles) long will be installed to provide gas service to the repository site (Figure 5-10).



Offsite Development – Richton Dome
Highway and Railroad Access Routes

Source: Adapted from SCC, 1984a.

Figure 5-9



Source: Adapted from SCC, 1984b.

Offsite Development – Richton Dome
Proposed Utility Connections
to Repository Site

Figure 5-10

The water supply for the Richton Dome repository will come from new wells located along the Bogue Homo River. This well field will be located about 4 kilometers (2.5 miles) northwest of the repository site. A small water treatment plant will be located adjacent to the well field. A 20-centimeter (8-inch) pipeline from a pump station will be built to deliver water to the repository.

5.1.2.3 Onsite Development

Onsite development will consist of site preparation and grading, completion of the onsite sections of the rail lines and site roadways, and construction or erection of the repository surface facilities.

Site preparation will encompass approximately 165 hectares (407 acres). An estimated 2.8 million cubic meters (3.7 million cubic yards) of fill and 3.7 million cubic meters (4.8 million cubic yards) of excavation will be required to level the site and develop the desired drainage patterns. The fill will be provided from excavation on the site and approximately 0.8 million cubic meters (1.1 million cubic yards) will be stockpiled for site restoration. Excavated topsoil would be used for landscaping within the site fence and recovered during decommissioning for restoration of the site.

The primary excavated material storage area will be the salt stockpile containing approximately 2.7 million metric tons (3.0 million tons) of mined salt, which is the estimated maximum needed to backfill all open underground excavations at any time in the repository operating life. The excavated salt will be mechanically conveyed to this 21-hectare (53-acre) area and stockpiled to an approximate height of 9 meters (30 feet).

Although it is not a standard practice in the salt industry to line salt storage areas, possible leaching of brine into the ground will be prevented by using liners. These will be natural (clays) or synthetic materials (polyvinyl chloride, polyethylene, or polypropylene). Before emplacement of a liner, the existing topsoil will be stripped, the subsoil material will be excavated to a certain depth, and selected backfill materials placed and compacted to form a sound foundation subbase for the liner and for the retention ponds and storage areas as a whole. Once the liner is placed in the salt pile area, an additional layer of compacted backfill material will be placed on top of the liner. This added backfill will allow use of heavy construction equipment on the salt pile without tearing or puncturing the liner.

When salt is exposed to the weather, a hard surface crust forms in a few days which tends to shed rain water (Ver Planck, 1958). According to the experience of the salt industry, stockpiled salt is not a source of windblown particles and crusting can be accelerated by wetting the pile. It is possible, however, that during salt handling, namely transfer of the salt from hoist to rail cars or other conveyances and salt-pile buildup (pile working surface), salt particles may become windblown.

Three major retention ponds will be constructed. The first pond will serve as the salt-runoff detention pond, which would be sized to hold a 100-year, 24-hour storm. The salt detention pond will occupy an area of approximately 4.9 hectares (12.2 acres). Because of the negative net evaporation rate in this region (i.e., precipitation exceeds evaporation), use of this pond and the other ponds for evaporation disposal of the storm-water runoff and/or wastewater is not feasible. Direct discharge to surrounding surface water is not considered a viable alternative. Therefore, the runoff will be disposed of under applicable regulations and may include disposal by deep well injection or thermal evaporation followed by salt recovery.

The second major retention system will serve as the treated wastewater holding pond. This pond would be the collection point for all nonradioactive liquid wastes (e.g., cooling tower blowdown, sewage plant effluent, etc.) and will cover approximately 3.6 hectares (8.9 acres) of the repository site.

The third major pond will be the receiving point for other storm-water runoff excluding the previously mentioned salt-pile storage area. This site storm-water retention pond will

cover approximately 7 hectares (17.2 acres) of the repository site and be sized to handle a 100-year, 24-hour storm event.

All three retention pond systems will be lined with a suitable material to prevent seepage of contaminated water into the ground. The lining of brine ponds is a common practice and has proved effective and reliable. Ponds as large as 20 hectares (50 acres), for example, are in use which are lined with 20-mil polyvinyl chloride on the bottom, where the plastic sheet is not reached by sunlight, and 30-mil hypalon (chlorosulfonated polyethylene) reinforced with nylon webbing on the sides, where the sheet is exposed to sunlight. It is a common practice to remove the existing topsoil before emplacement of the membrane and to set in place a network of plastic pipes perforated at the top, to be covered by a compacted backfill material. These pipes perform a dual function: they permit the escape through vertical side vents of gases which may collect under the lining, and provide access to leachate samples for monitoring the effectiveness of the liner. Natural materials such as brine-resistant clays can also be used in place of the synthetic liners. Monitoring is performed as above. It is presently planned to provide a monitoring system for the retention ponds and storage area which will characterize atmospheric emissions, surface runoff, subsurface seepage, and soil disturbance interactions.

Onsite roadways, along with the onsite rail yards, will be constructed during this phase. Interior site roads will be crowned while the perimeter site roads would be sloped inward to contain all surface runoff.

The major buildings will be constructed of concrete and steel. Building areas which will confine radioactive materials will be designed to withstand a design basis earthquake and design basis tornado, and other credible natural and human-induced events.

The waste handling and packaging facility, the largest building on the repository site, will encompass approximately 18,600 square meters (200,000 square feet) of ground-floor area. The tornado- and earthquake-resistant sections of the building will have walls and roofs constructed of thick reinforced concrete. All other areas of the building will be constructed of either steel or concrete.

It is estimated that 15,000 truck visits will be required to deliver concrete and steel, and approximately 9,000 truck visits will be needed to deliver other materials. The estimated total number of truck deliveries will be 24,000, at a rate of approximately 14 per day over the construction period. The number of passenger vehicles transporting personnel to the site is estimated to be 714 per day.

5.1.2.4 Shafts and Facilities Development

All the repository shafts will be excavated using conventional drill-and-blast methods. Potential high ground-water inflows and unstable ground in the sediments above the salt will require pretreatment by freezing to allow shaft sinking through these sediments.

Shaft linings will consist of concrete from the ground surface to 30 meters (100 feet) into the salt dome, a total depth of approximately 240 meters (790 feet). The linings will be cast in place behind the excavation as sinking progresses. The shafts will be unlined below the bottom of the concrete liners. Water seals will be placed where required to preclude interconnection between aquifers and to block ground water in the caprock from passing downward along the shaft lining. For more detail of the shaft sinking process, see Section 4.1.2.

The scheduled sequence of shaft development will begin with the service shaft and ventilation supply shaft, allowing initial subsurface development to begin. The remaining three shafts will be completed concurrent with the initial subsurface development.

Individual shaft outfitting will immediately follow the shaft excavation and lining activities. Shaft outfitting will encompass the installation of the hoisting systems, utility conduit runs, instrumentation, and all other equipment necessary for the shaft systems to operate properly. The parallel effort at the surface will be the construction of the surface

support facilities such as the shaft headframes, intake air filter buildings, exhaust air filter buildings, and related surface construction.

5.1.2.5 Underground Development

It is proposed that the subsurface excavation be performed mechanically (SCC, 1984a). The excavated salt will be transported by a haulage vehicle from the excavation face to a conveyor belt that will transport the salt to surge bins located near the service shaft. Conventional drill and blast excavation will be needed for the initial development of the shaft station areas. A feeder/breaker will be necessary to crush oversized rock prior to its placement on a conveyor belt system. Excavated salt in the surge bin will be loaded into the skips, which will then hoist the material to the surface. From the service shaft headframe, the excavated salt will be mechanically conveyed to either the salt stockpile area for long-term storage, or to the railcar area for transport and eventual disposal as described in Section 5.1.3.

After an appropriate monitoring period, storage rooms will be backfilled after waste is emplaced. Backfilling will be accomplished by mechanically compacting and pneumatically stowing salt as backfill material. Branch and main passageways will also be backfilled soon after the associated waste emplacement rooms are backfilled.

The initial development phase of the repository subsurface will begin when the service shaft and ventilation supply shaft are completed. The subsurface excavation to be performed in this initial development phase is shown in Figure 5-11 and will include the following:

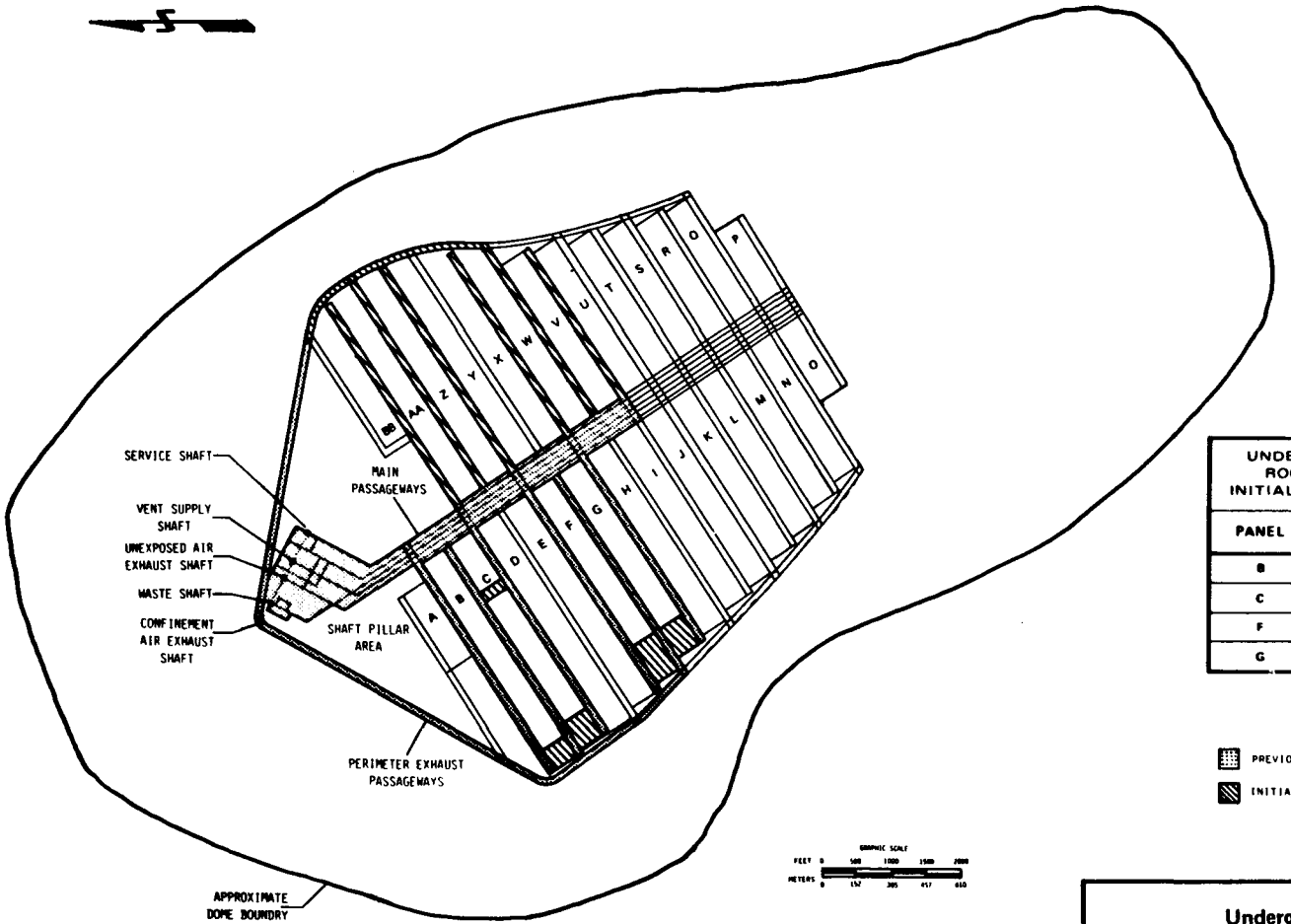
- Excavation of passageways in the shaft pillar area
- Excavation of the five main passageways to access all panels necessary for the various waste types in the first year of emplacement
- Excavation of branch passageways, exhaust branch passageways, and perimeter exhaust passageways necessary for the first 2 years of emplacement
- Excavation of storage rooms required for the first year of waste emplacement
- Completion of the remaining three shafts.

Table 5-4 lists a summary of estimated excavation, reexcavation (scaling), and backfill quantities for the repository subsurface. Reexcavation of passageways is necessary due to the slow closure that occurs because of the plastic flow of the salt.

5.1.3 Repository Operation Activities

The start of repository operations will be marked by the granting of an operating license by the NRC and the initiation of nuclear waste receipt, packaging, and emplacement activities. The estimated operating life of the repository will be approximately 50 years, during which the waste emplacement activities will be completed in the first 26 years. The number of employees required to operate the repository is shown in Table 5-2. Of this staff, approximately 20 percent will be directly involved with waste receiving, packaging, and emplacement operations; approximately 15 percent will be involved in underground mining operations; and the remaining 65 percent will be involved in administration, engineering, maintenance, security, and other support categories.

Estimated vehicular traffic during repository operation is given in Table 5-5. Upper limit shipping volumes for nuclear waste are based on the assumption that all shipments will be made by truck or rail using existing cask designs. However, a large portion of the nuclear waste is expected to arrive by rail, and future cask designs, both truck and rail, are expected to have greater capacity. Both factors are expected to markedly reduce the number of



UNDERGROUND STORAGE ROOM DEVELOPMENT INITIAL DEVELOPMENT PHASE		
PANEL	WASTE	NO ROOMS
B	TRU	6
C	DHLW/CHLW	6/7
F	SF	12
G	SF	9

PREVIOUSLY DEVELOPED

INITIAL DEVELOPMENT PHASE

Underground Activities
Initial Development Phase
Richton Dome

Figure 5-11

Source: Eschen, 1985.

Table 5-4. Summary of Excavation Quantities, Richton Dome

	Excavation Quantity, Tons			
	Construction	Operation	Decommissioning	Total
Passageways	5,330,000	4,739,000	0	10,069,000
Storage Rooms	357,000	12,215,000	0	12,572,000
Shafts	332,000	0	0	332,000
Miscellaneous	69,000	0	0	69,000
Subtotal, Initial Excavation	6,088,000	16,954,000	0	23,042,000
Reexcavation (scaling)	0	140,000	0	140,000
Total Excavation	6,088,000	17,094,000	0	23,182,000
Tons Required for Backfill	0	-10,255,000	-2,965,000	-13,220,000
Excess Mined Salt	6,088,000	6,839,000	-2,965,000	9,962,000

Table 5-5. Typical Vehicular Traffic Volumes During Repository Operations, Richton Dome[a]

Vehicles	Frequency
Rail Cars	
Nuclear[b]	15/week
Salt	56/week
Supplies	4/week
Truck	
Nuclear[b]	19/week
Salt	None
Supplies	270/week
Automobiles	500/day

(a) Assumed for design purposes; see Section 5.3 for analysis of transportation scenarios.

(b) The majority of the nuclear waste material would be transported to the site by rail car.

Source: SCC, 1984b

nuclear waste shipments. In addition to the incoming nuclear waste, the repository will also receive waste packaging material and additional equipment and materials to service the facility.

The estimated quantity of excess salt to be disposed of over the operating period of the repository is given in Table 5-4. A specific method for permanent disposal of excess salt has not been selected. This will be accomplished as part of the site-specific conceptual design for a repository in salt, and cannot be initiated until the President approves a salt site for site characterization. Several feasible candidate methods for salt disposal do exist and will be evaluated during conceptual design. These methods are discussed in Section 5.1.3.4, Salt Disposal; a representative disposal method is selected, and its impacts evaluated, in Section 5.3.5.

The Mine Safety and Health Administration (MSHA) is authorized to administer and enforce certain kinds of safety and health standards for protecting employees in the mining industry, pursuant to the Mine Safety and Health Act of 1977. The question of formal involvement of MSHA with the Civilian Radioactive Waste Management Program is not resolved at this stage. However, principal design, construction, and operating features should include provisions for worker protection by following the relevant requirements of 30 CFR Part 57, "Health and Safety Standards - Metal and Non-Metallic Underground Mines."

Regarding the construction and operation of the geologic repository operations area, 10 CFR 60.131(b)(9) states that to the extent the DOE is not subject to the Federal Mine Safety and Health Act of 1977, the design of the geologic repository operations area shall nevertheless include such provisions for worker protection as may be necessary to provide reasonable assurance that all structures, systems, and components important to safety can perform their intended functions.

The repository design must consider the relevant design requirements stated in three subchapters of 30 CFR Part 57, Chapter 1, Mine Safety and Health Administration, Department of Labor:

- Subchapter D - Electrical Equipment, Lamps, Methane Detectors; Tests for Permissibility; Fees
- Subchapter E - Mechanical Equipment for Mines; Test for Permissibility and Suitability; Fees
- Subchapter N - Metal and Non-metallic Mine Safety and Health.

Specific areas of interest in maintaining occupational safety during mining include:

- Mining Methods
- Fire Prevention and Control
- Working Environment
- Ventilation Systems
- Materials Handling and Storage
- Underground Utility Systems
- Occupational Safety Programs and Personnel Protection
- Emergency Plans
- Inspection, Testing, and Maintenance.

The Occupational Safety and Health Administration (OSHA) administers the Occupational Safety and Health Act of 1970, as amended (29 CFR Part 1910). The purpose of OSHA is to establish standards with which industries are generally familiar, and on whose adoption interested and affected persons have already had an opportunity to express their views. Such standards are either (1) national consensus standards whose adoption by affected persons has reached substantial agreement, or (2) Federal standards already established by Federal statutes or regulations. The Salt Repository project will use, where practical, the OSHA regulations, in particular 29 CFR Part 1910, "Occupational Safety and Health Act of 1970," and 29 CFR 1926, "Safety and Health Regulations for Construction."

Predictions of worker injury and fatality rates during salt mining operations at a repository are given in Section 4.1.2.2. Table 5-6 indicates possible injury and fatality rates to be expected during waste handling operations. Actual expected injuries cannot be predicted until repository designs are final.

5.1.3.1 Surface Waste-Handling/Packaging Operations

The estimated nominal design capacity of the repository will be 72,000 metric tons (79,200 tons) of heavy metal in the form of spent fuel and CHLW. In addition, the repository design will accomodate 3,510 MTHM of DHLW. The waste receiving rates for each waste form comprising this nominal capacity are plotted in Figure 5-12.

The anticipated sequence of repository operations will begin when the waste form has arrived at the repository by rail or truck in an approved, licensed shipping container. Notification of shipment will have been received and approved earlier so that receipt, handling, and emplacement operations for this waste shipment will have been integrated into the overall repository operations schedule.

At the repository security entrance, the shipping documents will be verified. Preliminary inspection of the shipping cask and carrier vehicle will then be performed. The shipping cask and carrier vehicle will then be moved into the repository area to the inspection station where they will be thoroughly checked for sabotage, structural condition, and surface contamination level. Based on results of these inspections, the cask and vehicle will then be moved to either the isolation bunker or the WHPF.

At the WHPF, the cask and vehicle will be moved to the cask cleaning and decontamination area where the exterior of the cask and vehicle will be cleaned to remove road dirt and any contamination. The cask and vehicle will then be moved into the receiving and packaging facility where the cask will be unloaded from the vehicle.

The shipping cask will then be moved to the cask preparation station to be prepared for the removal of the waste. The shipping cask will be positioned under the waste transfer port and the cask lid will be removed. The waste will then be removed from the cask, inspected, and transferred either to temporary storage or directly into the packaging hot cells. The cask lid will then be replaced and the shipping cask prepared for loading back onto the carrier vehicle. After loading, the cask and vehicle will be dispatched from the WHPF area to await movement off site.

The waste form will enter the hot cells either directly from the shipping cask or from the temporary storage area. Depending on the form of the waste, additional operations may be performed in the hot cells. For spent fuel, the waste form will move into the disassembly station where the fuel pins will be removed from the fuel assembly or box, consolidated, and placed into a waste package canister. This spent fuel waste package canister or the CHLW and DHLW canisters will then be moved to the packaging station where they will be placed inside the thick-walled container, and the container lid will be installed. The waste package will then move to the inspection station where the lid closure weld will be nondestructively examined, the surface contamination level checked, and appropriate identification numbers verified and recorded.

Remote-handled TRU will be inspected without repackaging and passed through the hot cell to the transfer cask station. Contact-handled TRU will be assembled onto 12-drum pallets which will then be loaded directly by forklift into the waste shaft hoist cage. At this point, the TRU will be lowered to the repository subsurface level.

At the transfer cask station, the waste package will be loaded into the transfer cask (a heavy, shielded container similar to a shipping cask) through a transfer port, with the transfer cask located outside the hot cell. The transfer cask containing the waste package will be moved to the waste shaft hoist. The transfer cask will then be loaded onto the hoist cage, lowered to the repository subsurface level, and unloaded onto an underground transporter. At this point, subsurface operations will begin.

Table 5-6. Injury and Fatality Incidence Rates at AEC Nuclear Facilities: 1943-1975[a][b]

Lost-time Injuries Per Million Work-Hours
Construction - 5.24
Operations - 2.01
Overall[c] - 2.75
Since 1958 - 2.2
Fatalities Per Million Work-Hours[d]
Construction - 0.117
Operations - 0.024
Overall - 0.046

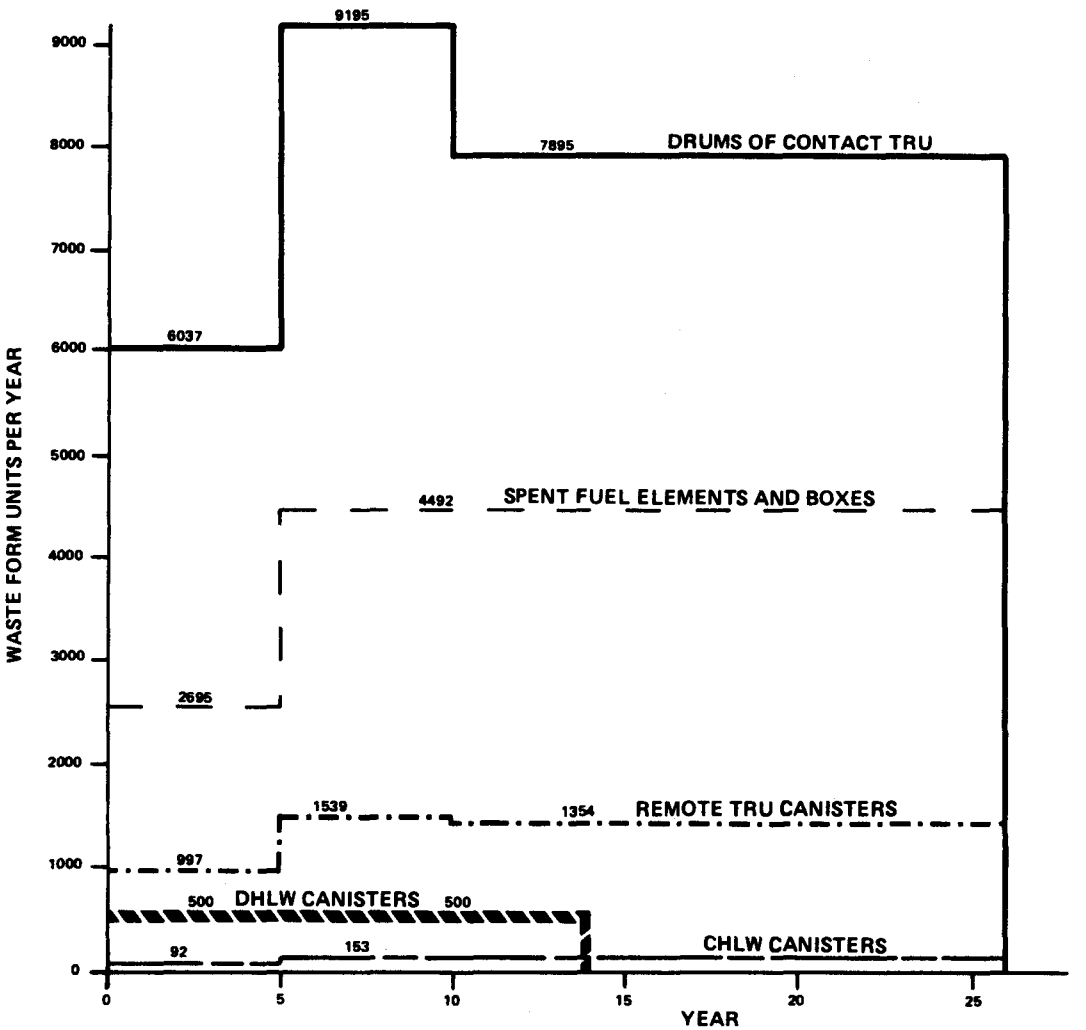
(a) The Atomic Energy Commission (AEC) nuclear facilities studied were Government owned nuclear energy facilities which were designed, constructed, and operated by contract with industrial, academic, and nonprofit organizations. Operations at these facilities included the production and processing of special nuclear and radioactive materials, development of nuclear reactors, development of nuclear explosives, and research in the physical and biological sciences.

(b) Total person-hours for repository construction and operation are, respectively, 14.8 million and 52.0 million.

(c) Overall = weighted average based on total number of work hours for each category.

(d) Derived from injury incidence rates by multiplying injury incident rates by ratios of fatalities to injuries.

Source: U.S. Atomic Energy Commission, 1975.



Explanation

DHLW = Defense High-Level Waste
CHLW = Commercial High-Level Waste
TRU = Transuranic Waste

Input to Packaging Facility
Richton Dome

Source: Adapted from SCC, 1984a.

Figure 5-12

At the transfer cask station, the waste package will be loaded into the transfer cask (a heavy, shielded container similar to a shipping cask) through a transfer port, with the transfer cask located outside the hot cell. The transfer cask containing the waste package will be moved to the waste shaft hoist. The transfer cask will then be loaded onto the hoist cage, lowered to the repository subsurface level, and unloaded onto an underground transporter. At this point, subsurface operations will begin.

Requirements for waste storage on the surface are established in the Generic Requirements for a Mined Geologic Disposal System (DOE, 1984, DOE/NE/44301-1). A temporary storage capacity equivalent of 3 months' waste receipts will be provided in order to minimize the effects of scheduled or unscheduled interruptions in repository operations. This requirement is subject to change if the monitored retrievable storage (MRS) is developed and will depend upon the established role of the MRS in the disposal scheme.

5.1.3.2 Subsurface Waste-Handling Operations

Subsurface waste emplacement operations will begin upon completion of the initial development phase. During this first year of operation, the room excavation operations will be moved to the side of the main passageways opposite the emplacement operations.

Once the waste package transfer cask is unloaded from the hoist onto an underground transporter, the transporter will move the waste in the transfer cask to the designated storage room and position the cask over the vertical borehole in the storage room floor. This vertical borehole and other waste storage-room emplacement preparations will have been performed prior to starting emplacement operations in that storage room. Once over the borehole, the bottom of the transfer cask will be opened and the waste package will be lowered into the borehole. The borehole then will be backfilled with crushed salt to storage room floor level. The transporter then will carry the empty transfer cask back to the hoist where the transfer cask will be loaded onto the empty hoist cage for transfer to the surface and reuse. The underground transporter then will be available to transport the next loaded transfer cask.

5.1.3.3 Retrievability

Section 122 of the Nuclear Waste Policy Act of 1982 (NWPA) (10 CFR Part 960) mandates that the repository shall be designed and built to permit retrieval of any spent fuel emplaced in the repository during an appropriate period of operation of the facility. The reasons for such retrieval, as per the NWPA, may pertain to public health and safety, or to the environment, or for the purpose of permitting the recovery of the economically valuable contents of such spent fuel.

The Civilian Radioactive Waste Management (CRWM) Program's position on the issue of retrievability is that the repository be designed, constructed, and operated so that the capability to retrieve the previously emplaced waste packages is retained. This condition will be maintained until the satisfactory completion of a performance confirmation program as stipulated by NRC's 10 CFR Part 60.111 and decommissioning activities are authorized by the NRC.

In accordance with the NWPA and 10 CFR Part 60, the geologic repository operations area will be designed so that any or all of the emplaced waste could be retrieved on a reasonable schedule starting at any time up to 50 years after waste emplacement operations are initiated, unless a longer or shorter time period is specified by the Secretary (DOE) and approved by the NRC. For design purposes, it is assumed that the actual retrieval, if retrieval proves to be necessary, would take as long as approximately the period used for waste emplacement and repository construction. This length of time is consistent with the NRC's provision in 10 CFR 60.111, in which public health and safety considerations are of primary importance in any waste retrieval operation.

The capability to retrieve the waste packages will be demonstrated prior to a decision to backfill the waste package storage room and will be maintained regardless of whether the storage rooms have been backfilled. Therefore, the decision to backfill would be based on an

evaluation of the advantages of early backfilling versus the disadvantages of increased difficulty of retrieval.

The Department of Energy has, during the summer of 1985, developed a position on retrievability to fully describe and document all design, construction, operation, and maintenance equipment requirements associated with retrievability. An evaluation of the effects of these requirements on the repository design and the associated equipment needs has not been completed at this early stage in the repository design process. These retrieval effects will be analyzed and addressed during the site characterization period and subsequent design phases supporting the license application.

5.1.3.4 Salt Disposal

As the result of mining activities, approximately 9,000,000 metric tons (10,000,000 tons) of salt materials will require disposal. The excess salt and salt-laden material brought to the surface during repository construction and operation could be disposed of in the following ways:

- Onsite disposal
- Commercial market
- Ocean disposal
- Mine disposal
- Offsite (surface) disposal.

The primary consideration in the selection of the option to be actually used will be assurance that the quality of the environment in the affected area will be adequately protected during this and future generations in accordance with the criteria set forth in the siting guidelines, especially 10 CFR 960.5-2-5, Environmental Quality. The selection will be based on a comparative evaluation of the advantages and disadvantages of all options suitable for a given site. Transportation with its potential impacts and costs is a significant factor in the evaluation but is given less weight than environmental impact. Knowledge gained from testing and experimentation during the site characterization phase will be incorporated in repository design, and will be applied to salt management during the operations phase to limit impacts.

Although the repository program has not advanced to the point where the final selection of a disposal method can be made using data specific to the selected site, the significant impacts of the options at potential sites can be reliably anticipated at this time. The following sections summarize the salient features of each option.

5.1.3.4.1 Onsite Disposal. This option requires the construction of a large surface storage area underlain and covered by impervious materials.

5.1.3.4.2 Commercial Market. Excavated salt would either be supplied through the General Services Administration to buyers or governmental agencies "as-is" or following some onsite processing.

Because transportation costs may exceed the market price of the salt, the DOE may have to subsidize the sale. Feasibility of this alternative is not fully developed.

5.1.3.4.3 Ocean Disposal. Excess salt could be converted into brine with either fresh- or seawater and could be dispersed in ocean waters through outfalls. Transport of either the brine or the solid material from the site to the disposal point would be required.

Activities will be conducted in a manner consistent with the Federal "Coastal Barrier Resources Act" (16 USC Sections 3501-3510) and with any approved State coastal zone management programs of the Gulf States involved.

5.1.3.4.4 Mine Disposal. Excess salt would be transported by rail to existing evaporite mines, transferred underground via a closed conveyor system, and packed into unused sections of the mines.

5.1.3.4.5 Offsite (Surface) Disposal. The disposed salt would be blended into a natural environment composed of evaporite materials of alkali flats and dried saline lake beds of very similar composition.

5.1.3.4.6 Choice of Mine Disposal as Representative Method. The supporting studies for the preceding sections identify mine disposal as being environmentally benign and technically feasible. Numerous mines were contacted (Scheriff, 1983) to locate evaporite mines with capacity to accept waste salt. These contacts have provided assurance that multiple mines with sufficient capacity are available.

Tentative mine sites have been identified within a few hundred miles of the repository site. This option is the representative disposal method.

Impacts of the mine disposal option are primarily related to transportation, and are discussed in Section 5.3.5, Salt Disposal.

5.1.3.4.7 Description of Salt-Handling Activities Related to the Mine Disposal Method. A general description follows of the physical activities likely to be performed at the repository site and at the disposal site if the salt disposal method selected were to be disposal in an existing mine. Several of these activities are general and would be applicable to other disposal methods.

5.1.3.4.7.1 Salt Handling at the Repository Site. The excavated salt is brought to the surface by the skip hoisting system. The skips discharge into a surge bin near the head frame, and the salt is then conveyed from the surge bin to the site salt stockpile or, if excess salt, to the railroad loadout area.

The excess salt is loaded into railroad cars for shipment to the excess salt disposal site. The handling, loading, unloading, and transporting of salt at the repository and at the excess salt disposal site are performed in an environmentally acceptable manner. As far as practical, conveyors, transfer points, and loadout structures will be enclosed and equipped with dust collection equipment to minimize impacts on the environment.

5.1.3.4.7.2 Salt Handling at the Disposal Site. Possible excess salt disposal locations for the Richton Dome site are in Iberville, Iberia, and St. Mary Parishes in Louisiana. The excess salt is dumped from the railroad cars into a track hopper and the salt is transported underground into an existing evaporite mine using one of several available conventional materials-handling designs. The salt is placed as a backfill in the previously mined rooms.

5.1.3.5 Treatment and Disposal of Other Repository-Generated Wastes

Liquid and solid wastes generated by repository operations are collected and treated on site and disposed of in an appropriate manner. Treatment and disposal are in compliance with applicable local, State, and Federal regulations.

Sanitary wastes are collected and transferred to the wastewater treatment facilities by a site sanitary sewage system. The sanitary waste treatment facilities are a packaged system that uses both primary and secondary treatment to remove 85 to 95 percent of the five-day biological oxygen demand (BOD) and a similar range of suspended solids. Following treatment, liquid effluents are discharged into the treated wastewater pond.

Industrial wastes such as used lubricating oil, laboratory chemicals, and nonradioactive cleaning solutions will be collected at the source. Most or all of these wastes will be transported off site to commercial disposal sites or recycling centers. Hazardous industrial wastes will be disposed of at offsite commercial facilities specifically designed for the purpose.

Radiological wastes consist of items generated on site in the course of normal operations; for example, used HEPA filters, anti-contamination clothing, contamination test swipes and solutions used to remove radioactive contamination. Solid radiological wastes are

collected at the source packaged as contact-handled TRU, and disposed of in the repository. Liquid radiological wastes are collected at the source and taken to the wastewater treatment facility in a drain system that is entirely separate from the sanitary sewer system. Radioactive liquid and solid waste system quantities are listed in Table 5-1. All inaccessible radiological waste piping is double-walled to preclude undetected leaks. These waste liquids are solidified on site and packaged as contact-handled TRU wastes.

All the ponds (storm-water detention, salt stockpile runoff and treated wastewater) are designed to contain the inflow from a 100-year, 24-hour storm event. When full, the pond will have spillways with the capacity to safely discharge a storm of greater magnitude without overtopping the embankment. All ponds will have an essentially impervious lining to prevent seepage of pond water into the underground aquifer. Each pond will contain facilities to monitor storm water and other effluents from the plant and evaluate them for radioactive and nonradioactive pollutants before being discharged to the existing natural surface drainage courses outside the repository. The total areas of the ponds are listed in Table 5-1.

5.1.4 Decommissioning and Decontamination

After the operational phase, the repository will be decommissioned and decontaminated (D&D). Detailed D&D plans will be developed and provided with the NRC construction application (i.e., following Title I design). Although future D&D requirements may differ from current requirements, the general philosophy to be followed is to reclaim the repository site to original site conditions as feasible and to complete backfill of the underground facilities to seal the drifts, haulageways, and shafts. During this period, the contaminated portions of the waste handling facilities could be cut up, packaged, and moved to the repository subsurface. The remaining open areas of the repository subsurface will be backfilled and sealed using the originally excavated salt material stored on site. The surface facilities will be dismantled and the surface area restored as feasible to final reclamation grade. Shaft backfilling will be composed of salt and selected materials with seal plugs at predesigned depths.

5.1.4.1 Surface Activities

Decommissioning operations will include decontamination and dismantling of the surface facilities, restoration of the site area to the final reclamation grade, and seeding if appropriate. Mechanical and chemical decontamination methods will be used to remove radioactive contamination from the WHPF and its support facilities. Contaminated materials not capable of being decontaminated will be transferred to the subsurface drift areas for emplacement. A final radiation survey of the surface facilities will be performed to ensure that all areas are below radiation levels that allow for unrestricted public access.

The final phase of the surface D&D is the dismantling of surface buildings and structures. Uncontaminated components from the demolition operations would be disposed of off the site. Metal, structural steel, and platework will be removed and transported off site as scrap materials. The site will be regraded to final reclamation grade and seeded to control erosion.

Ponds used for containment of surface water runoff from the facility and process water discharge will be surveyed for radioactive contamination. If radionuclide levels exceed acceptable limits, the material will be removed, packaged, and disposed of properly. If radionuclide levels in the pond water and sediments are within acceptable levels, the pond will be drained, backfilled, and graded consistent with the final reclamation topography.

5.1.4.2 Subsurface Activities

After all contaminated materials from surface decontamination and decommissioning are emplaced underground, the repository subsurface facilities will be closed by installing a repository sealing system. The repository seals will consist of subsystems to seal the rooms, drifts and passageways; the shafts; and the boreholes. The repository sealing system components will be designed to withstand the effects of design basis seismic events, anticipated thermal conditions, and expected ground swell or subsidence without unacceptable loss of

function. A schematic diagram of the sealing system is shown on Figure 5-13. A comprehensive description of the repository sealing system design and materials studies is contained in Kelsall et al., 1985 (BMI/ONWI-562). The sealing system will meet or exceed any applicable state requirements for plugging mine shafts or wells.

5.1.4.2.1 Room, Drift, and Passageway Seals. The bulk of the horizontal openings will be filled with crushed salt backfill, which under the stress and heat conditions will ultimately (in tens to hundreds of years) form into a solid mass of salt similar to the preemplacement conditions. Groups of rooms, called panels, will be isolated with precompressed salt blocks installed as masonry walls to provide isolation while the crushed salt is compacting. In the passageways connecting the shafts to the main disposal area, multiple concrete bulkheads will be installed. Portions of the drift between concrete bulkheads will be backfilled with an earthen material to provide redundancy.

5.1.4.2.2 Shaft Seals. After the passageways connecting the shafts have been sealed, the base of the shaft will be filled with structural concrete to support the loads imposed by the shaft sealing materials. Most of the shaft volume will be backfilled with crushed salt, in salt horizons only; dense earthen material, a mixture of clay and locally available materials; or general backfill, locally available material such as that removed during shaft sinking. At selected locations along the shaft, bulkheads will be constructed as shown on Figure 5-14.

The shaft lining will be removed at these bulkhead locations. These bulkheads will extend into the rock around the shaft to intercept and seal any fracture areas created by the sinking of the shaft and to prevent the transport of water outside of the sealed shaft. At the top of the shaft, a shaft cap of concrete will be placed.

5.1.4.2.3 Borehole Seals. Boreholes from the surface will be plugged as shown on Figure 5-15. In the strata where the repository lies, compacted crushed salt will be the primary constituent of the seal. Cement grout will be placed for several hundred feet above the salt and clay seal placed at the top of the grout. The remainder of the borehole will be filled with cement grout. Where necessary to seal behind the borehole casing, the casing can be perforated using oil field tools and grout squeezed through the holes into the formation.

5.1.4.3 Salt and Nonnuclear Waste Disposal

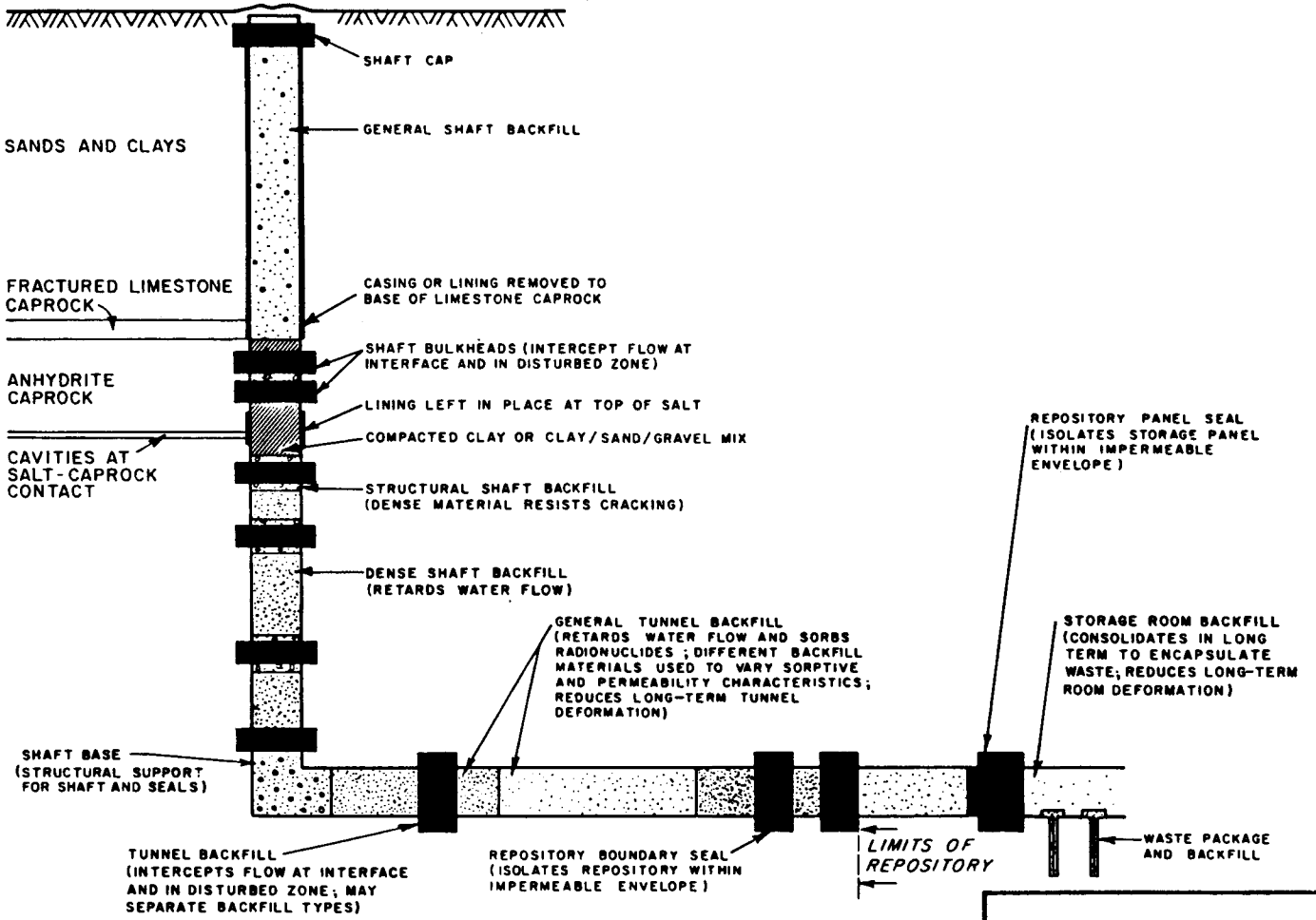
Water in the salt pile retention pond will be allowed to evaporate and dry by thermal evaporation or be disposed by deep well injection. The liner and salt-contaminated materials will be removed and the depression backfilled to final reclamation grade. Most salt contained in the surface stockpile will be used in backfilling subsurface facilities. Salt remaining after this operation will be transported from the repository site and disposed of in a manner similar to excess salt disposal during repository operations.

5.1.4.4 Labor Force

Decommissioning will resemble the construction phase and require personnel for dismantling, backfilling, and ground-surface restoration procedures. The size of the decommissioning-phase labor force will be smaller than the operations labor force, as shown in Table 5-2.

5.1.5 Postclosure Activities

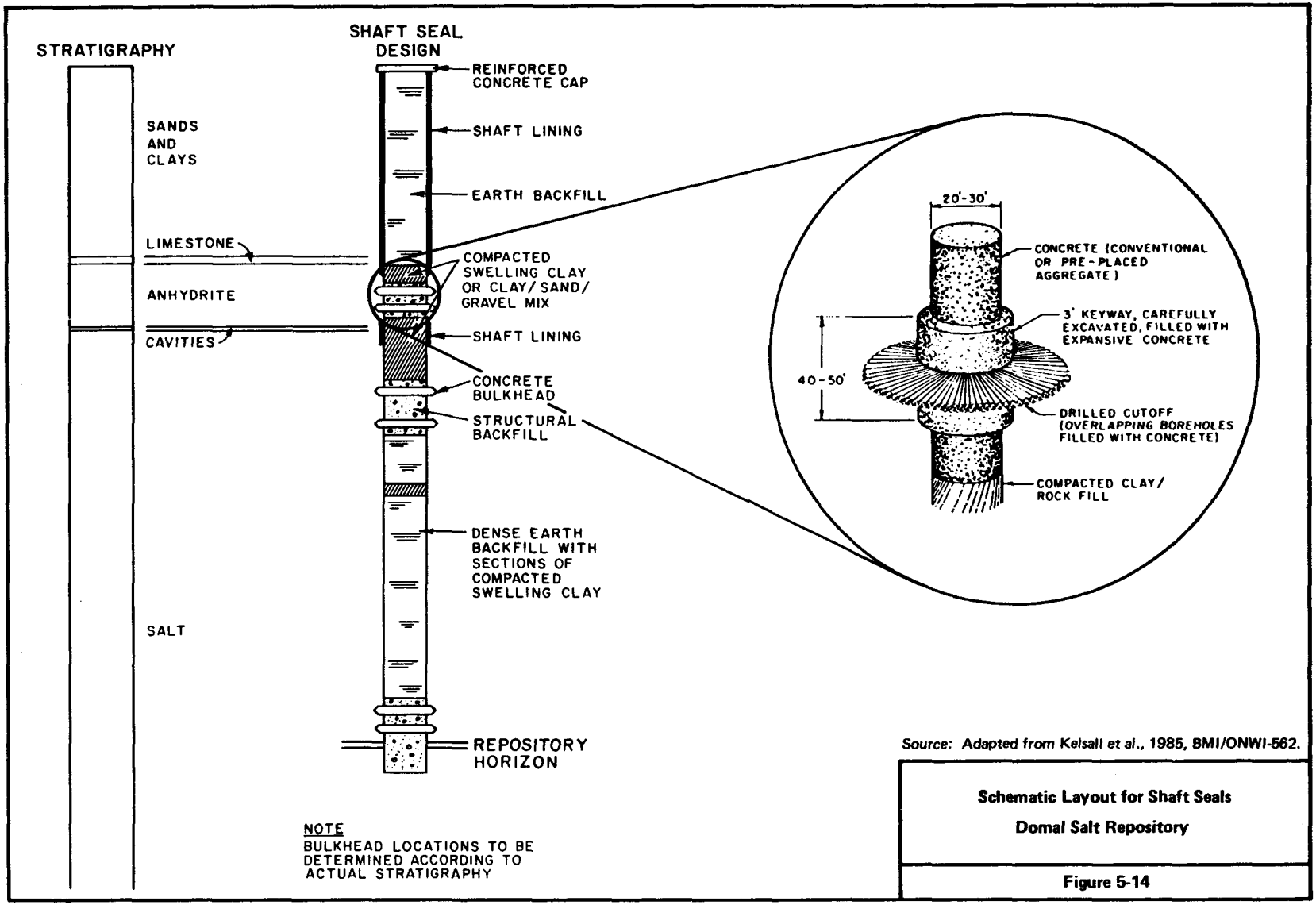
Following closure of the subsurface areas and decommissioning of the surface facilities, the repository will enter the postclosure phase. Generally, activities at the site will be those necessary for (1) active prevention against repository intrusion, (2) passive prevention against underground intrusion, and (3) possible active monitoring of repository conditions.



Repository Sealing System Schematic
Domal Salt Repository

Source: Adapted from Kelsall et al., 1985, BMI/ONWI-562.

Figure 5-13

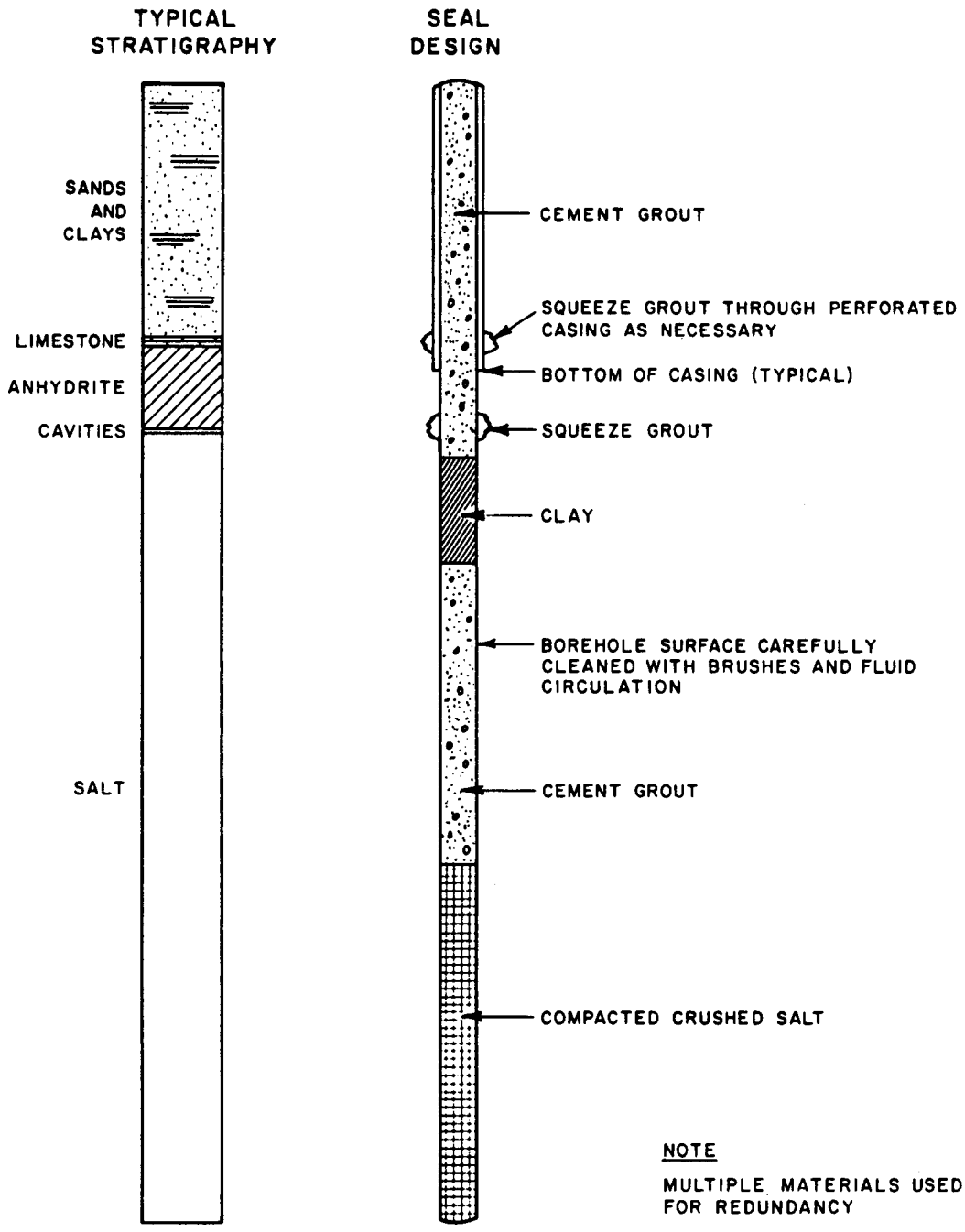


Source: Adapted from Kelsall et al., 1985, BMI/ONWI-562.

Schematic Layout for Shaft Seals

Domal Salt Repository

Figure 5-14



Schematic Design for Sealing Vertical Boreholes in a Salt Dome

Source: Adapted from Kelsall et al., 1985, BMI/ONWI-562.

Figure 5-15

5.1.5.1 Active Prevention

After closure, the DOE will maintain an institutional barrier into the foreseeable future. This arrangement should prevent subsurface exploration that might potentially affect the repository.

5.1.5.2 Passive Prevention

It is possible that institutional barriers and systems of record keeping and updating may fail in the future. For this reason, a passive barrier system will be used to notify future societies about the hazards below the surface.

Numerous options for passive barriers are being considered by the DOE (Kaplan, 1982, ONWI-354; Berry, 1983, ONWI-474). The options most likely to be implemented are a set of markers.

1. A set of 3- to 9-meter-high (10- to 30-foot-high) peripheral markers may be placed surrounding the outer control zone (the land owned by the DOE). These probably will be monolithic and shaped like tall pyramids. Simple warning symbols will be cast into each face. The markers likely will be spaced so a person standing at any point on the perimeter can view two markers.

2. A monument may be created and located over the center of the repository area. This marker will likely be pyramidal and be large enough to contain an internal area for accommodating details of the construction and hazards in the subsurface repository.

3. Earthworks of a size discernible by site visitors would likely be created. Probably these will be constructed around the central monument in the form of warning symbols.

4. A redundant set of warning symbols may be placed into the ground by tilling magnetite or some other site-anomalous material below the soil surface. These symbols, which may be quite large, will not be apparent to the eye but will be detectable by simple instruments.

5.1.5.3 Active Monitoring

While postclosure monitoring requirements have not been established by the NRC, it is possible that such requirements will be instituted. If postclosure monitoring is required, the DOE will probably retain a small technical staff and one of the small repository buildings.

5.2 EXPECTED EFFECTS ON THE PHYSICAL ENVIRONMENT

This section discusses the potential effects of repository development at Richton Dome on geologic conditions; hydrology; land use; terrestrial and aquatic ecosystems; air quality; aesthetic conditions; noise; and archaeological, cultural, and historic resources. Environmental effects of road and rail construction and upgrade are discussed briefly in this section, and are presented in greater detail in Sections 5.3.2 and 5.3.3.

The effects are based on the engineering feasibility studies for constructing and operating a repository at candidate salt sites (SCC, 1984b). This design is currently undergoing revision (Section 5.5) and some impacts could change. However, as indicated in Section 5.5, it is not expected that these design modifications will significantly increase environmental impacts. An impact analysis will be presented in the final environmental impact statement if this site is recommended for site characterization.

5.2.1 Geologic Conditions

The primary effects of repository development on geologic conditions are expected to be soil and topographic disturbances during site construction, and loss of potential mineral resources beginning at site development and extending for an undetermined period into the postclosure phase. These geologic effects are expected to include limited local, minor subsidence or uplift of the surface over the repository. There will be no other significant loss or modification of strata and rock other than the rock and salt actually removed in the process of underground development.

5.2.1.1 Surface Subsidence and Uplift

Two principal mechanisms affect movements within the rock mass and elevation changes of the ground surface above the repository. These are the following:

- Uplift caused by thermal expansion of the rock mass due to heating by the waste packages
- Subsidence caused by the creep of the salt into the subsurface workings.

In the preclosure period, cooling provided by ventilation of the repository tunnels will have a limited mitigating effect on the heating caused by the waste packages. In the postclosure period, uplift caused by thermal expansion will reach a maximum of about 0.77 meter (2.52 feet) approximately 1,000 years after waste emplacement (Wagner et al., 1985, BMI/ONWI-512). After this, cooling by ground-surface convection and radiation will dominate and will act to return the ground surface to its original elevation.

Mining subsidence occurs in a time frame of tens of years (depending on salt characteristics, thermal load, room design and support system, and the amount and effectiveness of backfill), but its effects are relatively small and will be masked by uplift due to thermal expansion. After some tens of thousands of years, when the repository has cooled down, the subsidence effect will result in a small amount of overall permanent subsidence of less than 1 meter (3.3 feet).

The DOE (1981, DOE/NWTS-147(2)) and Russell (1979) found that vertical uplift caused by heating of the repository could be as much as 3 meters (9.8 feet) and not cause environmental concerns. For example, Loken et al. (1984, Table 7-3) calculated a maximum surface uplift of 1 meter (3.3 feet). Note that this uplift is distributed gradually over the ground surface above the repository. This 1 meter (3.3 feet) does not represent a differential movement over a short distance that would cause significant shear distortion and cracking of the caprock. The finite element model used by Loken et al. (1984) accounted for heterogeneities of thermomechanical properties. Loken et al. (1984), ignored discontinuities such as joints and fissures not only because of lack of data, but also because their omission would overpredict the thermomechanical response. The calculations of Loken et al. (1984) overpredict the thermomechanical responses in another way. Because Loken et al. (1984) made an elastic calculation, they ignored any stress relief due to creep closure of repository excavations and compaction of room backfill. Therefore, much of the stress driving uplift would dissipate in the creep closure of the repository rooms and consolidation of crushed salt backfill and it is concluded that repository-induced uplift or subsidence will be less than a few meters and will be distributed over the land surface and will cause no environmental concerns. Because the uplift will be spread over thousands of years and progressively decrease after about 1,000 years, it should not significantly affect surface drainage gradients or ground-water flow patterns, nor should it cause major discontinuities in the salt, caprock, or overlying sediments that would provide possible pathways for ground-water intrusion.

Data are not sufficient to determine which type of movement (subsidence or uplift) will dominate at any particular time. They are compensating effects, however, and could result in little or no long-term net change in surface elevation. As was addressed in Chapter 3, the probability of seismic activity (Section 3.2.5.2), igneous activity (Section 3.2.5.3), and regional uplift or subsidence (Section 3.2.5.4) is low. Because repository development is not

expected to influence these geologic phenomena, no adverse impacts are expected. Further evaluation of regional and local seismicity, suspected local faults, and regional structure will be conducted during the site characterization phase as described in Section 4.1.1.2.

In the absence of impurity and heat, salt has negligible permeability. In the presence of heat, brine migration occurs. Within crystals, the most probable mechanism is thermal-gradient-induced migration of brine inclusions, in which salt dissolves at the hot interface and precipitates at the cooler interface after diffusing through the inclusion (Jenks and Claiborne, 1981, ORNL-5818, p. 15). This brine moves up the temperature gradient and stops at the crystal boundary. Under high enough temperature gradients, large brine inclusions can move across crystal boundaries, but it is thought that repository gradients will be too small to drive this type of migration. Consequently, any significant movement of liquid brine from crystal boundaries towards the emplacement hole must take place through connected pores and microfractures. Such movements could result from pressure gradients, temperature gradients, capillary action along previously unwetted surfaces, and water vapor moving under vapor pressure gradients.

Jenks and Clairborne (1981, ORNL-5818, pp. 117-118) calculated maximum rates of brine migration to be about 25 milliliters per year (0.6 fluid ounces) or less for packages of CHLW in domal salt, with the total amount of in-migration during the first 100 years after emplacement to be about 2.5 liters (0.7 gallons).

Providing care is taken to locate the emplacement holes in good quality salt containing a minimum amount of brine and impurities, brine migration should be limited to the immediate vicinity of the waste canisters. Hence, brine migration is not expected to have any significant effect on the physical environment.

The above discussion on brine inclusions does not consider "brine pockets." Brine pockets are relatively large volumes of entrapped brine which are found in some salt deposits and have accumulated in the intergranular spaces since the formation of the deposit. Efforts will be made to detect brine pockets during the site investigation phase and, if they occur, they will be dealt with during repository design or operations.

The thermal pulse from the repository has been estimated to be 1-2 C at the base of the shaft after 1,000 years (Kelsall et al., 1985, BMI/ONWI-562). This small temperature change should have a negligible effect on the stability and the deformation of the shaft, as well as minimal effect on the shaft seals.

Potential for impacts on salt dissolution has been evaluated. The presence of caprock over the dome indicates natural salt dissolution by ground water. Using conservative estimates for the timing of caprock development and the stratigraphy over the dome, the salt does not appear to have experienced significant dissolution since late Oligocene time (Section 3.2.5.7, Dissolution). Using the appropriate ground-water seals discussed under Hydrology (Section 5.2.2), development, operation, and decommissioning of the repository will not cause renewed salt dissolution or create possible pathways of ground-water infiltration.

Repository development is not expected to activate growth of the salt dome, and adverse impacts on repository development are not expected from this phenomenon. As discussed under Salt Dome Development and Geometry (Section 3.2.5.6), salt dome growth occurs over a period of millions of years and continues until the geologic forces causing the growth cease. Because these forces have ceased in the Mississippi Salt Basin, growth of Richton Dome is believed to have essentially ceased (Section 3.2.5.6).

5.2.1.2 Soils

Impacts on soils will result primarily from site construction and to a lesser extent from site operation. Site decommissioning and closure primarily involve site dismantling and restoration activities, which will mitigate long-term potential adverse effects on the soil.

5.2.1.2.1 Construction. Repository development includes site preparation, surface facility construction, shaft construction, and repository excavation (Section 5.1). Primary activities that will affect soils include the following:

- Construction of channel system to divert drainages around the surface facilities
- Removal of vegetation and topsoil and grading of 165-hectare (407-acre) area for surface facilities
- Construction of retention ponds and mud pits
- Transport and onsite storage of salt and other materials excavated from the shafts and subsurface openings
- Construction of access corridors for roads, railroads, and utilities over an area of approximately 196 hectares (483 acres).

Before construction of surface facilities, the entire area will be cleared, and drainages will be rechanneled and graded. The site layout and orientation (Figure 5-2) will be designed to minimize earthwork and disturbance of surface features to the extent possible. However, local topography and drainage patterns will be changed, an undetermined amount of topsoil will be stripped, and subsoil horizons will be mixed. Stripped topsoil will be stored on site for later site restoration activities (see Decommissioning and Closure, Section 5.2.1.2.3).

The disturbance of soil horizons and storage of topsoil may have several as-yet-unquantified impacts as follows:

1. Removal of vegetation and the organic surface layer may increase wind and water erosion.
2. Mixing topsoil with more alkaline lower soil horizons may reduce soil fertility.
3. Mixing and compacting soil horizons may reduce permeability, infiltration capacity, and hydraulic conductivity, possibly causing an increase in surface-water runoff and resultant erosion.
4. Stockpiled topsoil may suffer loss of fertility over the period of repository operation.

Approximately 2.8 million cubic meters (3.7 million cubic yards) of fill and 3.7 million cubic meters (4.8 million cubic yards) of excavation are estimated to be required for site preparation (Section 5.1.2.3). In some areas, only a portion of the upper soil horizon will be removed, while in others a greater depth of soil may be affected. Stripped topsoil will be stockpiled on site, and any other excess soil will be used to form a berm around the site or will be disposed of off site. In areas where fill is required, existing soil will be covered with overburden from excavation or with materials imported to the site for establishing suitable foundation conditions or surfaces.

Compaction of soil exposed by grading, removal of vegetation, and paving will reduce the infiltration rate of precipitation, possibly causing an increase in surface-water runoff and resultant soil erosion. Assuming worst case conditions, the universal soil loss equation indicates that approximately 852 metric tons per hectare per year (380 tons per acre per year) may be lost through erosion during repository construction. However, this estimate is not likely to be realized in practice because of both natural and human-induced conditions. The natural conditions include the rills, ridges, and other surface irregularities that tend to channel flow, decrease surface-water flow velocities, or create barriers to soil erosion. Also, several engineering measures can be adopted to minimize soil loss:

- Place dikes or culverts around or through the site to channel surface-water flow

- Diminish slope angles, thereby decreasing runoff-water velocities
- Place material over the surface of the soils to absorb the energy of precipitation and runoff
- Provide catchment basins on site
- Replace topsoil and follow with reseeding and mulching.

In addition, compacted soils will be ripped and disked to enhance surface-water infiltration and reduce erosion. Topsoil will be salvaged, stockpiled, and protected from erosion by mulching and reseeding. It will later be replaced over stripped areas, which have been scarified, to assist in site restoration activities. Soils will be replaced and graded to approximate preconstruction, topography, and horizon depths. Soil amendments will be used to increase soil fertility for revegetation activities, which include mulching and reseeding.

Approximately 2.7 million metric tons (3.0 million tons) of salt excavated from the shaft and underground facilities will be stored on site in a 21-hectare (53-acre) storage area as discussed in Section 5.2.1.3. Possible impacts from salt handling and transfer during construction are discussed in Section 5.2.10.

In addition to these major construction activities, minor effects to the soil may result from spills or leaks of fuel and oil and seepage of contaminants through the salt pile liner or pond liners. These impacts and mitigating measures are addressed in Section 5.2.10.

5.2.1.2.2 Operation. Operation of the repository will require continued maintenance of the salt pile and retention ponds. The ground-water monitoring system (Section 5.2.2.2) will detect seepage of contaminants from these areas into the soil. If necessary, corrective measures will be implemented.

The small quantity of wind-borne salt generated by the salt handling operations is not expected to be detrimental to the offsite soils. The rate predicted at 0.8 kilometer (0.5 mile) is 1 kilogram per hectare (0.9 pound per acre) of salt per year. The rate rapidly declines with increasing distance; between 1 and 2 kilometers (0.6 and 1.2 miles) only 0.1 kilogram per hectare (0.09 pound per acre) per year is expected (Section 5.2.10.2). By comparison, sea spray from Galveston Bay along the Texas Gulf Coast deposits approximately 250 kilograms per hectare (225 pounds per acre) of salt per year at a distance of between 750 and 1,100 meters (0.49 and 0.73 miles) (Wiedenfeld, 1978). Despite addition of airborne, soluble salt from nearby cooling towers, this Texas study showed that water moving through the profile removed additional soluble salts.

Much of the data on the effects of salt introduced to soil comes from studying roadside soils impacted by large quantities of salt from road deicing. A typical winter road salt application is between 18 and 23 metric tons (20 to 25 tons) per 1.6 kilometer (1 mile). This rate of salt application equals approximately 4,400 kilograms per hectare (4,000 pounds per acre) for a 30-meter (100-foot) right-of-way (Hutchinson, 1973). Deleterious effects to roadside soils are significant and include colloidal dispersion, reduced aggregation of alkaline soils, nutrient imbalance, and poor drainage (Hutchinson and Olson, 1967; Scharpf and Srago, 1974).

The expected annual deposition of windborne salt at the repository will be 250 times less than Gulf Coast deposits of sea spray salt and over 4,000 times less than a typical application of deicing salt. Thus, when compared to the above amounts of salt application, the amount of windborne repository salt is a relatively minor quantity.

The effects of this small amount of additional salt to the soil will probably be mitigated by the relatively high rainfall in the area. When sufficient quantities of water move through the soil profile, soluble salts will not accumulate because leaching will remove soluble salts in proportion to their concentration in the soil profile (Wiedenfeld, 1978).

Nevertheless, soil salinity will be monitored during repository construction and operation. The monitoring program will include periodic sampling and analysis of soils, surface and ground water. Salt concentration impacts can be reduced by adding calcium in the form of gypsum to flush excess sodium from the soil (Buschena and Sucoff, 1980; Leopold and Willing, 1984). Studies will be conducted during site characterization to quantify the amount of water that would be required to implement this measure.

5.2.1.2.3 Decommissioning and Closure. This phase will involve completing backfill of the underground facilities, sealing the drifts and shafts, dismantling the surface facilities, and regrading the site to gentle contours as discussed in Section 5.1.4. Those activities that potentially would impact soils include regrading of the surface facilities and the additional salt handling involved in moving salt from the salt pile to backfill the underground facilities.

Backfilling the underground facilities will involve taking salt from the salt pile to the shaft for transport to the underground facilities. Breaking the salt crust and loading, transporting, and unloading the salt would increase potential for wind-borne transport that could contaminate surrounding surface soils. As discussed in Section 5.2.1.2.2, such impacts are not expected to be significant.

Regrading of the surface facilities will involve disturbance of surface soils and temporary exposure of soils that previously would have been covered by the surface facilities, paved areas, ponds, and stockpile areas. This could result in increased soil erosion similar in magnitude to that expected during repository construction (Section 5.2.1.2.1). Reclamation will be completed by regrading to gentle contours, scarifying the surface, replanting with native vegetation, and mulching. Following reclamation, erosion conditions are expected to be similar to those before construction.

5.2.1.3 Mineral Resources

Surface and subsurface mineral rights to the controlled area will be held by the DOE throughout site construction, operation, and decommissioning. This control will continue into the postclosure phase for an undetermined period to prevent potential breach of the repository by incompatible activities such as mineral exploration and development. The impact of this ownership will be the elimination of any mineral resources in or under the controlled area from exploitation.

Avoidance of current resource production was a condition for site selection during the site screening process, and the restriction on development of currently uneconomic mineral resources is expected to have minimal local and regional effects. As discussed in Section 3.2.8, proven reserves within the site are limited to salt, sand and gravel, and underground storage space, all available elsewhere in the region. The potential for future brining or mining of salt is high; however, these potential resources are not unique to Richton Dome and no major adverse effects to regional resource development or the economy are expected. The potential for lignite and sulfur resources is considered highly speculative and negligible, respectively. There are no known significant reserves of oil and gas within the controlled area and the potential development of these resources is rated as speculative to poor. Therefore, there will be a very limited impact on mineral resource development.

5.2.2 Hydrology

Hydrologic and water quality impacts on surface-water and ground-water resources that could result from development of a nuclear waste repository at Richton Dome are discussed in this section. Impacts and mitigation measures are summarized as appropriate.

5.2.2.1 Surface Water

The existing hydrologic conditions in the Richton Dome vicinity are detailed in Section 3.3. In assessing potential effects of repository activities on surface-water hydrology and water quality, the following were considered:

- Possible stream diversion and channelization that may in turn locally affect flow volumes and rates

- Direct loss of federally classified wetlands

- Increases in suspended sediment concentration, turbidity, and nutrient concentration because of clearing, grading, stockpiling of excavated material, and filling, associated with construction of repository facilities and improvements to transportation corridors

- Degradation of water quality because of surface runoff or windblown salt from salt handling operations

- Degradation of water quality because of spills of fuels, lubricants, or other contaminants.

The Richton Dome area falls within the Richton, Rhodes, and Ovett quadrangles (USGS, 1982b, 1973, 1982a, respectively). These areas have been included in the National Wetlands inventory conducted by the U.S. Fish and Wildlife Service (FWS) (Hepner and Nault, 1984). The FWS has also been consulted (Neff, 1984) on the identification, location, and extent of any wetlands in the vicinity of the site that may be protected under Executive Order 11990, "Compliance with Wetlands Environmental Review Requirements," or related legislation. Examination of National Wetlands Inventory maps for the region (FWS, 1983) indicates approximately 6.6 hectares (16.3 acres) will be permanently impacted and approximately 0.9 hectare (2.2 acres) will be temporarily affected by development of the repository. These wetlands are located in the Fox Branch Creek drainage, and the Fox Branch Creek is ephemeral.

The classes of wetlands expected to be affected are characterized as follows:

- Palustrine forested wetland (PFO 1/4C): mixed broad-leaf deciduous/needle-leaf evergreen, seasonally wet for extended periods of time -- 5.1 hectares (12.7 acres)

- Palustrine emergent wetland (PEM 1A): persistent, temporary wetland, limited surface water -- 1.5 hectares (3.6 acres)

- Palustrine forested, intermittent riparian channels (PFO 1/4A): temporary wetland -- 0.9 hectare (2.2 acres).

Cut and fill activities associated with site preparation will result in the direct loss of these wetlands. The PFO 1/4A class, intermittent riparian channels, should be reestablished following channel diversion. Streams within the Richton Dome area are intermittent, functioning primarily as drainage courses. Thus, since flows are naturally interrupted, the planned channel diversion should have a minimal impact in a biological sense. Consideration will be given to channel sinuosity, gradient, and bank stabilization to mitigate against increased current velocities and associated bed erosion. Buffer strips at least 7.5 meters (25 feet) wide will be placed between the relocated channel and the construction site to provide added protection against sediment loading from site runoff. Channel modification will follow procedures outlined by Simpson et al. (1982) and the U.S. Department of Transportation (1979). Channel relocation will take place before site clearing and grading activities, so that, when coupled with onsite runoff controls, sediment loading will be kept to a minimum. Implementation of mitigation measures such as the use of coffer dams around excavated foundation areas for the new bridge crossing at Beaver Dam Creek, and other erosion controls, would greatly reduce potential water-quality impacts on nearby streams.

5.2.2.1.1 Construction. Because water supply needs for the repository will be met primarily by offsite wells, no surface water will be withdrawn or consumed. Impacts on surface water due to grading will be confined to potential alteration of the surface hydrologic regime and possible degradation of water quality both on site and off site. Such impacts are expected to be local, temporary, and minor.

Ponding of surface runoff in sedimentation ponds and salt pile runoff ponds will reduce surface runoff to local creeks. The extent and magnitude of this impact will be determined after site-specific engineering design plans have been finalized. Any stream diversion and rechannelization work will not impact runoff quantity since their flow will not be diverted from the watershed. Since none of the area above the dome lies within the 100-year floodplain, as discussed in Section 3.3.1.3, construction and operation of the repository will not have an impact on the floodplain management of the region. The Fish and Wildlife Service and the State wildlife agency will continue to be consulted on the disturbance and modification of waterways, in compliance with the "Fish and Wildlife Coordination Act" (16 USC Sections 661-666c).

Surface-water quality may be adversely affected through wind-borne transport of salt, from either direct deposition of this salt on surface waters or indirect runoff from salt-contaminated soils. Significant degradation of surface-water quality could potentially result from catastrophic releases of contaminated runoff from the sedimentation and salt pile runoff retention ponds. This could result from a major storm event which exceeds design capacity of the ponds, thus causing an overflow of their embankments. In the event of an overflow, there would be a diluting flush which would minimize any water-quality effects. Impact quantification will be determined from repository pond and embankment final design, and from surface flow data collected during site characterization. The potential for significant water-quality degradation from spills of fuels and other contaminants should be minor with the implementation of safeguard measures.

Mitigation measures planned to protect surface-water quality include the following:

- Construction of dikes for erosion control, use of water spraying for dust control, and use of coffer dams and culverts where appropriate
- Design of sedimentation ponds to capture and retain surface runoff from disturbed areas
- Implementation of planned channel diversion including provision of buffer strips
- Design of storm-water detention ponds and a salt pile runoff pond to hold the storm runoff from a 100-year, 24-hour storm event
- Periodic offsite disposal of accumulated wastewater
- Control of releases of salt particulates through repository air shafts by installation of filters
- Control of salt contamination resulting from spills of salt at transfer points and enroute to disposal sites through implementation of appropriate safeguards.

5.2.2.1.2 Operation. Impacts to surface-water resources will be similar to the types of water-quality degradation described above for construction activities. However, soil erosion and resulting turbidity in surface waters will be minimal, since the previously exposed soils will have been revegetated or artificially surfaced.

Although potential impacts could result from salt contamination during operational handling of salt, the chances of degradation of the water quality of the adjacent streams and water bodies by windblown salt would be small. Runoff from the repository site, where deposition rates are highest, will be retained and discharged off site only if it meets environmental discharge standards. The amount of salt deposited in the adjacent watersheds will be less than 1,800 kilograms (2 tons) per year, primarily affecting Beaver Dam Creek, Fox Branch, and Linda Creek. Conservatively assuming that all of the deposited salt will dissolve and run off with surface flows, the average annual increase in salinity in the surface runoff for these three creeks was estimated to be 0.1, 0.4, and 0.8 milligram per liter, respectively. Reported TDS concentrations for these creeks range from 32.0 to 43.0 milligrams per liter (Table 3-18). Thus, these increases in salinity would represent only minor changes in the water quality of the adjacent streams.

Another source of potential water-quality impacts is drainage from the salt pile runoff pond. The repository plans call for the diversion of all runoff from the salt pile into a retention pond. Because precipitation exceeds evaporation, excess salt-contaminated water will have to be disposed of either by discharging to local streams or by trucking to an existing licensed brine injection well. The method of disposal depends upon salt concentration.

Prediction of the salt concentrations within the pond has not been possible with available data. As the salt pile is initially built, rainfall may infiltrate through the salt and become salt-saturated (300,000 to 400,000 milligrams per liter). After the salt forms a crust, rainwater is expected to sluice over the surface of the crust and dissolve very little salt. Rainfall directly in the pond will serve to dilute its salt concentration, while evaporation will increase the concentration. It is the DOE's plan to monitor salt concentrations within the retention pond and, if the salt concentration is below 50 milligrams per liter, release water to surface streams in accordance with applicable regulations. Such a level is well below potable limits, and is therefore not expected to adversely affect water quality or downstream water uses.

If salt concentrations exceed 50 milligrams per liter, the DOE may truck the salt water to an existing licensed brine injection well (Section 5.1.2.3).

Other possibilities exist to mitigate salt pile runoff. The salt pile could be covered to reduce salt runoff from the pile. Only the pile runoff from uncovered areas would then require disposal, and the DOE believes that any underground injection requirements would thus be limited.

Another alternative for the elimination of salt runoff is to employ multiple effect evaporators, such as are used in the brining industry, to evaporate rainwater (Jenkins, 1984). Such evaporators require about 0.2 to 0.3 kilogram of steam per kilogram of rainwater (0.2 to 0.3 pound of steam per pound of rainwater). If all the pile runoff were evaporated, the process would require about 10,900 kilograms (24,000 pounds) of steam per hour. The planned repository steam plant size could be increased by about 20 percent to provide that steam.

5.2.2.1.3 Decommissioning and Closure. Surface-water-quality effects during this phase will be similar to those occurring during construction. Minimal increases in sedimentation, turbidity, and nutrient concentration can be expected. Limited salt contamination could occur when stored salt is transported to the underground repository for backfilling and for offsite disposal. These effects will be local and temporary.

5.2.2.2 Ground Water

The existing geohydrologic conditions in the Richton Dome vicinity are detailed in Section 3.3. Potential effects on ground-water flow and ground-water quality include the following:

- Lower potentiometric levels due to ground-water withdrawal for construction and operation
- Alteration of local recharge or discharge rates resulting from site preparation, including site clearing, grading, filling, and paving
- Disruption of the overdome ground-water flow system as a result of shaft construction
- Aquifer contamination resulting from hydraulic connections developed during shaft excavation
- Degradation of ground-water quality due to seepage of salt pile or salt-contaminated runoff, petroleum products, and other contaminants
- Degradation of ground-water quality due to deep well injection of salt pile and salt-contaminated runoff.

5.2.2.2.1 Construction. The withdrawal of ground water will have the greatest potential for impact on the ground-water flow regime. The potentially greatest impact on the ground-water flow regime will be the withdrawal of ground water for drilling activities. Local potentiometric levels in the Upper Aquifer may be lowered because of water withdrawal; however, the Upper Aquifer unit is expected to yield sufficient water for peak demand without significantly stressing the ground-water system. Ground-water withdrawals and reduction of potentiometric levels could result in leakage from the underlying saline aquifer into the Upper Aquifer units; however, this condition is not expected.

The effects of ground-water withdrawals for the construction and operation of the repository were estimated using the Theis equation (Theis, 1935, pp. 519-524). This method of analysis provides a conservative estimate of water-level declines, because the effects of leakage from adjacent beds or recharge from precipitation are not included. Based on the results of aquifer tests southeast of Richton Dome (Newcome, 1971, p. 36), a transmissivity of 560 square meters per day (4,000 square feet per day) and a storativity of 0.01 (dimensionless) are indicated and reflect values which may be encountered southwest of Richton Dome. Table 5-7 presents the decline in the water level at various distances from a single water supply well which would occur (1) at the end of the construction period: 6.25 years at 45 liters per second (700 gallons per minute); and (2) at the end of operation: 26 additional years at 15 liters per second (250 gallons per minute) (Table 5-1).

Increased pumpage during the last 30 years from the Catahoula Formation, which is included in the Upper Aquifer unit, has induced water level declines of 0.3 meter (1 foot) per year in Forrest County west of Richton Dome (Shows et al., 1966, Figure 29; and Newcome, 1975, Figure 10). Based on this rate of decline, saturated thicknesses near the site may decrease an estimated 4.9 meters (16 feet) by the year 2000. This decline is not expected to affect local water supply wells.

Site preparation, particularly grading and clearing, may alter local recharge or discharge rates. Vegetation removal and soil disturbance may alter the effective infiltration of surface water to ground-water systems. Also, retention ponds, storage areas, structures, and paved areas will make the surface facility area virtually impermeable. However, there should be no drastic change in recharge or discharge rates since the 165-hectare (407-acre) surface facility area is small compared to the total aquifer unit outcrop.

Repository shafts will be designed and constructed to avoid potential impacts to the surrounding ground-water system (Sections 5.1.1.3 and 5.1.2.4). An annulus around the shaft excavation area will be frozen to prevent sediment collapse and ground-water inflow (see Section 4.1.2.2 for a description of the freezing technique). Freezing the ground will not affect the ground-water flow system outside the frozen area (freeze wall).

While the potential exists for contamination between aquifers during shaft construction, this will be minimized by the freeze wall and other construction techniques. As shaft walls are completed, liners and water seals will be used to block water flow along the perimeter of the shaft and thus to prevent aquifer cross-contamination. In addition, monitoring wells around the shaft will be sampled to detect cross-contamination. If necessary, remedial measures such as grouting or pumping can be implemented.

Since effluent from the onsite sewage treatment plant and salt pile and surface runoff will be stored in appropriate retention ponds, ground-water quality will not be affected unless there is an unlikely accidental release. Accidents that could degrade ground-water quality include retention pond leakage and spills of fuel oil or other contaminants. Ground-water monitoring wells will be sampled regularly to detect contamination caused by leakage or salt infiltration. A double liner system with collector drains is planned for the salt runoff pond and salt pile. This system will permit recovery of leaked fluids by pumping from the drainage layer. Impacts on ground-water quality due to infiltration of precipitation through salt-contaminated soils are expected to be minor. Impacts would be similar to those during operation, which are discussed below.

Table 5-7. Decline in Water Levels Resulting From Repository Construction and Operation, Richton Dome

From Well	End of Construction Drawdown		End of Operation Drawdown	
	Meters	Feet	Meters	Feet
At the well	17.7	58	6.7	22
1 mile	3.7	12	1.8	6
5 miles	1.2	4	0.9	3
10 miles	0.3	1	0.6	2

5.2.2.2.2 Operation. Potential impacts could arise from ground-water withdrawals, salt storage/disposal, leaks or spills, and ground-water infiltration of wind-borne salt as described above for construction activities. Ground-water demands will be reduced to about 15 liters per second (250 gallons per minute) from the peak construction demand of about 45 liters per second (700 gallons per minute) (Section 5.1). The impact of ground-water withdrawals on ground-water levels near the supply wells during the operational phase was analyzed and is presented in Table 5-7. Since the thickness of the Upper Aquifer unit is 300 to 400 meters (980 to 1,300 feet) in the vicinity of Richton Dome (see Section 3.3.2.1), the declines depicted in Table 5-7 are not expected to affect local water supply wells.

Changes in ground-water quality caused by infiltration of precipitation through soils contaminated by windblown salt are expected to be minor. Model studies of repository operation show that deposition of salt will be on the order of 1 kilogram per hectare (0.9 pound per acre) per year in the repository area, decreasing to 0.1 kilogram per hectare (0.09 pound per acre) per year at a distance of 1 to 2 kilometers (0.6 to 1.2 miles). If all this salt were carried to the water table and distributed in the top 3 meters (10 feet) of the saturated zone, it would represent an annual increase in salinity of about 0.01 to 0.1 milligram per liter in the ground water beneath the site area. Even over the 26-year operating life of the repository, this would represent an increase of less than 3 milligrams per liter. It is unlikely that even this small increase would ever occur, since some of the salt would be removed by runoff and carried to the runoff retention ponds or to surface-water courses.

5.2.2.2.3 Decommissioning and Closure. Surface structures will be removed and the site will be regraded to approximate preconstruction conditions (Section 5.1.4). These activities will be performed in accordance with applicable regulations. Ground-water protection measures will be incorporated as appropriate.

In summary, waste repository development at Richton Dome poses no long-term threat to surface-water or ground-water quality. The hydrologic regime will not be impacted in a major way. The most significant potential water-quality effects are associated with the handling and disposal of salt-contaminated runoff. The salt management system will be given special attention to ensure adequate protection of water resources.

5.2.3 Land Use

The major land-use impacts expected to occur within the Richton Dome area during repository development include a loss of forest lands within the restricted area, restriction of land-use activities within the controlled area, and increased residential and commercial development in adjacent communities. These impacts are discussed below for each phase of repository development: construction, operation, and decommissioning.

5.2.3.1 Construction

As described in Section 5.1.1.5, prior to repository construction the DOE will obtain title to the dome area, a surface area of approximately 2,222 hectares (5,489 acres) which has been previously defined (Section 3.4.1 and Figure 5-2). The direct and indirect impacts on land use will be the greatest during repository construction. During this phase, the surface facilities area, access roads, and railroad spur corridors will be cleared and graded in preparation for construction, and land use will be controlled within the dome area. The increase in residential and commercial use will also be greatest during construction; these population-related impacts are discussed in detail in Section 5.4, "Expected Effects on Socioeconomic Conditions."

Forest. As described in Section 3.4.1, the Richton Dome area is about 65 percent forest land, and at present the land use within the 165-hectare (407-acre) restricted area is predominantly commercial forest.

Approximately 25 percent of the total 360 hectares (890 acres) required for repository surface facilities and utility corridors will have been previously disturbed during site characterization, and the loss of the remaining 75 percent of the affected area constitutes a

small portion (about 0.15 percent) of the total forested land in Perry County. These estimates of impact are reasonably conservative; the extent of actual land-use preemption and long-term impact will be substantially smaller because some of the land to be disturbed during repository construction has recently been cleared or reseeded, and because any marketable timber remaining within the disturbed areas will be harvested for sale before site preparation. In addition, some of the disturbed area may be returned to its prior use after decommissioning and closure.

A portion of the rail access route utilizing the abandoned Illinois Central Gulf (ICG) rail line passes through the De Soto National Forest. ICG has retained ownership to the rail line through the Forest. The DOE will determine current ownership and will consult with the Forest Service and private landowners as necessary to acquire rights. The Federal Land Policy and Management Act of 1976 (43 USC Sections 1761[a] [6] and [7]) allows the Secretary of Agriculture to grant rights-of-way for transportation through national forests. Implementing regulations (36 CFR 251.53) provide for issuance of special use authorization for transportation rights-of-way.

The representative access road, as described in Section 5.3.2, may pass through two farming areas. However, final alignment of this road will be selected so as to minimize the impact on farms.

Prime Farmland. As discussed in Section 4.2.1.1.1, approximately 46 hectares (115 acres) or 2.3 percent of the soils within the Richton Dome area are classified as prime farmland (Brooks, 1985). The DOE has filed Form AD 1006 in compliance with the Farmland Protection Policy Act (7 USC Sections 4201-4209) and has evaluated the effect of the repository on prime farmland. Soil protection measures will be taken, as described in Section 5.2.1.1 and Section 5.1, to minimize impacts. The DOE will compensate farmers for any removal of farmland or loss of productivity to the extent allowed by law.

Urban and Other. Land-use impacts are expected to be minimal with respect to Hattiesburg, Laurel and Petal. As discussed in Section 5.4.1, these areas will experience a 2 to 3 percent increase in population in 1995 due to in-migration. This is expected to be within their capability to absorb new residents and will result in minimal change in land-use patterns.

Richton, however, could experience some alteration to its land-use development. The Richton, Mississippi, Comprehensive Plan (Southern Mississippi Planning and Development District, Inc., 1974) identifies the town's long-range goals as annexation of "all feasible areas adjacent to Richton in order to increase the tax base and provide stable economics for the city." In addition to this goal, increased industrial development is also identified as a long-term goal (BNI, 1982, ONWI-193, p. 155). As discussed in detail in Section 5.4.1, Richton will experience a 37 percent increase over its baseline population in 1995 due to in-migration. This may result in urban expansion beyond that anticipated. One land use impact to the town of Richton will be in that portion of the town which would be located within the controlled area. If the controlled area boundary retains its present location, several existing houses and a church could be affected as residents within this area may have to be relocated. The town of Richton could lose a small area of land zoned for residential use. Any displaced residents suffering financial losses would be compensated. As indicated in Section 5.4.1.4, all displaced residents would be compensated under the Uniform Relocation Assistance and Real Property Aquisition Policies Act of 1970. Grants-equal-to-tax payments would be available to the community of Richton to compensate for any taxes lost from lands within the controlled area (Section 5.4.5.1).

The areas of the town of Richton next to the controlled area are also zoned for residential use. Since these areas would be more than 3.2 kilometers (2 miles) from the repository surface facilities, it is not anticipated that there would be a conflict between the residential land use and activities at the repository. The DOE has no plans to develop that portion of the controlled area which is next to this residential land. The presence of the controlled area should not otherwise affect present deed, development, or zoning restrictions in the adjacent residential areas.

The potential land use impact to the town of Richton would be the restriction of residential development to the west of the town. This would be incompatible with the Richton Comprehensive Plan, which anticipated low and medium density residential development for the area to the west of the town's boundary (Southern Mississippi Planning and Development District, 1974). However, since approximately 58 percent of the town is undeveloped, as indicated in Section 3.4.1, there should be adequate land within the town's boundary to accommodate anticipated increases in housing. If additional residential land is required, development could proceed to the south of the town. Future industrial and commercial development should not be affected because these two land uses will continue to be concentrated in the eastern half of the community, where there is ample area for expansion.

In conclusion, the town of Richton may experience significant land use impacts if the repository is constructed on the Richton Dome. With the implementation of sound urban planning and the use of programs to compensate individuals and entities, these impacts should be mitigatable.

There should be no access impacts on airspace which conflict with the Camp Shelby military operation area (Area 170A), as discussed in detail in Section 4.2.1.1.2. The principal access routes to be used for the repository, Mississippi State Highways 15 and 42, will not interfere with U.S. 98 or State Highway 29, the major access roads to Camp Shelby. Since this area is over the southern portion of the dome, while repository surface facilities are in the northern portion of the dome, no conflicts are expected.

Salt Deposition. Salt excavated during construction and operation will be temporarily stored on site. Any potential impact on land use would result from the loss of forest or crop productivity caused by the deposition of fugitive salt. An evaluation of salt-related impacts is described in detail in Section 5.3 (also see Section 5.4.2 on economic impacts). Insignificant effects on forest and crop productivity are expected because only a small area is to be impacted from the salt pile and only minor levels of salinity buildup, which can be accommodated without having adverse impacts on crop and tree growth, are expected. Transport of salt by rail is not expected to affect land use along the routes because of the use of various enclosures and the use of dust collection equipment to reduce airborne particulates (Section 5.1.1).

Wetlands. The site is bisected by branches of the Fox and Pine streams. Wetlands within the site exist principally in narrow banks along either side of these streams and their many small tributaries (Goldman, 1985). The disturbance of 7.5 hectares (18.5 acres) of federally identified wetlands within the area of repository development constitutes a potential land-use conflict. (See 10 CFR Part 1022 for Compliance with Floodplain/Wetlands Environmental Review Requirements.) Repository development will temporarily affect 0.9 hectare (2.2 acres) and will result in the direct loss of 6.6 hectares (16.3 acres). See Section 5.2.4 for a further description of wetland impacts.

Recreation. Lands associated with the Richton Dome site are sometimes used for recreational purposes such as hunting. The purchase of this site may preclude such activities. However, other nearby recreational areas are available. The boundary of the De Soto National Forest lies 5.5 kilometers (3.5 miles) from the center of the site. This forest contains the Leaf Wilderness Area and Black Creek Wilderness Area, which are over 32 kilometers (20 miles) from the site (Section 3.4.1). There will be no direct impacts from repository development on these areas. Moreover it is unlikely that development and operation of the site will significantly change the nature of these areas or available recreational resources pursuant to the requirements of the Wilderness Act (16 USC Sections 1131-1136) and the National Forest Organic Legislation (16 USC Section 475).

Residences. Repository development will have a direct impact on private land use in the controlled area. A number of residences will have to be relocated (Section 5.4.1.4).

Based on further examination of salt management practices and results at the Retsof Mine, Texas Gulf & Potash Mine, Potash Corporation of Americas Canadian Mine, Project Gnome, and WIPP (Parsons-Redpath, 1984), no apparent changes in offsite land use were found. It is reasonable to expect similar results at the Richton Dome site based on this experience.

5.2.3.2 Operation

Repository operation will occur for 26 years and will continue to preempt land uses at the site for that time. The incremental land-use impacts associated with operation of the repository will parallel those changes that were discussed under Section 5.1.2, Repository Construction Activities. Some land uses, such as forestation (see also Section 5.4.2), may return in the nonrestricted portion of the controlled area if radiological risks do not exist and if these activities are not incompatible with repository purposes. There will be a long-term indirect effect on the town of Richton, which will experience changes in its urban and commercial land use. Because industrial development would be constrained on the western side of the town, some rezoning may be required to accommodate industrial development in other areas of the town.

As the repository begins and continues operation, it is expected that other industries and commercial establishments will locate in the region to support both the repository facility and the population increases in the nearby communities. Any increase in industrial and commercial activities will result in further population growth, which will necessitate the conversion of land used for other purposes to urban uses. See Section 5.4.1 for a discussion of expected amounts and locations of residential expansion.

The access road and railway spur will also continue to preempt foresting and some farming during repository operation. This may alter farm management practices.

5.2.3.3 Decommissioning and Closure

Decommissioning the repository will involve dismantling the surface facilities, the rail spur, and most access roads. During decommissioning and closure, the land disturbed for repository surface facilities and access routes will be cleared, graded, and revegetated. The salt pile area will be reclaimed, with topsoil restored and seedlings planted. Salt will be backfilled. Salt waste not backfilled will be transported and disposed at a licensed landfill (Section 4.2.1.1). Restriction on surface and subsurface activities in the controlled area will continue indefinitely. A long-term plan will be developed to determine the types of land uses permissible following decommissioning. Permanent markers placed in the dome vicinity should not interfere with land uses.

5.2.3.4 Mitigation

The DOE plans to minimize, where possible, disruption to use of land and will provide appropriate compensation for land acquired (Section 5.4.1.4 described mitigative measures). A mitigation plan will be developed to minimize land impacts. Topsoil will be replaced where it has been disturbed by repository development. Moreover, the application of recognized procedures for the physical and chemical reconditioning of disturbed soils within the repository site is expected to return the affected acres of prime agricultural land back to near their original prime agricultural status. See Section 5.2.1.1 for further discussion of the impacts of soil disturbances.

5.2.3.5 Cumulative and Long-Term Impacts

Repository development should have relatively few cumulative or long-term effects on land use. Some amount of land will continue to be controlled by the DOE. The amount of forest land lost would be small relative to the total available in Perry County (see Section 5.4). Any prime farmland not in the restricted area will be restored as close to its original condition as practicable, pursuant to the Farmland Protection Policy Act (7 USC Sections 4201-4209). There will be no direct impacts on the De Soto National Forest and its Wilderness Areas. Salt impacts on forest and crop productivity are expected to be insignificant (Section 5.2.5). See Section 5.4.2.3 for a discussion of economic impact on forests.

There may be a long-term indirect impact on the town of Richton in that land-use patterns will have evolved differently than originally predicted in the town's comprehensive plan, although development of the repository could contribute to some of the long-term goals of the

town. While some surface uses may be permitted, no subsurface activities will be allowed within the controlled area, precluding future resource development in the 2,222-hectare (5,489-acre) area. See Section 5.2.1.2 for further discussion on mineral impacts.

5.2.4 Terrestrial and Aquatic Ecosystems

The following assessment of ecological impacts resulting from construction, operation, decommissioning, and closure of a repository at Richton Dome is based on available information (Section 3.4.2). Future ecological studies outlined in Section 4.1.3.1 will provide additional information for a more specific evaluation of impacts.

5.2.4.1 Terrestrial Biota

5.2.4.1.1 Construction. The major impacts on terrestrial biota resulting from repository construction will be the direct loss of vegetation and wildlife habitat from the surface facilities area and its access and utility corridors. A total of approximately 165 hectares (407 acres) of land will be cleared for the surface facilities area and for the access corridors, of which about 28 hectares (68 acres) will already have been cleared during shaft construction.

Clearing activities will remove essentially all vegetation from designated areas, including various softwood and hardwood tree species. Where possible, all timber will be commercially harvested; all other vegetation will either be burned, buried, or disposed of off site under applicable regulations. Because of the recent clearcutting on the Richton Dome, only clearing for the transportation and utility corridors will result in significant but localized impact to vegetation.

As discussed previously in Section 5.2.2.1, 6.6 hectares (16.3 acres) of federally classified wetlands will be lost as a direct result of cut and fill activities associated with site preparation. This is a long-term and unavoidable impact associated with the development of this site. Expected impacts on nearby portions of the wetlands include changing water levels, altered plant species composition, and a reduction in productivity. Mitigation measures to be considered under 10 CFR Part 1022 (Compliance with Floodplain/Wetlands Environmental Review Requirements) could include enhancement and management of other wetlands within the controlled area or elsewhere as appropriate to compensate for those areas lost at Richton Dome. These measures will be developed in consultation with the Fish and Wildlife Service under the Fish and Wildlife Coordination Act (16 USC Sections 661-666c).

Existing wildlife habitats will be lost in the areas cleared for construction of the repository and its access corridors. Some mortality will occur to small mammals and reptiles during clearing; however, all birds and most mammal species may be displaced into nearby, undisturbed habitats. Some mortality within these displaced animal populations will occur because of increased competition for food and cover. As the construction of buildings and landscaping is completed, new wildlife habitats will be created.

In addition to direct losses of habitat and the displacement of wildlife species residing in affected areas, construction activities are likely to affect wildlife in adjoining areas due to noise. lights, and increased human presence. Loss of additional wildlife may result from increased roadkills, hunting, and poaching activities. These latter impacts will be controlled as necessary by worker education and awareness programs.

Approximately 2.7 million metric tons (3.0 million tons) of salt will be stored on site for up to 26 years. Windblown salt particles will be dispersed during the exhaust of underground mining operations and surface handling. The stabilized surface storage pile is not expected to contribute to windblown salt due to the rapid crusting characteristic of salt in the environment. Dispersion modeling of salt deposition suggests that maximum rates of deposition will be 1.0 kilograms per hectare (0.9 pounds per acre) less than 0.8 kilometer (0.5 mile) from the source. Deposition rates fall off rapidly from that point (see Section 5.2.10.2).

Although salt deposition will practically be unmeasurable beyond the controlled area, vegetation within this area may exhibit some symptoms of salt stress over the life of the repository. Plants exposed to elevated salt levels are affected by (1) osmotic inhibition of water absorption, (2) alteration of mineral nutritional balances in plant tissue, and (3) toxicity of specific ion concentrations, particularly sodium and chloride. Actual plant stress could be a combination of these mechanisms or cumulative. Environmental conditions, including moisture, temperature, and time of day, also influence the effects of salt. Vegetation with a low tolerance for salt is most likely to be adversely affected. Maas and Hoffman (1977) show that, in general, grasses tend to be more tolerant than broad-leaved plants. This subject is discussed in more detail in Section 5.2.10.2.4.

Loss of habitat through salt damage or other repository construction activities will be reviewed by the FWS under the Fish and Wildlife Coordination Act (16 USC Sections 661-666c). The DOE will continue discussions with the FWS to develop appropriate measures for reducing or mitigating any potential habitat loss. The DOE will also work with the FWS to identify and mitigate any impacts to bald and golden eagles pursuant to the Bald and Golden Eagle Protection Act (16 USC Sections 668-668d). The repository vicinity is within the known range of these raptors. Baseline biological surveys and site inspections will satisfy compliance requirements for this act.

Other impacts resulting from the development of linear corridors supporting site operations (railroad spur, transmission line, access road addition upgrades, and possible water and gas pipelines) may be anticipated. These are discussed in detail in Section 5.3.2.

5.2.4.1.2 Operation. Impacts on terrestrial biota resulting from operation of the repository include loss of vegetation and displacement of wildlife over the 26-year life of the project, potential contamination from pollutants, and a possible increase in roadkills.

The vegetation cover, existing habitats and associated animal species will be lost from 165 hectares (407 acres) of land for the operational life of the project. A limited amount of habitat could be regained on portions of right-of-way, which are reclaimed following completion of studies, and on landscaped portions of the repository.

During operations, wildlife in adjoining areas will be affected by increases in noise, light, and human presence. Loss of additional wildlife will result from increased roadkills, hunting pressure, and potentially, poaching. These impacts will be mitigated as necessary by worker awareness and education, busing of workers, and restrictions on recreational activities.

Possible impacts from deposition of windblown salt particles from salt transfer and handling will be similar to those experienced during the construction phase. These impacts will probably be measurable only on site, depending on deposition rate and susceptibility of species present. Windblown salt particles would be generated during salt mining and handling; due to natural crusting of salt in humid environments, the salt storage pile is not expected to contribute to any windblown salt. Saline runoff from the salt pile will be contained within a system of drainage ditches and an evaporation/retention pond. Since not all brine will naturally evaporate, it will be regularly transported off site to an appropriate disposal facility. Thus, adverse effects of salt deposition or runoff on vegetation or wildlife are not expected.

5.2.4.1.3 Decommissioning and Closure. Impacts on terrestrial biota resulting from decommissioning and closure of the repository would be minor; this phase of the project will generally promote the return of plant and animal species to the site. During decommissioning, wildlife in adjacent areas will continue to be affected by increased noise levels, lights, and human presence. Some wildlife will continue to be lost due to roadkills, increasing hunting, and poaching. As decommissioning is completed and site reclamation and revegetation efforts succeed, recovery of plant and animal populations may result from the increases in available habitat and habitat diversity. A description of site restoration procedures is presented in Section 5.2.1.1.

5.2.4.2 Aquatic Biota

5.2.4.2.1 Construction. Impacts on aquatic biota during repository construction could result from minor drainage relocation, temporary increases in turbidity and sediment load, minimal offsite transport of wind-borne salt, spills of toxic materials (e.g., fuels), and increased fishing pressure, which is considered a secondary impact.

The Richton Dome area falls within the Richton, Rhodes, and Ovett quadrangles (USGS, 1982b, 1973, 1982a, respectively). These mapped areas have been included in the National Wetlands Inventory conducted by the Fish and Wildlife service (Hepner and Nault, 1984). The Fish and Wildlife Service has also been consulted (Neff, 1984) about the identification, location, and extent of any wetlands in the vicinity of the site that may be protected under Executive Order 11990, Protection of Wetlands, or related legislation. Examination of National Wetlands Inventory maps for the region (FWS, 1983) indicates approximately 6.6 hectare (16.3 acres) will be lost and approximately 0.9 hectare (2.2 acres) will be temporarily affected by development of the repository. The classes of wetlands expected to be affected are characterized as follows:

- Palustrine forested wetland (PFO 1/4C): mixed broad-leaf deciduous/needle-leaf evergreen, seasonally wet for extended periods of time - 5.1 hectares (12.7 acres)

- Palustrine emergent wetland (PEM 1A): persistent, temporary wetland, limited surface water - 1.5 hectares (3.6 acres)

- Palustrine forested, intermittent riparian channels (PFO 1/4A): temporary wetland -0.9 hectare (2.2 acres)

Cut and fill activities associated with site preparation will result in the direct loss of these wetlands. The PFO 1/4A class, intermittent riparian channels, should be reestablished following channel diversion. Streams within the Richton Dome area are intermittent, functioning primarily as drainage courses. Although no fish or other important aquatic species are expected to be present in these ephemeral drainages, all aquatic flora and fauna present will be lost in relocated sections. Recolonization of new channels will be slow but eventually will replace aquatic populations lost in relocating.

During construction, temporary increases in turbidity and sediment loads may occur in streams near and within the Richton Dome area, including Fox Branch, Linda Creek and Beaver Dam Creek. The extent of the turbidity and sediment and their effect on resident aquatic biota will depend upon the timing, intensity, and duration of local storms. Consideration will be given to channel sinuosity, gradient, and bank stabilization to mitigate against increased current velocities and associated bed erosion. Buffer strips at least 7.5 meters (25 feet) wide will be placed between the relocated channel and the construction site to provide added protection against sediment loading from site runoff. Channel modification will follow procedures outlined by Simpson et al. (1982) and the U.S. Department of Transportation (1979). Channel relocation will take place before site clearing and grading activities, so that, when coupled with onsite runoff controls, sediment loading will be kept to a minimum.

The FWS and State fisheries department will be consulted on potential impacts to wetland habitats under the Fish and Wildlife Coordination Act. Losses of such areas may require appropriate mitigation as determined by those agencies. During site characterization studies, these wetlands and riparian areas will be surveyed using established field techniques such as the FWS Habitat Evaluation Procedures (see Section 4.1.3.1.2). Such studies may serve as a basis for conducting a floodplain/wetland assessment under 10 CFR Part 1022 (Compliance with Floodplain/Wetlands Environmental Review Requirements). Since ground water will be used to supply the estimated 0.14×10^9 gallons of water required for construction, existing surface water sources will not be affected.

Impacts of any construction activities resulting in spills and contamination from non-radioactive materials, such as salt, fuels, chemicals, and construction materials, will be

minimized through the use of the runoff/sediment retention system described in Section 5.1 and above in Section 5.2.4.1.2. Depending on the nature and duration of spills, impacts on aquatic biota could occur through contamination of both water and sediments.

Deposition of windblown salt from salt handling and transfer operations (see Section 5.2.2.1) may adversely impact aquatic biota if salt concentrations in surface waters reached harmful levels. Salinity of surface waters near Richton Dome will increase by less than 1.0 milligram per liter (1.0 part per million). Although prediction of specific effects is difficult because of the wide tolerance of many species for accepting elevated salt concentrations for short periods (Hale, 1973), this concentration is well below reported harmful levels for both fish and their food chain populations. Various studies have shown such levels to range from 400 parts per million for trout (Schraufnagel, 1967) to 9,100 parts per million for perch (California Department of Transportation, 1975) to 20,000 parts per million for crawfish (Loyacano, 1967).

Increased fishing pressure from workers may have some adverse impact on game fish populations in streams and lakes in the vicinity of Richton Dome. If necessary, restrictions can be placed on fishing within the controlled area, and State fish and game authorities can take action to prevent over-fishing in the surrounding area.

5.2.4.2.2 Operation. Potential impacts on aquatic biota during operation of the repository could result from windblown salt contamination of surface waters, spills of salt or other materials, and increasing fishing pressure, as discussed above under construction impacts (Section 5.2.4.2.1). Similar mitigation measures will be used during operations. Because fewer activities disturb ground and surface waters during facility operation (as compared with construction), the overall level of impact to aquatic biota will be smaller. Surface-water resources will not be required to supply the estimated 2.45×10^9 gallons of water needed during repository operations. Thus, aquatic habitats will not be adversely affected.

5.2.4.2.3 Decommissioning and Closure. Impacts on aquatic resources during decommissioning will be similar in nature to those discussed previously in Section 5.2.4.2.1. Temporary increases in siltation of nearby streams will occur during final grading of the site and reclamation activities, and impacts due to wind-borne salt will be similar to those occurring during operation. Once reclamation and revegetation activities are completed, aquatic resources are expected to return to the population levels found prior to site disturbance. Reclamation may also restore the 6.6 hectares (16.3 acres) of wetlands lost during repository development.

5.2.4.3 Threatened and Endangered Species

If species protected under the Endangered Species Act of 1973 (16 USC Sections 1531-1543) are found to be present and in continuing discussions with the FWS, it is determined that repository development may adversely affect a protected species, the DOE will initiate appropriate measures to avoid the impact.

5.2.4.3.1 Construction. The endangered red-cockaded woodpecker occurs in Perry County; however, much of the area in which construction is to occur has been clearcut recently and therefore does not contain the mature pine trees that provide the habitat necessary for this species. Development of access and utility corridors may affect potential woodpecker habitat as well as habitats for several threatened and endangered species known to occur in the general region (Section 3.4.2). Should future studies (Section 4.1.3.1) document the presence of any threatened and endangered species, appropriate measures to avoid impacts will be implemented in consultation with State fish and game agencies and the FWS, pursuant to the Endangered Species Act of 1973 (16 USC Sections 1531-1543).

No threatened or endangered aquatic species are known to occur in affected portions of streams or ponds within the Richton Dome area or immediately downstream. Field sampling prior to site characterization will determine existence of such species.

5.2.4.3.2 Operation. Any threatened or endangered species present in the vicinity of the site at various times of the year (see Section 3.2.4.3) will be susceptible to repository impacts described in Section 5.2.4.1.2 above. Appropriate avoidance measures will be developed in consultation with the FWS and State of Mississippi Fisheries and Wildlife departments. Operation of the access and utility corridors will not adversely affect protected species.

5.2.4.3.3. Decommissioning/Closure. Any natural ecosystems that result from site restoration and revegetation (see Section 5.2.1.1) and that may remain protected could provide habitat for threatened or endangered species that might be present at various times of the year. No adverse impacts are expected.

5.2.5 Air Quality

Repository construction, operation, and decommissioning and closure activities will affect air quality as a result of earthmoving equipment, stationary and portable diesel-powered equipment, a concrete batch plant, a natural gas-fired steam plant, mine ventilation exhausts, salt handling activities and windblown dust. This section makes an assessment of the potential air quality impacts by a comparison with the appropriate National Ambient Air Quality Standards (NAAQS).

Project related emissions analyzed are particulates, oxides of nitrogen (NOx), sulfur dioxide (SO_2), and carbon monoxide (CO). To determine compliance with the appropriate NAAQS, particulate and NOx emissions and their impacts are examined in detail. Estimated concentrations of SO_2 and CO, based on maximum annual emissions of these pollutants, are small relative to the respective NAAQS (BNI, 1985b). Consequently, SO_2 and CO are not considered further.

5.2.5.1 Activities and Emissions

The repository project consists of three periods of activity: (1) construction, which includes the site clearing, surface construction, and underground development phases; (2) operations; and (3) decommissioning and closure. Summaries of particulate and NOx emissions are presented in Tables 5-8 and 5-9, respectively, for the three construction phases and the operations phase (BNI, 1985b). These are the expected maximum annual emission rates based on available engineering descriptions (Section 5.1.1 through 5.1.4). Source inventory has been changed since the modeling analysis discussed below was performed. The implications of these changes are evaluated in ONWI (1986). Though small differences may exist, conclusions remain as stated.

5.2.5.1.1 Repository Construction. The primary source of particulate emissions (fugitive dust) during the three repository construction phases is due to earthmoving activities. Particulate emissions from engine exhausts are included in the earthmoving fugitive dust emission rates. Maximum annual particulate emissions are 178 tons per year, which occur during the site clearing phase. As the repository site is developed, emissions from earthmoving activities become progressively less. At the same time, as shown in Table 5-8, other sources of particulate emissions become active. During the underground development phase, emissions of salt particulates occur from load-in and maintenance of the salt storage pile, and from two mine vent exhausts.

Particulate emission due to wind erosion from disturbed areas of the site and from active areas of the salt storage pile are not included in Table 5-8 but are considered in estimating project related impacts. Annual emissions from disturbed areas and the salt pile are estimated to be 7 tons per year and 3 tons per year, respectively. The determination and application of these emissions is discussed further in Section 5.2.5.2.

Maximum erosion potential from disturbed areas is expected to occur during the site clearing phase and decrease as the site is developed. During the underground development

Table 5-8. Maximum Repository Particulate Emission Rates (tons per year)

Source	Site Clearing[a]	Surface Construction[b]	Underground Development[c]	Operation[d]
Earthmoving (Fugitive dust)	178	63	58	21
Concrete Batch Plant	0	15	10	0
Material Handling	0	10	10	3
Salt Handling[e]	0	0	15	15
Mine Vent[f] Exhaust (f) (Salt)	0	0	1	9
Mine Vent[f] Exhaust (f) (Diesel)	0	0	0	1
Steam Plant	0	0	7	7
Total	178	88	101	56

Note: Emissions from the concrete batch plant, the two mine vent exhausts, and the steam plant are considered to be point sources. All other sources are considered area sources.

(a) Maximum emission rate occurs during year 1.

(b) Maximum emission rate occurs during year 3.

(c) Maximum emission rate occurs during years 5, 6, and 7.

(d) Maximum emission rate occurs during years 8 through 26.

(e) Estimate due to salt dumping and equipment working on the pile.

(f) Emissions presented are total mine vent exhaust emissions and are apportioned as follows: 36 percent of the emissions are from the confinement air exhaust stack; 64 percent are released from the unexposed air exhaust filter building.

Source: BNI, 1985b.

Table 5-9. Maximum Repository Oxides of Nitrogen Emission Rates (tons per year)

Source	Site Clearing[a]	Surface Construction[b]	Underground Development[c]	Operation[d]
Steam Plant	0	0	100[e]	100[e]
Diesel Equipment, Vehicles	514	419	506	49
Mine Vent Exhaust[f]	0	0	0	20
Total	514	419	606	169

Note: Emissions from the two mine vent exhausts and the steam plant are considered to be point sources. Vehicle emissions are considered to be an area source.

(a) Maximum emission rate occurs during year 1.

(b) Maximum emission rate occurs during year 3.

(c) Maximum emission rate occurs during years 5, 6, and 7.

(d) Maximum emission rate occurs during years 8 through 26.

(e) Calculated at 100 percent utilization and for conventional burners. New design burners can decrease emissions to about 50 tons per year. Expected utilization will reduce emissions to about 20 tons per year.

(f) Emissions presented are total mine vent exhaust emissions and are apportioned as follows: 36 percent of the emissions are from the confinement air exhaust stack; 64 percent are released from the unexposed air exhaust filter building.

Source: BNI, 1985b.

phase, wind erosion is expected to be minimal because of the presence of many surface structures and equipment laydown areas which would act as windbreaks. Furthermore, revegetation and paving of most of the remaining exposed areas is planned. Maximum erosion potential from the salt pile is expected from the actively developed areas of the pile, beginning during the underground development phase and lasting about 5 years. Wind erosion of the small salt pile remaining after site characterization is expected to be negligible because the pile will be covered.

NOx emissions increase slightly during the three phases of repository construction due to increased vehicle and mobile equipment activity.

Maximum annual NOx emissions occur during the underground development phase with the initiation of steam plant operations (see Table 5-9).

5.2.5.1.2 Operation. Particulate emissions during the operations phase are similar to those of the underground development phase except that earthmoving equipment fugitives are minimal (see Table 5-8). Wind erosion of disturbed areas is expected to be negligible. Wind erosion from active areas of the salt pile would occur until the pile is filled to capacity, probably in the first year or two. The pile would be covered thereafter. Total NOx emissions are noticeably less during this phase, primarily due to decreased vehicle and mobile equipment activity (see Table 5-9).

5.2.5.1.3 Decommissioning and Closure. Particulate emissions during decommissioning will result from earthmoving equipment, stockpile removal, transport of salt, and fracturing of concrete structures and other facilities. Impacts from decommissioning activities are not modeled. Water sprays will be used to contain fugitive dust during decommissioning; disturbed areas will be reclaimed as described in Section 5.1.4.1. It is expected that these activities can be scheduled, and emissions controlled, to the extent necessary to prevent exceedances of the NAAQS.

Particulate and NOx emissions are expected to be insignificant during repository closure, and they are not modeled.

5.2.5.1.4 Mitigation. The mitigation measures for fugitive dust and mobile NOx emissions discussed in Section 4.2.1.3.1 will be used during the repository phases. For fugitive dust, the control program has a goal of a 95 percent reduction, to be accomplished primarily by the application of water and chemical suppressants to disturbed areas and haul roads. Additional controls may be applied, such as speed control on earthmoving vehicles and haul trucks, paving of haul roads, minimizing the size of disturbed areas, extending construction schedules and covering of storage piles. Control of NOx emissions from diesel exhaust will be as required of manufacturers by Federal regulations. Inspection and maintenance of these controls by contractors will be a project requirement.

Mitigative measures are required to reduce the amount of particulate salt emissions associated with the salt storage pile. Salt will be conveyed from the service shaft to the pile in a totally enclosed conveyor/transfer system. Salt pile load-in emissions will be reduced by using a wind guard to minimize the drop height of salt through the free air. Wind erosion emissions from the salt pile will be reduced due to the natural crusting tendency of salt. Crusting will be promoted by daily watering of the pile. Inactive areas of the salt pile will be covered. The application of these control measures is accounted for in the modeling of TSP and salt deposition impacts (BNI, 1985b). After the salt pile is filled to design capacity, hauling of excess salt to offsite disposal areas will require load-in of railcars and trucks. These activities will occur in enclosed areas. Transport vehicles will be covered.

5.2.5.2 Methodology

The EPA Industrial Source Complex Dispersion Model (ISC) (Bowers et al., 1979) was used to estimate atmospheric concentrations of TSP and NO_2 and deposition of salt particles around the site area. ISCST (short-term) was used to estimate 24-hour average TSP concentrations. ISCLT (long-term) was used to estimate annual average TSP and NO_2 concentrations and total

annual salt deposition. The rationale for selecting this model, the meteorological input data, and the background TSP and NO_2 concentrations for determining air quality impacts (35 and 20 micrograms per cubic meter, respectively) are discussed in Section 4.2.1.3.2.

Emissions during the site clearing and operations phases (Table 5-8) were used to model 24-hour and annual TSP impacts. Emissions during the underground development and operations phases (Table 5-9) were used to model annual NO_2 impacts. The site clearing and underground development phases represent the periods of maximum expected impacts during the repository phases for TSP and NO_2, respectively.

Emissions during the operations phase (Table 5-8) were used to model annual salt deposition rates around the site area. Similar impacts are expected during the underground development phase, as discussed below.

5.2.5.2.1 Construction. Particulate emissions during site clearing were modeled as area sources (BNI, 1985b). On a 24-hour basis, fugitive emissions due to earthmoving and related activities were assumed to occur over a disturbed area of 100 acres on any given day (25 acres are considered to be actively scraped and compacted; the remaining 75 acres are less active with hauling and related equipment activities). For modeling purposes, a nominal repository site area of 163.8 hectares (405 acres) was represented by a square 1,280 meters (4,200 feet) on a side. Wind erosion emissions were assumed to occur over the entire repository site area, which implies the entire site had been previously disturbed. Wind erosion was assumed to occur only when the wind speed at the eroding surface exceeded the threshold of 12 miles per hour.

On an annual basis, both earthmoving and wind erosion fugitive particulate emissions were assumed to occur over the entire 163.8-hectare (405-acre) area modeled as site clearing activities progress during the year.

Wind erosion from disturbed areas were calculated using a predictive emission factor equation (Bohn et al., 1978). The emissions are a function of surface erodibility, soil silt content precipitation - evaporation index, and wind speeds above the threshold value given above.

The ISC model requires a particle size distribution as input to account for the variable effects of deposition in estimating concentrations and total deposition. The distribution used in these analyses is adapted from the results of fugitive dust measurements at western surface coal mines and is discussed in BNI (1985b). This distribution was used for all sources of particulate emissions (fugitive dust and salt).

Annual NOx emissions from mobile sources were assumed to occur over the 163.8-hectare (405-acre) modeled area during the underground development phase. The steam plant was modeled as a buoyant, elevated point source (BNI, 1985b).

5.2.5.2.2 Operation. Particulate emissions were modeled as a combination of area and point sources (BNI, 1985b). On a 24-hour basis, emissions due to vehicle movement and materials handling activities are assumed to occur over the 163.8-hectare (405-acre) modeled area. Salt handling emissions are modeled as an area source assumed to occur over 10 percent of the total surface area of the salt pile (or about 5 acres), on any given day. This represents a reasonable estimate of the active area over which freshly loaded salt may be moved as the pile is built and the area which would be subject to wind erosion. The remainder of the pile will be either covered or undeveloped. Mine vent exhausts from the confinement and unexposed air exhaust filter buildings were modeled as point sources. Salt and diesel engine exhaust particulate emissions were combined and apportioned to each of the mine vent exhaust points as discussed in Table 5-8. The steam plant was modeled as a buoyant, elevated point source.

Annual particulate emissions from these sources were modeled in the same manner except for salt handling and wind erosion of the active salt pile area. Emissions from these sources

were assumed to occur over 20 percent of the total surface area of the salt pile. This represents one-fifth of the 5-year period expected to be required to fill the salt pile to capacity.

Wind erosion emissions from active areas of the salt pile were calculated using a predictive emission factor equation for active storage piles (EPA, 1983). The emissions are a function of silt content, the frequency of precipitation, and wind speeds above the threshold value of 12 miles per hour at the eroding surface.

Annual NOx emissions from the steam plant and from mine vent exhausts were treated as point sources. Table 5-9 describes the apportionment of emissions between the two mine vent exhaust points. NOx emissions from vehicle exhausts were assumed to occur over the 163.8-hectare (405-acre) modeled area (BNI, 1985b).

5.2.5.3 Air Quality Impacts

This section addresses the results of the air quality modeling analyses. Additional details appear in BNI (1985b).

5.2.5.3.1 Regulatory Review. The primary criterion in determining Prevention of Significant Deterioration (PSD) applicability is whether a facility is a "major source" of criteria air pollutants. The sources of particulate and NOx emissions discussed earlier are not included in the list of 28 major stationary sources subject to an emission limitation of 91 metric tons (100 tons) per year. To be considered a major source, project-related stationary-source emissions would have to be greater than 227 metric tons (250 tons) per year (40 CFR 51.24[b][1]).

Stationary sources of particulate emissions during repository construction and operation include the concrete batch plant, the mine vent exhausts, and the steam plant. All other particulate emissions are from mobile sources or are fugitive emissions and are, therefore, not considered in the major source determination (Mississippi Regulations APC-S-2; 40 CFR Section 52.21 [b][1][iii]).

Stationary sources of NOx emissions during repository construction and operation include the steam plant and mine vent exhausts. All other NOx emissions are due to nonstationary mobile sources. Table 5-9 indicates that stationary emissions reach a maximum of 109 metric tons (120 tons) per year during repository operation, and are less during all other phases.

For the purposes of this EA, the DOE concludes that the repository project is not subject to PSD requirements because stationary source emissions do not exceed the threshold limit of 227 metric tons (250 tons) per year.

In the interpretation of the modeling results presented below, air quality impacts are considered to be significant if the NAAQS are exceeded, i.e., those ambient concentrations which "... allowing an adequate margin of safety, are requisite to protect the public health" and those levels which "... are requisite to protect the public welfare from any known or anticipated adverse effects associated with the presence of air pollutants in the ambient air" (EPA, 1971).

5.2.5.3.2 Uncertainties. Prior to discussing modeling results, it is important to point out that there are uncertainties in the air quality impact analysis associated with particulate emission rates. Emisson factors, particle size distributions, and control factors used to estimate particulate emission rates are drawn from the published literature. While the DOE considers that these data are the best available for use in the impact analysis, the DOE recognizes that there are uncertainties inherent in their use. For example, fugitive dust emission factors are based on limited measurements at other locations and for other types of earth-moving activities where natural soil characteristics, such a silt and moisture content, are different from those existing at the site. Particle size distributions from studies of western coal were used for both fugitive dust and salt emissions. Dust control efficiency values (50 percent using water application and vehicle speed limits, and 90 percent using

chemical suppressant application and vehicle speed limits) can involve sizeable errors. The DOE believes the values used herein are achievable with a well designed and carefully conducted mitigation program. Uncertainties inherent in emission rate estimates have not been quantified; they could result in either higher or lower air quality impacts.

5.2.5.3.3 Estimated Concentrations. The highest and second-highest 24-hour TSP concentrations off site were estimated. The second-highest offsite values are reported as maximums for comparison with the 24-hour NAAQS, which are not to be exceeded more than once per year. EPA recommends the use of the highest offsite 24-hour TSP concentrations for comparison with the applicable NAAQS standard whenever 1 year of meteorological data is used (as opposed to the second highest value when 5 years of data are employed). This comparision is presented in "Evaluation of Air Quality and Noise Impact Assessments - Richton Dome" (ONWI, 1986). It will be seen in that report that the conclusions presented here remain unchanged as a result of that comparison. The highest annual offsite concentrations of TSP and NO2 are also reported. "Off-site" refers to points at or beyond the Controlled Area Boundary (CAB), as presented in Figure 5-2.

Maximum offsite 24-hour TSP, and annual average TSP and NO_2 concentrations are summarized in Table 5-10. Total concentrations representing the sum of incremental concentrations plus background values identified in Section 3.4.3.1 are presented.

The results indicate that the primary and secondary 24-hour NAAQS for TSP, and the annual NAAQS for TSP and NO_2 will be met during repository construction operation, and decommissioning and closure. On this basis, the DOE concludes that the repository project will not have a significant impact on air quality.

5.2.5.3.4 Estimated Salt Deposition. Annual salt deposition rates were estimated using the methodology discussed in Section 5.2.5.2. Estimated salt deposition will amount to approximately 1 kilogram per hectare (0.9 pound per acre) at approximately 700 meters (2,300 feet) from the salt pile on an annual basis. Deposition rates diminish rapidly with distance, to approximately 0.1 kilogram per hectare (0.09 pound per acre) 1 to 2 kilometers (0.6 to 1.2 miles) from the salt pile. A more detailed discussion of the results is presented in BNI (1985b). Impacts resulting from these deposition rates are discussed in Section 5.2.10.

A qualitative evaluation has been made of the potential effects on the dispersion of salt from a tornado striking the salt storage pile. The amount of salt transported by a tornado would depend on the size, intensity, and speed of the tornado; state or condition of the salt pile; and threshold velocity at which salt aggregate would be lifted from the pile.

In the Richton Dome area, the recurrence interval for a tornado striking any point is once in 932 years (see Section 3.4.3.3). Considering that the salt pile will be developed to its approximately 2.7 million metric tons (3.0 million tons) of mined salt capacity in about 5 years during the construction phase of the repository and will be covered thereafter, the likelihood of a tornado damaging the pile is quite small. However, should such an event occur, maximum deposition may occur anywhere from 10 to 60 kilometers (about 6 to 37 miles) downwind of the site (Battelle's Pacific Northwest Laboratories, 1979, DOE/ET-0029, Vols. 1-3). Point deposition values within this area may be significantly greater than the maximum annual deposition rate reported above for normal meteorological conditions.

5.2.6 Aesthetic Conditions

Introduction of large structures and associated development to a rural landscape may affect the visual character of the Richton Dome site and vicinity. Potential project facilities affecting aesthetic conditions include waste handling facilities; mine support facilities (head frames, salt storage pile, ventilation exhaust, and supply buildings, etc.); administration and support buildings; and utilities and utility support facilities (Section 5.1).

Table 5-10. Air Quality Impacts During Repository Construction and Operation at the Richton Dome Site

Pollutant	Averaging Time	Location	Maximum Concentrations (micrograms per cubic meter)		NAAQS (micrograms per cubic meter)
			Construction	Operation	
TSP	24-hour	CAB[a]	146[b]	75	260/150[d]
TSP	Annual	CAB	41[b]	38	75
NO_2	Annual	CAB	60[c]	24	100

(a) Controlled Area Boundary.
(b) Site Clearing Phase.
(c) Underground Development Phase.
(d) Primary Standard/Secondary Standard.

Note: Background TSP value is 35 micrograms per cubic meter. Background NO_2 value is 20 micrograms per cubic meter.

Sources: BNI, 1985b; 40 CFR Part 50.

As discussed in Section 3.4.5, a site-specific inventory of aesthetic resources has not been completed for Richton Dome. During site characterization, the U.S. Forest Service Visual Management System (VMS) inventory will be conducted to provide a basis for determining specific impacts of repository development (Section 4.1.3.1). Once the inventory is completed, the repository surface facilities and structures associated with transportation and utilities will be reviewed to determine compliance with quality objectives developed using the VMS system. The following assessment of aesthetic impacts is based primarily on existing project design information, topographic maps, aerial photographs, and site reconnaissance.

5.2.6.1 Construction

During construction, activities potentially affecting aesthetic conditions include surface preparation and grading as well as erection of the repository surface facilities. Major buildings will be constructed of concrete and steel. Fugitive dust emissions resulting from activities such as excavation, movement of major equipment, and onsite traffic will produce dust clouds. However, these dust clouds will be visible from offsite vantage points for short periods; they will dissipate before reaching offsite locations. Also, state-of-the-art dust control methods will be used.

Apart from normal earthmoving machinery, the most visible features will be the concrete batch plant and cranes. Night lighting may also affect aesthetic conditions. Impacts to air quality, which may affect visibility in the immediate vicinity during site preparation, are discussed in Section 5.2.5.1.

5.2.6.2 Operation

Project facilities potentially affecting aesthetic conditions at Richton Dome include the following: an 81-meter (265-foot) headframe for the service shaft, which will be lighted at the top; a 60-meter (197-foot) meteorological tower; new road and rail corridors; and other facilities within the 165-hectare (407-acre) restricted area. All disturbed areas that are not paved, gravelled, or otherwise covered will be planted with shrubs, trees, grass, or other ground cover compatible with natural vegetation. Where possible, buildings and other structures will be arranged and painted to blend with the surrounding environment.

Preliminary visibility analyses using 1-meter (3-foot)-diameter weather balloons suspended approximately 50 and 61 meters (165 and 200 feet) above the site suggest that structures at these heights may be visible from an area on Mississippi State Highway 42 located about 2.4 kilometers (1.5 miles) south of the restricted area, but will probably not be visible from Mississippi State Highway 15. Portions of the headframe for the service shaft, the meteorological tower, and the waste shaft may therefore be visible from Mississippi State Highway 42. It is predicted that visual contrast from Mississippi State Highway 42 will be low because of the short duration of the visibility to travelers on the highway (Scott, 1984, pp. 1-4). The new power lines are on 15-meter (50-foot) double poles spaced 152 meters (500 feet) apart (see Figure 4-9 for a drawing of a typical tower). These power lines will cause some visual impact, appearing as dark lines on the horizon.

The visual impacts of night lighting will be determined from field studies (Section 4.1.3.1, Aesthetic Resources). Directional lighting will minimize visibility of the light from the surrounding area. Also, impacts from lighting of perimeter fencing will be avoided by using infrared lighting with TV monitors.

The repository facilities would affect the same sized area and would have the same structure heights as the Leaf River Forest Products Company, which is located near New Augusta, approximately 14.5 kilometers (9 miles) south of the site. Beyond a viewing distance of approximately 1.6 kilometers (1 mile), the Leaf River Forest Products Company facilities are not especially noticeable against the landscape (Thomas, 1984).

5.2.6.3 Decommissioning and Closure

After final emplacement of nuclear waste canisters, the repository will be decommissioned and closed. All structures, including meteorological towers and shaft head frames, will be dismantled and transported from the site, and the landscape will be graded and revegetated to blend with surrounding topography. Transportation and utility facilities may be decommissioned or converted to other uses.

Postclosure activities will include installation of markers or monuments, and a small building to be used as a monitoring station (Section 5.1.5). The aesthetic impacts of these monuments or markers will depend upon the final design or type of passive prevention barrier selected, and are expected to be minimal.

5.2.7 Noise

This section discusses noise criteria, modeling methodology, impacts from repository construction, operation, and decommissioning and closure, and possible mitigation measures. Also included are discussions of impulsive noise and ground vibrations from blasting. The location of Richton, the nearest community, is indicated in Section 4.2.1.6. The nearest residence is located 1.1 kilometer (0.7 mile) from the proposed repository site center.

5.2.7.1 Noise Criteria

There are no Federal, State, or local noise regulations applicable to the repository site. However, the DOE intends to use EPA noise guidelines, with appropriate abatement, to achieve compliance with the Noise Control Act of 1972 as amended by the Quiet Communities Act of 1978 (42 USC Sections 4901-4918).

As discussed in Section 4.2.1.6.1, two indicators of broadband environmental noise impact are used here: (1) percent highly annoyed (Schultz, 1978); and (2) energy equivalent day/night sound level, L_{dn}, used to protect the public from the effects of noise (EPA, 1974).

The EPA has also set criteria to protect against hearing loss. The details, application, and interpretation of these criteria are discussed in Section 4.2.1.6.1.

5.2.7.2 Methodology

Potential noise impacts from repository construction and repository operation have been modeled as separate cases for the proposed Richton Dome site (BNI, 1985a). For modeling of repository construction and operation, each piece of equipment was assigned a stationary location based upon a typical repository plot plan. Although the location of most equipment will change during the construction period, the movement of equipment was not modeled. Section 4.2.1.6 describes the model employed and the basic assumptions. Source inventory including traffic volume has been changed since the modeling analysis discussed below was performed. The implications of these changes are evaluated in ONWI (1986). Although small differences exist, conclusions remain as stated.

The effects of an average annual temperature inversion at 425 meters (1,400 feet) above the earth's surface, which corresponds to the annual mean afternoon mixing height, was also included in the modeling. The predicted levels represent the incremental contribution to the existing ambient sound level. Noise levels for standard equipment with no special noise controls were used and all noise sources were presumed operating simultaneously. Types of construction equipment used will be similar to that used during site characterization (Section 4.2.1). Repository construction activities are described in Section 5.1.2. For the purpose of assessing potential noise impacts, the peak activity period for construction was modeled. This corresponds to a 5-month period in which both site preparation activities and surface and shaft construction activities proceed concurrently (see Section 5.1.2). Equipment and activities modeled during operation are described in Section 5.1.3. These activities include on-site salt handling and rail yard operations, project traffic, and one round-trip train operation along the rail corridor. Equipment duty cycles and loading conditions during each work shift were considered in the modeling.

5.2.7.3 Noise Impacts

Potential noise impacts caused by construction, operation, and decommissioning and closure are discussed below. The discussion in Section 4.2.1.6.5 on impacts from tonal noise also applies to the repository.

It is believed by the DOE that the noise modeling carried out in this section was based on the best available meteorological data, the latest literature on sound emission levels, and the state of the art of noise modeling techniques. However, uncertainties do exist in this modeling and are caused largely by

- Uncertainties in sound emission levels to approximately $\pm$ 5 dB
- Consideration of wind and temperature gradient effects on noise propagation. Unfavorable gradients (when occurring) can significantly increase noise propagation toward a given receptor whereas favorable gradients can significantly reduce such impacts.
- Pine forests which over a large portion of the Richton dome area have not been accounted for in the modeling. They could provide over 10 dBA noise reduction (Section 4.2.1.6.7).

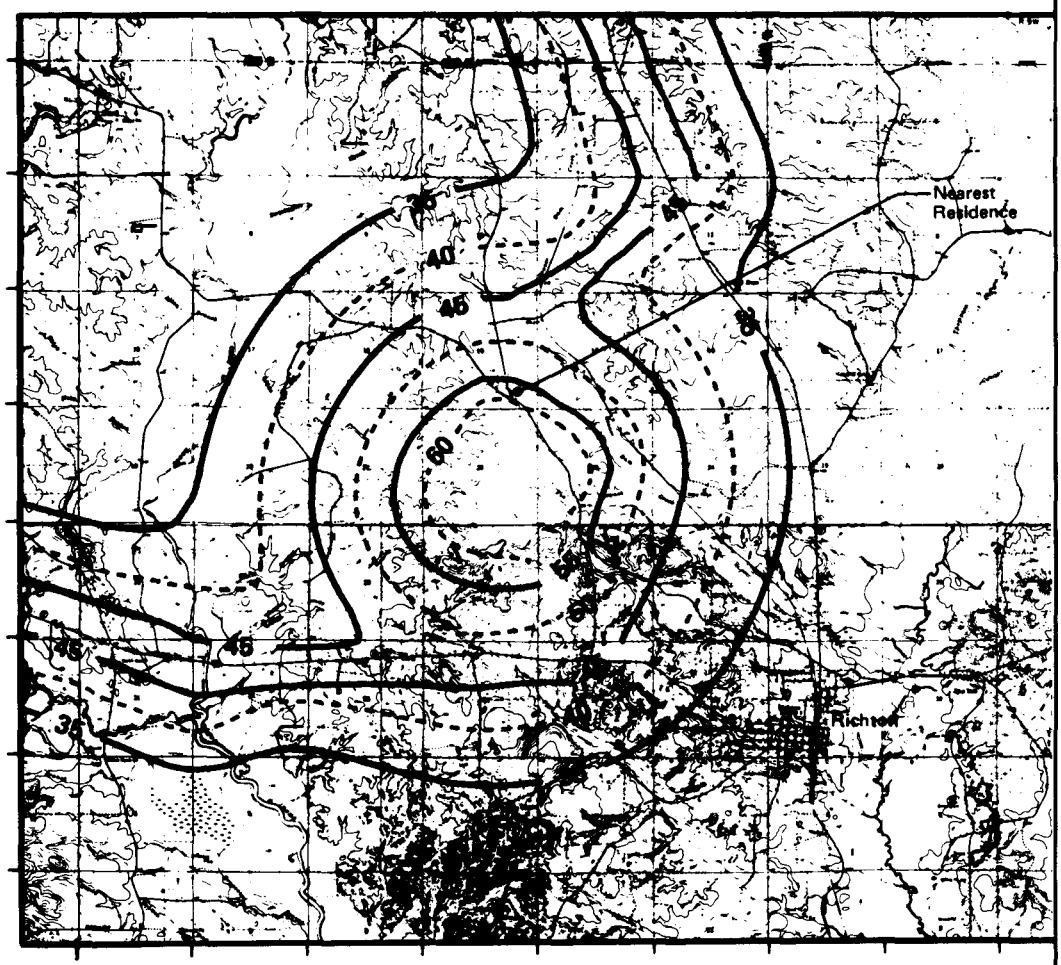
The accumulated effects of these uncertainties can be large at any point and at any time outside the site boundary.

5.2.7.3.1 Construction. As discussed in Section 3.4.4, the existing L_{dn} value is estimated to be between 35 dBA and 45 dBA, with levels of 45 dBA and above being more typical near roadways and residences and within the community of Richton. The noise modeling results are presented in Figure 5-16, which presents the L_{dn} isopleths due to repository construction. A legend relating L_{dn} to "percent highly annoyed" is also provided in Figure 5-16. Noise modeling indicates that maximum construction noise levels in the vicinity of the Richton Dome facility will not exceed the estimated minimum background value of L_{dn} 35 dBA beyond 4.5 kilometers (2.8 miles) from the center of activities, except along highway and rail corridors. Beyond this distance, the maximum expected intruding noise will be below 35 dBA and will not be heard.

The L_{dn} 45-dBA contour lies approximately 2.9 kilometers (1.8 miles) from the center of activities. The increase in noise outside the L_{dn} 45-dBA contour is insignificant. Significant increases in noise may occur between the L_{dn} 45-dBA contour and the L_{dn} 55-dBA contour. However, these levels are below the EPA guideline to protect the public from activity interference and are expected to be acceptable to most residents. The L_{dn} 55-dBA contour, which is the EPA guideline level, lies approximately 1.4 kilometers (0.9 mile) from the surface facility center. Two residences but no other sensitive receptors such as churches and schools lie within this contour (USGS, 1973, 1982a, 1982b, 1982d). On the basis of the EPA 55-dBA guideline, these residents will experience significant noise impact and may be highly annoyed.

The construction of the rail spur will extend the area of impact beyond the site boundaries. Although noise levels from rail construction have not been modeled, an estimate of potential for noise impacts may be made based on the expected equipment inventory. The amount of equipment is less than that associated with site construction; therefore, the extent of the impact zone is expected to be less. Areas exceeding L_{dn} of 45 dBA are expected within 0.6 kilometer (0.4 mile) on either side of the rail corridor. Areas exceeding an L_{dn} of 55 dBA are expected to extend less than 0.3 kilometer (0.2 mile) on either side of the rail corridor. The extent of noise impact will depend on the number of people in these areas of influence.

Local traffic on highways and roads leading to the site will increase noise levels. The L_{dn} 55-dBA contour will extend approximately 0.02 kilometer (0.01 mile) on either side of rural roads leading to the site. The average noise along highways leading to the site will increase less than 5 dB and will not normally be noticeable.



Noise Isopleths in dBA

Scale

0 ½ 1 2 Mi

0 1 2 3 4 Km

Community Reaction

L_{dn}, dBA	Percent Highly Annoyed
45	0
50	0
55	3
60	8
65	15
70	24
75	37

Source: BNI, 1985a.

Richton Dome
Repository Construction
Day/Night Sound Level Contribution

Figure 5-16

Noise from surface blasting associated with construction of vertical shafts will be similar to that described in Section 4.2.1.6 and will occur over a period of 4 days for each of the shafts. Each of the possible nine blasts per day will consist of up to fifteen impulses (charges) separated by one-half second. The peak pressure level from shaft blasting will be about the same; however, there may be more charges per blast depending on the shaft diameter. The peak levels from blasting under conditions favorable to sound propagation will be audible at distances up to 17.5 kilometers (11.6 miles). The C-weighted day/night level of 45 dB, used to indicate when 2 percent of the population may be expected to be highly annoyed, will extend to 1.6 kilometers (1.0 mile), an area which includes the nearest residence. These distances will be approximately halved during average meteorological conditions but blasting will still be audible in the town of Richton. Cumulative effects of blasting noise have been considered. The highest peak sound pressure will be below 90 dB at 1.0 kilometer (0.6 mile). These conditions are below the criteria given in Section 4.2.1.6 for impulsive noise, and cumulative adverse health effects to the general public are not expected. Projections of ground motion due to blasting are below 2 millimeters (0.08 inch) per second at the nearest residence. The resulting vibration levels at the nearest residence are below the threshold of perception and well below the levels (13 millimeter [0.5 inch] per second) which cause structural damage to houses (Siskind et al., 1980).

Masking by broadband noise from construction will reduce the likelihood of annoying audible tones at noise-sensitive areas (e.g., residences). Further details of tonal noise impacts are discussed in Section 4.2.1.6.

In summary, local impacts will vary from day to day depending on the level of construction activity. The noise levels will decrease from peak values and approach levels for operations. The short-term (5-month) local peak impacts from site construction may include the following:

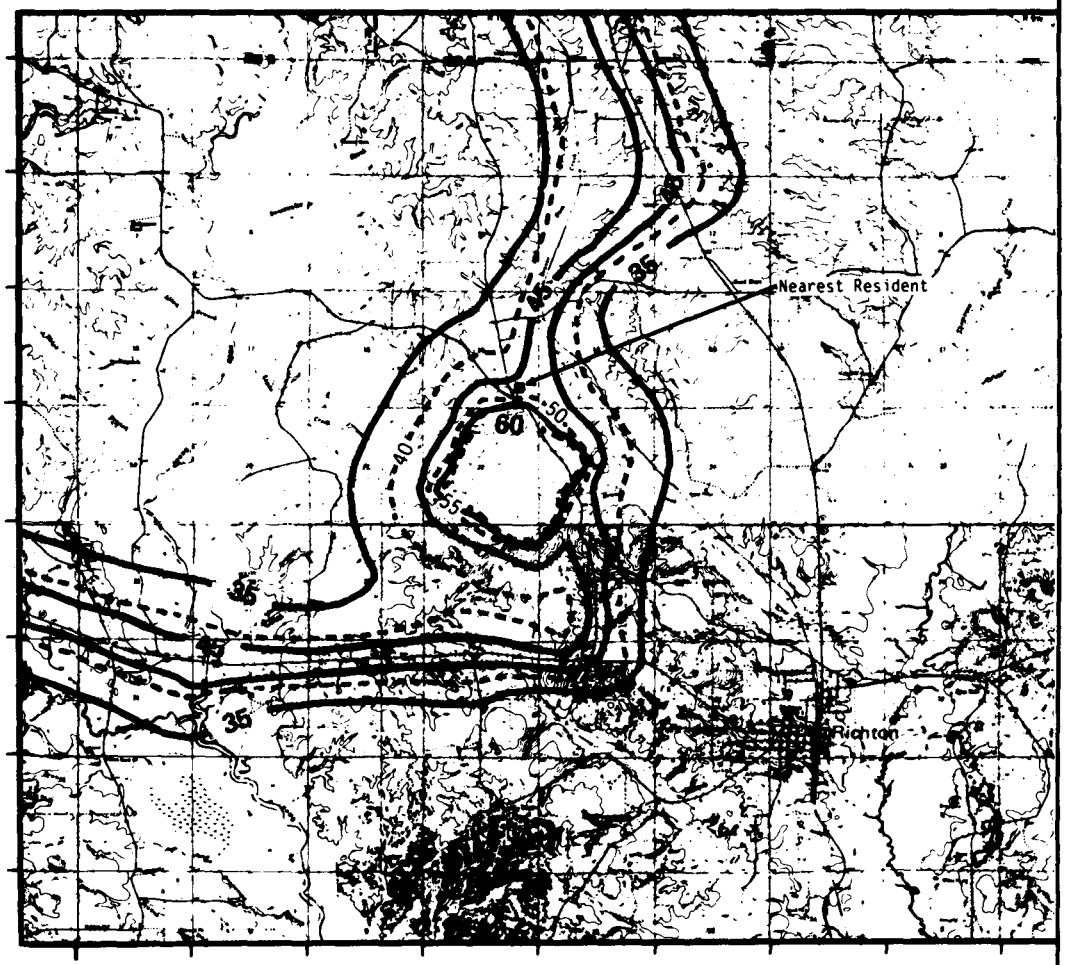
1. Some individuals may be highly annoyed if living in areas where noise levels exceed the EPA criterion of L_{dn} 55 dBA. This includes areas within 1.4 kilometers (0.9 mile) of the surface facility center, within 0.02 kilometer (0.01 mile) of highways leading to the site, and within 0.3 kilometer (0.2 mile) of railroad construction activities. Two residences are within 1.4 kilometer (0.9 mile) of the site center.

2. The nearest residents may be highly annoyed during the initial 4 to 12 days of shaft sinking if blasting occurs during meteorological conditions which favor sound propagation.

5.2.7.3.2 Repository Operation. Noise predictions for repository operation utilize the same ambient conditions and assumptions used for construction. Rail traffic and automobiles and trucks along the highway will intermittently affect nearby receptors. Much of the mechanical equipment will be located in buildings constructed of concrete and steel having wall thicknesses between 30.5 and 61 centimeters (12 and 24 inches). The noise reduction provided by such massive enclosures will vary from 35 dB for the low octave bands to over 70 dB for the high octave bands (Watters, 1959). Thus, noise from equipment located within these buildings will be sufficiently reduced so that it will not be a significant contributor to community noise. These sources, and those below ground in the repository, were not considered in the modeling.

Noise modeling results are presented in Figure 5-17. The figure presents L_{dn} isopleths due to repository operation and a legend relating L_{dn} to "percent highly annoyed."

Although site activity may occasionally be audible, areas between the L_{dn} 45-dBA contour and the 35-dBA contour are not expected to be significantly affected by noise from site activities. The L_{dn} 45-dBA contour will extend approximately 1.3 kilometers (0.8 mile) from the surface facility center. One residence may lie within this area according to the U.S. Geological Survey map (USGS, 1973, 1982a, 1982b, 1982d), but noise impacts are within the EPA guidelines for acceptability.



Noise Isopleths in dBA

Scale
0 ½ 1 2 Mi
0 1 2 3 4 Km

Community Reaction

L_{dn}, dBA	Percent Highly Annoyed
45	0
50	0
55	3
60	8
65	15
70	24
75	37

Source: BNI, 1985a.

Richton Dome
Repository Operation
Day/Night Sound Level Contribution

Figure 5-17

Some individuals could be highly annoyed if living in areas where project noise exceeds L_{dn} of 55 dBA. The L_{dn} 55-dBA contour extends approximately 1.0 kilometer (0.6 mile) from the surface facility center. No residences, churches, or schools lie within this potential impact zone according to the U.S. Geological Survey (1973, 1982a, 1982b, 1982d).

Operation of the rail line will result in a L_{dn} 55-dBA contour which extends approximately 20 meters (65 feet) on either side of the rail line. A normal rail right-of-way is 12 meters (40 feet) on either side of the track center line. No residences have been identified within this potential impact zone. The areas of impact will be wider as the rail lines approach the site where the noise from site operation will combine with that from rail operation. The L_{dn} 45-dBA contour will extend approximately 80 meters (260 feet) on either side of the rail line. Residents within the L_{dn} 45-dBA contour and the L_{dn} 55-dBA contour may experience noise levels that are higher but are within EPA guidelines for acceptability.

Facility operation will increase local highway traffic, thereby increasing existing noise levels by approximately 3 dB for each doubling of traffic volume. The L_{dn} 55-dBA contour will extend approximately 20 meters (65 feet) from the site access road. Depending on the final routing, approximately four residences may be impacted (USGS, 1973, 1982a, 1982b, 1982d). Except for occasional railroad activities, no impulse noise sources would be present during plant operation.

In summary, potential long-term (life of repository operation) noise impacts will be evident in areas within 1.0 kilometer (0.6 mile) of the surface facility center where levels are expected to exceed the EPA recommended criterion of L_{dn} 55 dBA. No residences (USGS, 1973, 1982a, 1982b, 1982d) exist within this area. The community of Richton is not expected to be affected by noise from the proposed repository operation.

5.2.7.3.3 Decommissioning and Closure. Noise due to decommissioning and closure of the site has not been modeled. It is anticipated that these activities can be scheduled, and sound power levels controlled, such that the sound levels would not exceed those identified for repository construction.

5.2.7.4 Noise Mitigation

The preceding noise analysis assumes that no special noise control measures are incorporated for machinery or activities. Section 4.2.1.6 describes several mitigative measures that may be taken to reduce noise impacts during site characterization. These measures are also applicable to the repository phase, and include the use of noise control devices on selected equipment to reduce noise emission, erection of barriers or enclosures around major noise sources to reduce noise transmission in the direction of noise-sensitive areas, and purchase or lease of a buffer zone where noise impacts are significant. Maintaining a buffer zone of 0.2 kilometer (0.13 mile) of pine forest along the repository boundary would reduce noise impact.

Mitigative measures will be selected and implemented as necessary to limit impacts to acceptable levels. If the Richton Dome site is selected, mitigative measures will be developed based on identified need and discussions with appropriate agencies.

5.2.8 Archaeological, Cultural, and Historical Resources

This section assesses the impacts that construction, operation, and decommissioning and closure may have on cultural resources.

5.2.8.1 Construction

As discussed in Section 3.4.6, little is known of the prehistory or history of the immediate project area. No sites or Native American concerns have been recorded, nor have any specific surveys been performed. The potential for discovering undisturbed surficial cultural resources is low due to previous land disturbance in the area.

Surveys will be performed in consultation with the State Historic Preservation Officer (SHPO) to identify all unrecorded sites within the repository surface area. If appropriate, consultations with Native American groups having possible traditional ties to the project area will be conducted to satisfy the requirements of the American Indian Religious Freedom Act. A qualified archaeologist will monitor construction activities to ensure that no unexpected resources are disturbed until a determination of significance can be accomplished. Mitigative measures, including excavation, salvage operations, and avoidance, may be required for any resources identified in the intensive survey.

Cultural resources located during the surveys will be evaluated using the criteria for eligibility to the National Register of Historic Places defined in 36 CFR Part 60. Site evaluations and determinations of eligibility will be submitted to the Mississippi SHPO and the Keeper of the National Register for concurrence pursuant to 36 CFR Part 60. Mitigation plans will be developed for all significant resources in consultation with the Advisory Council on Historic Preservation and the SHPO. Whenever possible, significant resources will be avoided by relocation or redesign of the proposed activity area. When avoidance is not possible, mitigation may necessitate recovery of scientific data. The level of data recovery required will vary by site and will be determined in consultation with the SHPO. Mitigation efforts may include limited subsurface testing, surface collection of artifacts, recording of architectural features, or large-scale data recovery through excavation.

Not all aspects of proposed repository development pose potentially adverse impacts to cultural resources in the project area. Possible beneficial effects of the proposed action include the addition of valuable data to the state plan on the regional and local history and prehistory resulting from cultural resource surveys and any mitigation efforts implemented. In addition, prohibiting future drilling and mining activities within the repository controlled area may help protect cultural resource sites that may be located there.

5.2.8.2 Operation

Operation of the proposed repository will pose no foreseeable direct impacts to cultural resources. All major land-disturbing activities will have occurred during construction of the facility and associated infrastructure. Potentially adverse indirect impacts may result, however, from the increased numbers of workers in the area. Indirect impacts to cultural resources consist, generally, of vandalism, artifact collection, and disturbance resulting from the recreational pursuits of off-duty workers and their families. These potential impacts will be mitigated based on guidelines to be developed in consultation with the SHPO and Advisory Council.

5.2.8.3 Decommissioning and Closure

Although the existence of significant cultural resources is unlikely, decommissioning and closure of the repository has the potential to adversely impact cultural resources if a new area is disturbed. Direct impacts may result from placing peripheral markers around the perimeter of the controlled area, creating earthworks, and placing redundant warning symbols in the soil around the repository. Before land-altering activities are started outside the restricted area, surveys will be conducted to locate and evaluate cultural resources in areas of potential impact.

Potential indirect impacts associated with the numbers of decommissioning personnel involved are similar to those for construction and operations. Possible adverse impacts can be mitigated through the continued use of employee education programs or site protection measures.

5.2.9 Radiological Effects

As with exploratory shaft development (Section 4.2.1.9), repository construction and operation will result in releases of radon and daughter products to the environment. The rate of release and attendant level of impact will depend principally on the rate at which salt is mined from the repository, and the content of radioactive elements in the salt. During site

characterization, the radioactive content of the salt formation will be precisely measured and an estimate of radon impact on the environment will be made.

Dose consequences of operational releases are assessed in Section 6.4.1. No repository-associated radon impacts are expected during repository closure and decommissioning, because no additional salt will be mined.

5.2.10 Impacts of Salt Management and Disposal

This section summarizes the potential environmental impacts associated with the management of salt and salt-laden rock during repository construction, operation, and decommissioning and measures for mitigating those impacts. The discussion is presented in three parts: (1) the management practices are briefly described in the context of their potential for releasing salt to the environment; (2) measures for mitigating the impacts from these sources are discussed, and the basis for assessing the impacts are described; and (3) the options for permanently disposing of the excess salt are identified and described.

5.2.10.1 Salt Management and Control

The repository development will involve mining, handling, transport, onsite storage, reuse, and disposal of salt and salt-laden rock. The discrete elements of this salt management process are illustrated in Figure 5-18 along with each element's potential contribution to an overall salt emission and likely mitigation measures for each source point.

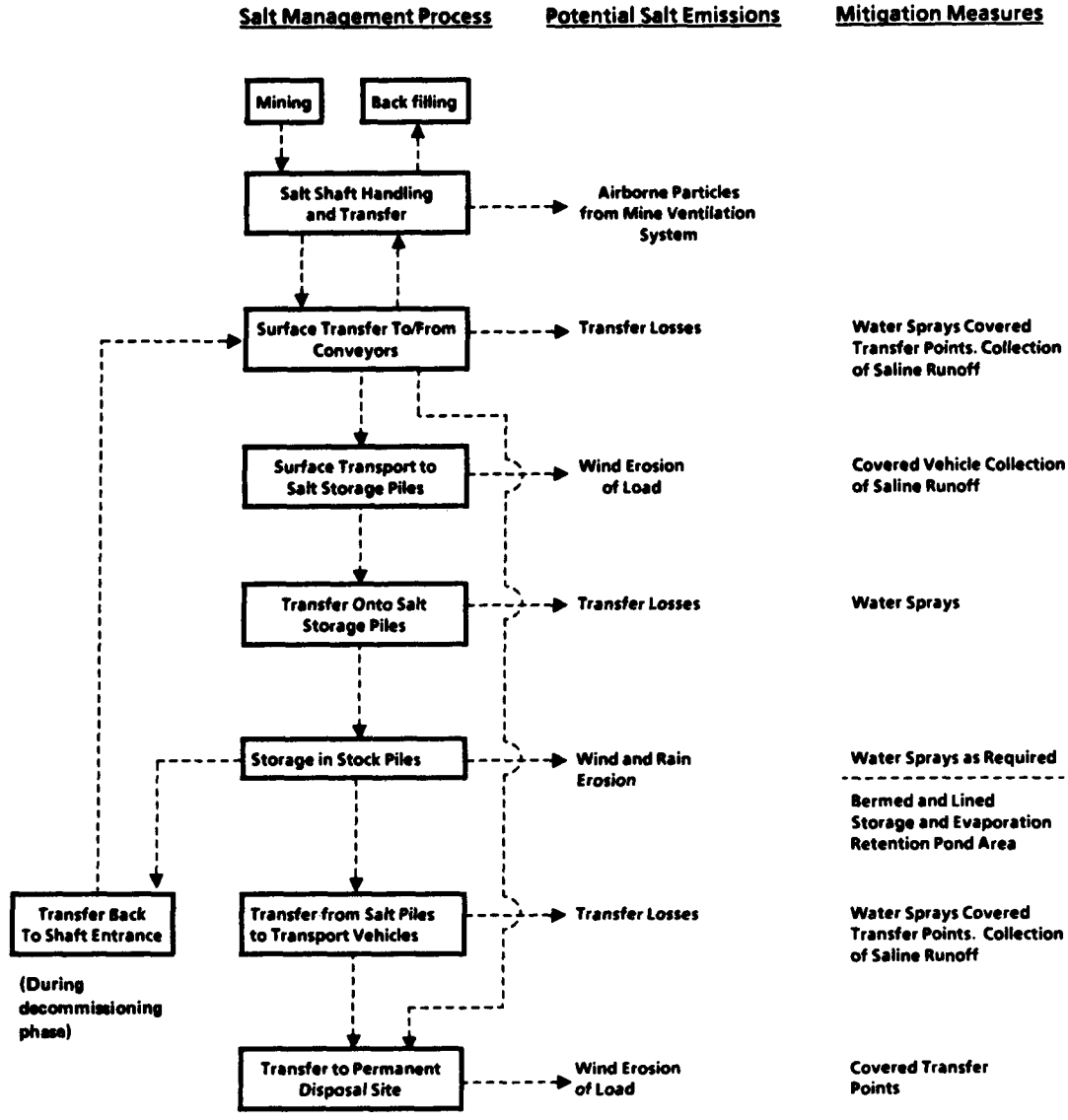
Repository development requires the excavation of corridors and waste emplacement rooms within the salt deposits. Salt excavated during repository construction will be brought to the surface for both immediate offsite disposal and stockpiling for backfilling during decommissioning. Salt excavated during repository operation will be transferred from the development area directly to the emplacement area for use as backfill. Excess salt will be hauled to the surface for offsite disposal. The quantities of excess salt produced during construction, operation, and decommissioning are presented in Table 5-4 and discussed in Section 5.1.3.

Mined salt is lifted to the surface via a skip and transferred by covered conveyors either to the rail car loading facilities for transfer off site or to the salt storage pile. Emissions of salt to the atmosphere occur at the outlet of the mine ventilation system and at the point of transfer of the mined salt to the surface transport vehicle. Saline water, from either the salt control devices or as storm runoff, will be collected and conveyed to the evaporation/retention pond.

Although the surface transfer systems will be covered, small losses may occur along the haulage route. These will be collected as saline runoff and moved to the evaporation/retention pond.

When salt is exposed to the weather or another source of moisture, a hard surface crust, which tends to shed rain water, forms in a few days (Ver Planck, 1958). According to the experience in the salt industry, stockpiled salt is not a source of windblown particles, and crusting can be accelerated by wetting the pile. Freshly deposited material will be wetted, after spreading and compacting, to mitigate any wind effects (Section 5.1.2.3) (Parsons-Redpath, 1984). The active face of the salt storage pile will be kept moist, as required, to accelerate crust formation. Once the crust is established, further watering will not be necessary.

Possible leaching of brine from the evaporation/retention pond into the ground will be prevented by using double liners. These can be made of natural clays or synthetic materials (polyvinyl chloride, polyethylene, or polypropylene). A leachate collection system will be installed between the liners to monitor the integrity of the liners. The existing topsoil overburden will be stripped before emplacement of the liner and an engineered sound sub-base established. If a synthetic liner is used, an additional layer of compacted backfill material will be placed on top of the liner so that it can accommodate heavy equipment.



Salt Management Flow Diagram

Figure 5-18

Three major retention ponds will collect runoff from the shaft area, haul roads, and mined material stockpiles. In addition, water collected in the shaft sumps will be periodically pumped to the evaporation/retention pond. The salt pile runoff evaporation/retention pond will be designed for an operational volume equivalent to 100 percent of the rainfall volume from a 100-year, 24-hour storm falling on the areas that drain to the evaporation retention pond (Section 5.1.2.3).

Project GNOME and the Waste Isolation Pilot Plant (WIPP) involved salt management practices similar to those that will be employed at the repository. The knowledge gained from those two projects, therefore, provides useful insight (INTERA, 1978).

Activities associated with the December 1961 Project GNOME underground nuclear test resulted in a substantial volume of sodium chloride salt being excavated and stored on the site. The storage facility for the salt is an area of approximately 1.2 hectares (3 acres) enclosed by a dike and fence. The salt pile is stored inside the dike and fence but is otherwise open and exposed to the elements of the environment. The project GNOME test site is located approximately 48 kilometers (30 miles) southeast of Carlsbad, New Mexico. Soil samples and ecology surveys indicate that insignificant wind erosion and dispersion is occurring at the Project GNOME salt pile, and that there is little, if any, attendant adverse impact on the immediate surrounding environment due to salt dispersion by wind (INTERA, 1978).

The Waste Isolation Pilot Plant (WIPP), presently under construction approximately 40 kilometers (25 miles) east of Carlsbad, New Mexico, will test the feasibility of storing nuclear defense wastes in salt. Excavated salt has been stored in an uncovered, unlined pile holding about 136,170 metric tons (150,000 tons) of salt. The pile is surrounded by a bermed ditch, which collects and evaporates the precipitation that falls on the pile (average rainfall: 23 centimeters (9 inches) per year). The salt is crusted over, and rainfall does not penetrate the pile. No problems with wind dispersion of the stored salt have been experienced (DOE, 1980, DOE/EIS-0026; 1984, DOE/NE/44301-1).

5.2.10.2 Impact of Salt Management

Soil productivity, water quality, ecosystems, and land use can be impacted by salt transported through air and water pathways. Assessment of the potential impacts requires identification and quantification of the various factors involved. For example, airborne salt can impact crop productivity by uptake through the plant's roots and deposition on the foliage. In these cases, not only must deposition rates be estimated, but irrigation rates, rainfall patterns, etc., must be taken into account. Repository deposition rates are predicted to be 1.0 kilogram per hectare (0.9 pound per acre) per year at 0.8 kilometer (0.5 mile), decreasing to 0.1 kilogram per hectare (0.09 pound per acre) per year at 1 and 2 kilometers (0.6 and 1.2 miles) from the salt storage pile (see Section 5.2.5). The highest deposition rate per unit area would occur within the fenced area. The confidence level at which the deposition rate can be predicted will be improved by monitoring actual deposition during site characterization.

The amount of salt dispersed by a tornado would be limited by the crustation and reconsolidation of the salt storage pile and would be limited to the working face of the pile. The probability of a tornado strike to the site is addressed in Section 5.2.5.

Factors are identified in the following sections for each category of impact, and numerical values are provided to the degree that current information allows. Knowledge gained during characterization will be used in repository design and the planning of operating procedures.

5.2.10.2.1 Impacts on Soils. In preparation for the salt pile and associated evaporation/retention pond facilities, topsoil will be removed and stored for reuse during decommissioning. Proper lining and salt management activities will preclude contamination of soils under and adjacent to these facilities. Based on the deposition of windblown salt estimated for the repository operations, the annual salt deposition rate is small, about 1 kilogram per hectare (0.9 pound per acre) per year. This deposition rate will result in an incremental

increase in salt concentration of the topsoil estimated to be 0.2 part per million for soil having density of about 1,600 kilograms per cubic meter (100 pounds per cubic foot). The potential impact of this incremental increase in salinity on soil fertility is not known, but the impact will be minimal and will decrease with increasing distance from the site.

Accidental salt spills could adversely affect soils in a limited area by altering the cation ratios, which could produce sodic conditions. This would lead to dispersion of soil aggregates and loss of soil permeability. Reclamation would consist of containing the area within a berm and flooding with water, to which amendments such as calcium chloride have been added (Hoffman and Meyer, 1982; Rhoades, 1982). The amendment would restore permeability as the water penetrated the soil, and the leachate would be collected by drains and disposed of properly.

5.2.10.2.2 Impacts on Surface Water Quality. Runoff from the region around the salt pile will be collected and channeled into evaporation/retention ponds. However, in the Richton Dome area, the precipitation is higher than the evaporation; therefore, there will be excess saline water, which will be disposed of off site. This saline water will be disposed of under applicable regulations and may include disposal by deep well injection or thermal evaporation followed by salt recovery (Section 5.1.2.3).

Based on predicted salt deposition rates (Section 5.2.5), potential degradation of the water quality of the adjacent streams and water bodies by windblown salt would be small. The majority of the salt emission would be deposited within the site boundary; runoff from this area will be retained in the evaporation/retention pond (Section 5.1.2.3). The amount of salt deposited in the adjacent watersheds will be less than 1,800 kilograms (2 tons) per year, primarily affecting Beaver Dam Creek, Fox Branch, and Linda Creek. Conservatively assuming that all the deposited salt will dissolve, runoff for these three creeks was estimated to be 0.1, 0.4, and 0.8 parts per million, respectively. Reported total dissolved solids (TDS) concentrations for these creeks range from 3.2 to 43.0 parts per million (Table 3-18). Thus, these increases in salinity would represent only minor changes in water quality of the adjacent streams and would not impact any downstream water bodies such as the Leaf River.

5.2.10.2.3 Impacts on Ground Water. The area of the salt pile and associated evaporation/retention ponds will be lined with salt-resistant double liners to minimize impacts to ground water. Salt concentrations between the liners will be monitored at various points around the site as an early warning system for possible salt contamination. Should salt be detected, appropriate measures will be taken to (1) restore the integrity of liners, (2) remove leaked effluents from between the liners, and (3) pump the leakage back to the surface.

Changes in ground-water quality due to infiltration of precipitation through soils contaminated by windblown salt will be minor. Modeling studies show that the deposition of salt from the repository will be about 1 kilogram per hectare (0.9 pound per acre) per year in the site area, diminishing to 0.1 kilogram per hectare (0.09 pound per acre) between 1 and 2 kilometers (0.6 and 1.2 miles) away (Section 5.2.5). If all of this salt were carried to the water table and distributed in the upper 3 meters (10 feet) of the saturated zone, it would represent an annual increase in salinity of 0.01 to 0.1 part per million. However, it is unlikely that all wind-deposited salt could reach the water table, as much of it will be transported with storm runoff to the evaporation/retention ponds.

5.2.10.2.4 Impacts on Ecosystems. Impacts on terrestrial and aquatic biota resulting from repository development and operations were discussed in Section 5.2.4. The discussion below focuses on impacts from salt management.

The ions present in common salt, those of sodium and chloride, are universal components of plant materials. However, excessive amounts of these ions deposited on vegetation or present in the soil are harmful to plant growth. The major toxic effect is osmotic inhibition of water absorption; a common symptom is leaf-tip burn. Salinity levels (generally expressed as electrical conductivity) at which a definite reduction occurs have been reported (Wadleigh and Sherman, 1978; Bernstein and Howard, 1958). Vegetation with low tolerance to salt is most likely to be affected.

Based on air dispersion, water quality, and soil analyses described in previous sections, the amounts and concentrations of salt leaving the fenced surface facility by wind or water dispersion will be small. No significant increases in soil are expected outside the fenced surface facility, and hence, no adverse effects on vegetation are expected (Section 5.2.10.1). No significant increases in the salt concentration of neighboring streams will occur (Section 5.2.10.2) and, as a result, no impacts to resident aquatic biota are expected.

5.2.10.2.5 Impacts on Land Use. Deposition of windblown salt from the salt stockpile will not significantly affect plant growth (Section 5.2.10.2) and, consequently, use of land for agriculture and forestry at the Richton Dome site. The impact will be minimal because predicted salt deposition rates are low (Section 5.2.10). In addition, deposition decreases with increasing distance from the site and most deposition will be confined to within the fenced surface facility area. Control measures discussed in Section 5.2.10.1 will minimize the potential for soil and vegetative impacts that would affect agriculture and forestry use at the Richton Dome site.

The empirical evidence for crops and trees similar to those found at the Richton Dome site indicates that deposition rates far in excess of those predicted are required for any damage to occur. Little et al. (1958) found that lobolly pines and other coniferous species along the Chesapeake Bay survived brackish water flooding even though salt concentrations ranged from 2,040 to 4,340 kilograms per hectare (1,856 to 3,944 pounds per acre).

A study of the effects of the salt cooling tower at Chalk Point, Maryland (Maryland Department of Natural Resources, 1978), reported that no significant effects on corn, soybean, or tobacco occurred at salt deposition rates below 240 kilograms per hectare (216 pounds per acre) per year.

5.2.10.3 Salt Disposal and Impacts

The development of a mined geologic repository in underground salt deposits will involve excavating large-diameter shafts from the surface to the underground geologic formation and tunneling drifts in which the waste packages will be placed. More than half of the excavated material will be used to backfill the mined areas after the placement of the wastes. The backfill material will be stored on the site and the excess (9 million metric tons [10 million tons]) will be permanently disposed of.

5.2.10.3.1 Disposal Options. The excess salt and salt-laden material brought to the surface during repository construction and operation could be disposed of in the following ways (Section 5.1.3.4):

- Onsite disposal
- Commercial market
- Ocean disposal
- Offsite (surface) disposal
- Mine disposal.

Selection of the disposal option will be based on a comparative evaluation of the advantages and disadvantages of all options suitable for a given site. A principal factor in such an evaluation will be the potential for environmental impact. The primary consideration will be assurance that the quality of the environment in the affected area during this and future generations will be adequately protected. Transportation, with its potential impacts and costs, also will be a significant factor in the evaluation.

The potential environmental impacts of each option have been identified and evaluated (D'Appolonia Consulting Engineers, 1976; BGI, 1983, ONWI-453; NUS, 1984; Scheriff, 1983; Langill, 1983; SCC, 1984a) and the results of these works provide a basis for comparing the advantages and disadvantages among the options. While the repository program has not advanced to the point where the final selection of a disposal method can be made using data specific to the selected site, the significant impacts of the options at potential sites can be reliably anticipated at this time. The following sections summarize the salient feature of each option (also see Section 5.1.3.4).

Onsite Disposal. Onsite disposal would require the construction of a large surface storage area, about 81 hectares (200 acres) in area and 8 meters (25 feet) high and underlain and covered by impervious materials. As discussed in Section 4.3.4.2, this option is relatively low in cost and has few immediate environmental impacts. Problems in ensuring long-term integrity of the landfill raise questions about long-term environmental impacts.

Commercial Market. Excavated salt would either be supplied through the General Services Administration to buyers or governmental agencies "as is" or following some onsite processing. Because the salt would be removed from the repository site, there would be no potential for long-term impact. Potential for short-term impacts would be limited in duration to the operating period of the repository and in magnitude to those of a commercial salt production facility.

If transportation costs exceed the market price of the salt, a subsidy might be required. Feasibility of this alternative has not been fully developed.

Ocean Disposal. The excess salt could be converted into brine and dispersed in ocean waters through outfalls. Transport of either the brine or the solid material from the site to the disposal point would be required.

As discussed in Section 4.3.4.2, such disposal techniques employed in the Gulf of Mexico have experienced negligible impacts on marine biota. There remains a concern regarding a potential for long-term irreversible changes that have not yet been observed in the short-term.

Offsite (Surface) Disposal. The potential for impact of this option would depend heavily on the environment chosen for disposal. Alkali flats and dried saline lake beds present the least potential for impact since the disposed salt would be blended into a natural environment composed of evaporite materials very similar in composition to the material being disposed.

Short-term impacts would occur from transport and leveling of the salt over the lake bed; long-term impacts are not expected.

Mine Disposal. Excess salt would be transported by rail to existing evaporite mines, transferred underground via a closed conveyor system, and packed into unused sections of the mines. The principal impacts of this option would be the transport of salt from the repository site to the mine used for disposal. Those impacts would occur only during the operation of the repository and, therefore, would be short term.

There are no expected long-term impacts associated with this option.

The supporting studies for the preceding sections identify mine disposal as being environmentally benign and technically feasible. Numerous mine operations were contacted (Scheriff, 1983) to locate evaporite mines with the capacity to accept waste salt. These contacts have provided assurance that many mines with sufficient capacity are available.

Tentative mine sites have been identified within 480 kilometers (300 miles) of the repository site. The resulting transportation impacts, both environmental and economic, are relatively modest. This tentative choice could be modified, if warranted, on the basis of new information that will be obtained during the characterization phase.

Disposal in such a mine would eliminate the need to isolate the excess salt from the surrounding environment. Any mine selected as a candidate to receive excess salt would be subjected to detailed geotechnical, hydrological, and mine engineering evaluation to determine its suitability for that purpose.

5.2.10.3.2 Impacts of Disposal. For any selected disposal option, the excess salt will be loaded into hopper-type railroad cars and shipped to the disposal site. In the case of the reference option the excess salt will be shipped to a salt mine in Iberia or St. Mary Parish, Louisiana. Approximately 56 rail cars of salt will be removed from the site each week. The

Southern Pacific will be the likely railroad used; the distance is about 480 kilometers (300 miles). The salt will then be fed to skip loaders and transported down into the mine for backfilling. Conveyors will be covered and loadout structures enclosed as much as practicable with dust collection/suppression equipment used to reduce escape of salt dust. Thus, every effort will be made to limit additions of salt dust to the environment. Land use would not be adversely affected by using existing or abandoned mines, and air quality would be protected from further degradation by use of dust collection and suppression devices during unloading.

In the event of an accidental spillage of salt during transport, the potential impacts will depend on the following factors:

- Location and quantities involved
- Proximity to water bodies
- Cleanup response time
- Weather conditions during the period.

Impacts resulting from accidental transportation spills on land will be localized and short term. Spills occurring during precipitation could lead to infiltration of saline runoff. During dry conditions, a small plume of dust would be generated at the accident site, settling out within a short distance. Some vegetation that is not otherwise crushed or broken by either the vehicle or its load may demonstrate symptoms of salt stress after prolonged exposure to salt drift or runoff in the event the site is not rapidly cleaned up. Procedures will be established to reload the salt into another vehicle, test soils for elevated salt concentrations, reclamate soil, and remove and replace soil or vegetation as necessary.

There is a lesser probability that accidental spillage into a body of water would occur. In that event, mitigation action would be more difficult and time dependent. If effective mitigation is not feasible, precautions are possible that will reduce the probability even lower, e.g., route selection and train speed control.

5.3 EXPECTED EFFECTS OF TRANSPORTATION AND UTILITIES

This section describes potential effects associated with the transport of nuclear wastes to the Richton Dome site (Section 5.3.1); with construction of and improvements to transportation corridors (Section 5.3.2); with non-nuclear transportation during construction, operation, decommissioning, and closure (Section 5.3.3); and with the utilities required for the repository (Section 5.3.4).

5.3.1 Nuclear Waste Transportation

Information about the costs and risks of transporting nuclear waste to the Richton Dome site is summarized in this section to fulfill the NWPA requirements that costs and impacts of waste transportation be considered in repository siting. The bases for these results are presented in Appendix A. Because these costs and impacts are largely national in scope, the first sections of this analysis consider waste transport from the point of generation or storage to the repository. Later sections address regional impacts and site-specific concerns.

During preparation of Section 5.3.1., an attempt was made to address site-specific concerns about impacts to the existing transportation network. Many site-specific concerns are institutional issues discussed in Appendix A and in "The Institutional Development of the Transportation System" (Section 3.3.3) of the Mission Plan (DOE, 1985, DOE/RW-0005, p. 98).

Nuclear waste to be disposed of in a deep-mined geologic repository comes from a variety of sources across the United States. Wastes being considered for disposal include spent nuclear fuel; spent fuel consolidated at a Monitored Retrievable Storage (MRS) Facility and the associated wastes generated from consolidation; defense wastes; and high-level waste (HLW) from the cleanup of the West Valley, NY, commercial reprocessing facility.

The two waste acceptance systems used in this analysis are described in Appendix A. One system is called the Authorized System and the other is called the Improved Performance

System. The impacts both these systems have on waste transport to the repository will be presented in this section.

The Authorized System is based on receipt of waste shipped directly from where it was generated to the Richton Dome candidate repository site. Using the Authorized System, 62,000 MTU (metric tons of uranium) of spent fuel from commercial nuclear power plants would be received.

Additional waste sources considered in the Authorized System include HLW from the cleanup of the commercial reprocessing plant at West Valley, New York, and from defense-related reprocessing activities at Savannah River, South Carolina; Idaho Falls, Idaho; and Hanford, Washington. The Mission Plan discusses receipt of the equivalent of 8,000 MTU of defense and West Valley HLW, making the evaluation consistent with the Nuclear Waste Policy Act of 1982 (NWPA), which states that the total capacity of the first repository shall be limited to 70,000 MTU until the second repository is in operation. Based on evaluations documented in Appendix A, waste equivalent to 11,425 MTU of defense waste and 400 MTU of West Valley HLW may be available for disposal. To be conservative, this section considers the potential impacts of transporting 62,000 MTU of spent fuel plus the equivalent of 11,825 MTU of HLW to the repository site.

The Improved Performance System is based on the receipt of consolidated spent fuel from an MRS facility. Generally spent fuel would first be shipped to the MRS for consolidation and storage if required (see Section 5.3.1.1 for a detailed description of the MRS senario). Then all the consolidated spent fuel, along with additional wastes generated during the consolidation process, is shipped directly from the MRS facility to the Richton Dome site using dedicated trains (trains that contain only cars destined for the repository and travel from the MRS facility to the repository as a unit). The total quantity of consolidated spent fuel shipped from the MRS is 62,000 MTU. The Improved Performance System also considers the same additional waste sources as were considered in the Authorized System, namely wastes from cleanup of the West Valley, New York, facility and from three defense-related reprocessing activities (Table 5-11). For the purpose of this analysis, it is assumed that these waste forms are shipped directly to the repository under both the Authorized and Improved Performance systems.

The following subsections summarize waste transportation activities, the cost of such activities, the radiological and nonradiological risks associated with nuclear waste transport, and regional risks of nuclear waste transport.

5.3.1.1 Waste Transportation Activities

The Section 5.3.1 introduction briefly described the basis for the transport impact assessment. To describe the nuclear waste transportation activities, it is necessary to specify the geographic distribution of waste sources and the quantity of waste from each source location.

For the Authorized System, the transportation analysis considers the shipment of spent fuel from each reactor to the Richton Dome candidate site. The reactor sites considered, the quantity of waste shipped from each site, and the distance from each reactor site to Richton Dome by highway and railroad are included in the analysis. Because of uncertainty about the combination of truck and rail transport, both 100 percent truck transport and 100 percent rail transport are considered.

For the Improved Performance System, both truck and rail transport are considered from the reactor sites to the MRS facility, but only rail transport of consolidated spent fuel is considered from the MRS facility to the Richton Dome site. The point of origin for the consolidated spent fuel shipments is taken to be Oak Ridge, Tennessee.

In Appendix A, the transportation impacts of four cases involving the MRS operations are presented. The first case ships 62,000 metric tons (68,343 tons) of spent fuel to the MRS, consolidates and overpacks the spent fuel so it is ready to emplace upon arrival at the

Table 5-11. Lifetime Nuclear Waste Shipment Requirements to the Repository, Richton Dome

Waste Receipt Cases	Total Packages	100 Percent Truck Payload[b]	100 Percent Truck Number of Shipments	100 Percent Rail Payload[b]	100 Percent Rail Total Shipments	Shipment Miles (Millions)[f] 100% Truck	Shipment Miles (Millions)[f] 100% Train
Component 1: Spent Fuel Direct to Repository							
PWR[a]	--	2	43,611	14	6,190		
BWR	--	5	26,942	36	3,737		
Total	--		70,553		9,927	67.4	11.0
Component 2: Defense HLW and West Valley Wastes							
Defense Wastes[c]							
SRP	11,600	1	11,600	5	2,320		
INEL	9,000	1	9,000	5	1,800		
Hanford	2,250	1	2,250	5	450		
Total Defense Waste	22,850		22,850		4,570	28.0	6.5
WV-HLW	800	1	800	7	115		
Total	23,650		23,650		4,685	1.0	0.2
Component 3: Spent Fuel to MRS							
PWR	--	2	44,222	14	6,267		
BWR	--	5	26,346	36	3,667		
Total	--		70,568		9,934	48.8	8.0
Component 4: Consolidated Spent Fuel from MRS							
Consolidated Spent Fuel	--			24 PWR[g] 80 BWR	8,074		
Hardware	5,455	--	--	4	1,364		
High Activity Waste (HAW)	5,084	--	--	4	1,270		
CH-TRU[g] 36 Drums/PKG Trupack)	11,400	--	--	72[d]	159		
Total					10,867	6.3(d)	6.3(d)
Authorized System Description (Components 1 & 2 direct to Repository)							
Spent Fuel	--	--	70,553	--	9,927		
Defense HLW and West Valley Waste	--	--	23,650	--	4,685		
Total	--	--	94,203	--	14,612	96.4	17.7
Improved Performance System Description (Components 2, 3, & 4)							
Spent Fuel	--	--	70,568	--	9,934		
Consolidated Spent Fuel to repository	--	--	(d)	--	10,867		
Defense & West Valley HLW	--	--	23,650	--	4,685		
Total	--	--	94,218	--	25,486	84.1	21.0

(a) PWR - pressurized water reactor; BWR - boiling water reactor.
(b) Payload refers to number of fuel assemblies, canisters, waste packages, or drums per transport package.
(c) Two packages per railcar.
(d) All shipments from MRS to repository via dedicated trains.
(e) SRP = Savannah River Plant; INEL = Idaho National Engineering Laboratory.
(f) One-way-loaded miles.
(g) 100-ton cask 24 PWR assemblies in ready-to-emplace waste packages, 30 BWR assemblies in one ready-to-emplace package.

repository, and uses a 91-metric ton (100-ton) rail cask to ship the consolidated spent fuel to the repository. The 91-metric ton (100-ton) cask is also used to transport the hardware and high-activity wastes generated during the consolidation operation. The second case is similar to the first, with the exceptions that a 136-metric ton (150-ton) rail cask is used in place of the 91-metric ton (100-ton) cask, and the consolidated spent fuel is not overpacked before shipment. The third case takes all the fuel generated west of longitude 100 degrees and ships it directly to the repository. Longitude 100 degrees passes through the Texas Panhandle; about 7.5 percent of the waste is generated west of this longitude. The remaining 92.5 percent of the spent fuel is shipped to the MRS. The fourth case is similar to Case 3, except the 136-metric ton (150-ton) transport cask is used and the consolidated spent fuel is not overpacked at the MRS. Fuel shipped from the MRS to the repository is transported in 91-metric ton (100-ton) rail casks as ready-to-emplace waste packages, making this case similar to Case 1 for these shipments.

In the EA it is desirable to give conservative impacts. A comparison of the four cases in Appendix A shows that Case 1 (overpacked fuel in a 91-metric ton [100-ton] rail cask) is the most conservative MRS case. Cases 3 and 4 are not considered meaningful for Richton Dome because they were developed to reduce the impact on western repositories of siting the MRS at an eastern location. If all spent fuel were to go to the MRS, which would happen in Cases 1 and 2, then fuel discharged from western reactors would first travel east for storage at the MRS and then west for disposal at western repositories. By eliminating Cases 3 and 4 for Richton Dome, Case 2 (non-overpacked consolidated spent fuel transported in a 136-metric ton [150-ton] cask) is considered the minimum impact case. The maximum impact case (Case 1) requires four times more shipments than the minimum case. Because the EA attempts to bound the impacts on the high side, only the least favorable of the Improved Performance cases, Case 1, will be shown in this section. Numbers for Case 2 are given in Appendix A.

5.3.1.1.1 Shipment Requirements. Because the Authorized System and the Improved Performance System contain common elements, their shipment requirements can be analyzed using four components which contain elements of both systems. These four components are as follows:

- Component 1: Transport of 62,000 MTU of spent fuel from the reactors directly to the repository using 100 percent truck transport or 100 percent rail transport
- Component 2: Transport of 22,850 canisters of defense waste and 800 canisters of West Valley HLW from their points of origin to the repository using 100 percent truck transport or 100 percent rail transport
- Component 3: Transport of 62,000 MTU of spent fuel from the reactor sites to the Oak Ridge, Tennessee, MRS facility using either 100 percent truck or 100 percent rail
- Component 4: Transport of consolidated spent fuel from Oak Ridge, Tennessee, to the Richton Dome repository using dedicated train.

The estimated number of truck and rail shipments required for nuclear waste transport for the four components for all waste types is shown in Table 5-11. Also shown in the table are the cask capacities used for each of the packagings. These capacities are based on current waste package data and packaging technology. The use of current packaging technologies in no ways implies existing packagings will be used.

For the spent fuel to repository component (Component 1), an estimated 71,000 shipments would be required for 100-percent truck transport, and approximately 10,000 shipments would be required for 100 percent rail transport.

The defense wastes and West Valley HLW component (Component 2) would require approximately 23,700 shipments using 100 percent truck transport or 4,700 shipments using 100-percent rail transport. The breakdown of shipments among the waste sources is presented in Table 5-11.

For Component 3, which considers shipment of 62,000 MTU of spent fuel to the MRS by truck or rail, the 10,000 rail shipments and 71,000 truck shipments approximately are about equal to the numbers required for Component 1 where the shipments were sent directly to the repository. The actual numbers may differ slightly because of shipping schedule differences.

Component 4, which considers shipment, from the MRS facility to the repository, of 62,000 MTU of consolidated spent fuel and waste from consolidation and waste package fabrication, will require approximately 8,100 cask shipments or approximately 1,600 dedicated train shipments of ready-to-emplace waste packages over the repository's lifetime. It is estimated that another 2,800 casks which contain wastes produced from the consolidation operation will also be shipped in the dedicated trains over the repository's lifetime.

From these four components, it is possible to construct the shipment requirements, costs, and risks associated with both the Authorized System and the Improved Performance System. The Authorized System includes Components 1 and 2; the Improved Performance System includes Components 2 through 4. The shipment data for these two transport systems are shown at the bottom of Table 5-11.

5.3.1.1.2 Waste Transportation Costs. The NWPA specifically requires that the costs of transporting nuclear waste be included in siting decisions. To estimate the total life-cycle costs of transporting nuclear waste to the Richton Dome site, the shipment information in Table 5-11 has been used with the source distribution data. These costs were developed using data and techniques summarized in Appendix A. The total life-cycle costs for the two Mission Plan Transportation System are shown in Table 5-12. The costs shown are the projected total transport costs for the repository shipping lifetime (approximately 25 years) expressed in undiscounted 1985 dollars.

The costs consider fleet capital, fleet servicing, and maintenance and shipping charges. Fleet capital costs were based on transportation system characteristics and comparison with costs of existing transportation systems. Servicing and maintenance costs were estimated by multiplying a fraction of the unit capital costs per year by the operation fleet size. It was also assumed in the capital cost estimate that the fleet would be replaced for any shipment schedule that exceeded 15 years. Based on the shipment schedule shown in Appendix A, the cask fleet was completely replaced for spent fuel, West Valley and defense HLW from Savannah River. The cask fleet was not replaced for Idaho Falls and Hanford, and West Valley HLW shipments.

Freight charges were based on published tariffs, where available, and estimates were based on shipments of spent fuel where no tariffs have been published. Charges for physical security in transit were based on current spent fuel escorting experience. These costs were applied to all waste forms. This is believed to be conservative in that current regulations do not include such requirements for HAW, HDW, and CH-TRU reprocessing waste shipments from the MRS.

To place the total transport cost in perspective, this cost is less than one percent of the cost to consumers who use electricity generated by nuclear power. It is also one of the smaller components in the total cost of waste disposal.

5.3.1.2 Radiological and Nonradiological Effects Associated with Nuclear Waste Transport

The measure used for estimating the radiological and nonradiological effects of nuclear waste transport to the Richton Dome site is the risk of several categories of health effects to the general population. The categories are broadly divided into nonradiological and radiological health effects.

5.3.1.2.1 Nonradiological Health Effects. The potential nonradiological health effects include injuries and fatalities associated with transport vehicular accidents as well as pollution health effects caused by truck and train emissions, primarily in urban areas. Accident rate experience, using transportation accident rate statistics to estimate the number of nonradiological injuries and fatalities, is described in Appendix A. Pollution health effect estimates were based on analysis methods and data developed by the Transportation Technology

Table 5-12. Total Life Cycle Nuclear Waste Transport Cost, Richton Dome[a]

Receipt Type	Cost, millions of dollars (1985) 100 Percent Truck Transport	100 Percent Rail Transport
Authorized System		
Spent fuel and West Valley waste	722	699
West Valley waste	7	10
Defense waste	207	272
Total--Authorized System	936[e]	982[e]
Improved Performance System[d]		
Spent fuel shipments to MRS	600	594
Consolidated spent fuel for MRS	421[c]	421
HAW/HDW from MRS[b]	80[c]	80
CH-TRU[b]	8[c]	8
West Valley waste	7[c]	10
Defense Waste	207	272[e]
Total--Improved Performance System	1,323[e]	1,384[e]

(a) From Appendix A.

(b) HAW = High activity waste; HDW = hardware; CH-TRU = Contact-Handled Transuranic Waste.

(c) Dedicated train cost of consolidated spent fuel included to completely describe system using truck transport for spent fuel to MRS and for defense and West Valley wastes to the repository.

(d) Ready for emplacement waste packages in 91-metric-ton (100-ton) casks -the most conservative MRS case.

(e) Sum of component values shown may not add up to total because of round off.

Center (TTC) at Sandia National Laboratories and are summarized in Appendix A. These analyses conclude that essentially all pollution health effects from transportation occur while vehicles are traveling through urban areas. Appendix A provides estimates of the fractions of travel through urban areas for shipments to the repository sites. These estimates were used to estimate the pollution health effects shown in Table 5-13.

5.3.1.2.2 Radiological Health Effects. The radiological impact analysis included health effects associated with both normal transport and very infrequent accidents potentially severe enough to release some of the radioactive material being carried. Health effects included both acute fatalities and latent cancer fatalities (LCFs) to both the present and future generations. The computer code RADTRAN-II (see Appendix A) was used to make the estimates. RADTRAN-II models both incident-free radiological exposure and the consequence of radiological releases following severe accidents. The results depend on such factors as population density, distance, transport mode, cask capacity, and accident rates. The results of the analyses show that no acute radiation fatalities are projected to occur as a result of radioactive releases from any postulated accidents. Thus, only LCFs have been included in the analyses presented in Appendix A and in this section.

Table 5-13 summarizes the nonradiological and radiological risk measures for transporting waste to the Richton Dome site. To obtain an upper bound estimate, both the Authorized System and the Improved Performance System have been evaluated. Analyses which maximize truck and rail shipments for the two systems show that the upper bound truck radiological risk estimates are obtained using the Authorized System and upper bound rail radiological estimates are essentially the same for both cases. The purpose of this analysis is to bound the impacts rather than compare the two transportation systems. Even for the bounding case, however, the risks are very small compared to other risks. This perspective is discussed in Section 5.3.1.2.3.

The limiting impacts over the approximately 25-year repository shipping lifetime are as follows: the maximum number of injuries projected to occur from traffic accidents are 71 for rail and 250 for truck; the maximum number of fatalities projected to occur from traffic accidents are 7 for rail and 21 for truck; and radiation exposure resulting from normal transport is estimated to result in less than 1 LCF to present and future generations for rail and approximately 6 LCFs for truck transport. The potential risk associated with accidents severe enough to release some of the radioactive material being transported to the repository is less than 1 fatality over the operating period of approximately 25 years.

5.3.1.2.3 Risk Perspectives. To be meaningful, the data on the risks of nuclear material transport to a candidate repository site should be placed in perspective. During the minimum shipping period of 25 years, 113,000 LCFs would be predicted to occur in the United States from background radiation, using the same models and data as in this analysis, which is based on methods developed by the Committee on the Biological Effects on Ionizing Radiation of the National Academy of Sciences (1980). Based on the accident data for 1983 (National Safety Council, 1984, p. 56), 112,500 individuals would be predicted to die during a 25-year period as a result of accidents involving truck tractors and semi-trailers. For transport of all freight over all rail lines in the United States during a 25-year period, using the 1983 accident data (National Safety Council, 1984, p. 78), 27,000 individuals would be projected to die. Based on these values, the fatalities resulting from accidents rather than from the radiological nature of the cargo are less than 0.02 percent of the fatalities attributed to the transport of commercial freight. The LCF estimate is less than 0.01 percent of those fatalities attributable to natural background radiation. Thus, all national risks resulting from nuclear waste transport are extremely small, relative to other comparable risks. This conclusion is valid for both the Authorized and the Improved Performance Systems described here and in the Mission Plan.

5.3.1.3 Access Routes and Mode of Transport

The most visible impact on the region around the repository would be the regular transport of waste materials into the region. The frequency of shipments would depend on the ratio

Table 5-13. Total Risk of Nuclear Waste Transport During the Operational Period to the Richton Dome[a][b]

Risk Measure	Waste Transport Mode[b]	
	100% Rail	100% Truck
Authorized System		
Nonradiological		
Number of Injuries	17	240
Number of Fatalities	1.6	19
Pollutant Health Effects[c]	0.2	0.2
Radiological[d]		
LCFs from Normal Transport	0.2	6.3
LCFs from Accidents	0.02	0.03
Improved Performance System[f]		(e)
Nonradiological		
Number of Injuries	71	250
Number of Fatalities	6.7	21
Pollutant Health Effects[c]	0.2	0.2
Radiological[d]		
LCFs for Normal Transport	0.2	5.3
LCFs for Accidents	0.03	0.03

(a) From Appendix A.
(b) Includes DHLW and WVHLW shipments.
(c) Calculated latent cancer fatalities from vehicle emissions to present and future generations.
(d) Calculated latent cancer fatalities from radiation exposure to present and future generations.
(e) Truck shipment risks include rail shipment risks from dedicated train shipments from the MRS to the repository.
(f) Ready for emplacement waste packages in 91-metric-ton (100-ton) casks - the most conservative MRS case.

of truck to rail transport used. The daily receipt estimates for the Authorized and Improved Performance Systems are shown in Table 5-14. For the Authorized System, the maximum receipt rates would be 16 trucks per day for the 100 percent truck transport and 3 rail cars per day for the 100 percent rail transport. For the Improved Performance System, as shown in Table 5-14, the expected number of shipments arriving daily would be about 4. The payload of the casks and the mix of rail and truck shipments will have a great effect on the daily receipt rates. To provide an example using both shipment modes and state-of-the-art casks, McSweeney et al. (1984, Table 4) reported that on a typical day the repository would receive 2 rail car shipments and 2 truck shipments. Thus, except for nonroutine circumstances, the 16 truck shipments per day is not expected to be exceeded.

The exact route of transport to the site from the many waste generation and storage points in the United States is difficult to project for rail transport because the routes may depend on contractual agreements with waste carriers entered into by the DOE. For highway transport, the local routes are uncertain because the State of Mississippi may designate preferred alternative routings using Department of Transportation guidelines. Thus, the analysis presented here is based on routes judged by the DOE to be reasonable.

The region, as defined for this regional analysis, is the area within a radius of 200 kilometers (125 miles) centered on the restricted area. The 200-kilometer (125-mile) radius was selected to include the major rail interchange locations that may be used to transport waste to the site. The 200-kilometer (125-mile) radius is also expected to include all the major interstate highways that would be considered feasible access routes to the region. The major area highways and rail lines are shown in Figure 5-19. The following paragraphs will consider the regional impacts first of highway transport, and then of rail transport.

5.3.1.3.1 Highway Transport. The potential highway routes to this site are largely dictated by DOT highway routing regulations (49 CFR 177.825), which require carriers of spent fuel and HLW to follow interstate system highways unless an alternative route has been specifically designated by the appropriate State agency.

The States of Mississippi and Alabama could play an important future role by designating alternative noninterstate highway routes in the region under consideration. However, since these states have not exercised this option it is assumed that the major interstate highways within the region are the routes for the present analysis of highway impacts.

The three most plausible highway routes based upon the regulatory constraints just discussed are shown below:

1. I-59/I-20 South and West. Traffic from much of the northeast and middle Atlantic states would enter the region traveling south and west on I-59/I-20 to Meridian. The waste would then be carried south on I-59 to Laurel. The most direct highway from Laurel to the site is Mississippi State Highway 15 to the repository access road entrance, about 6 kilometers (4 miles) north of Richton.

2. I-20 East and I-59 South. Traffic from western states could enter the region traveling east on I-20 through Jackson. Traffic from midwestern and central states could be routed via I-55 to Jackson, then east to Meridian on I-20, and then I-59 to Laurel for connection with Mississippi State Highway 15 as above. Shipments from western and midwestern states could entail circuitous routing in Mississippi unless the State determined that an adequate noninterstate highway (U.S. 49) is available between Jackson and the Laurel/Hattiesburg area.

3. I-10 West and I-59 North. Traffic from Florida and some parts of the southeast could be routed via I-10 through Mobile to the vicinity of Slidell, Louisiana. The shipment could then proceed north to Laurel on I-59 and access to Mississippi State Highway 15. This routing could also conceivably be used for some shipments from the west via I-12 to Slidell.

Table 5-14. Average Daily Waste Receipts for the Authorized and Improved Performance Systems

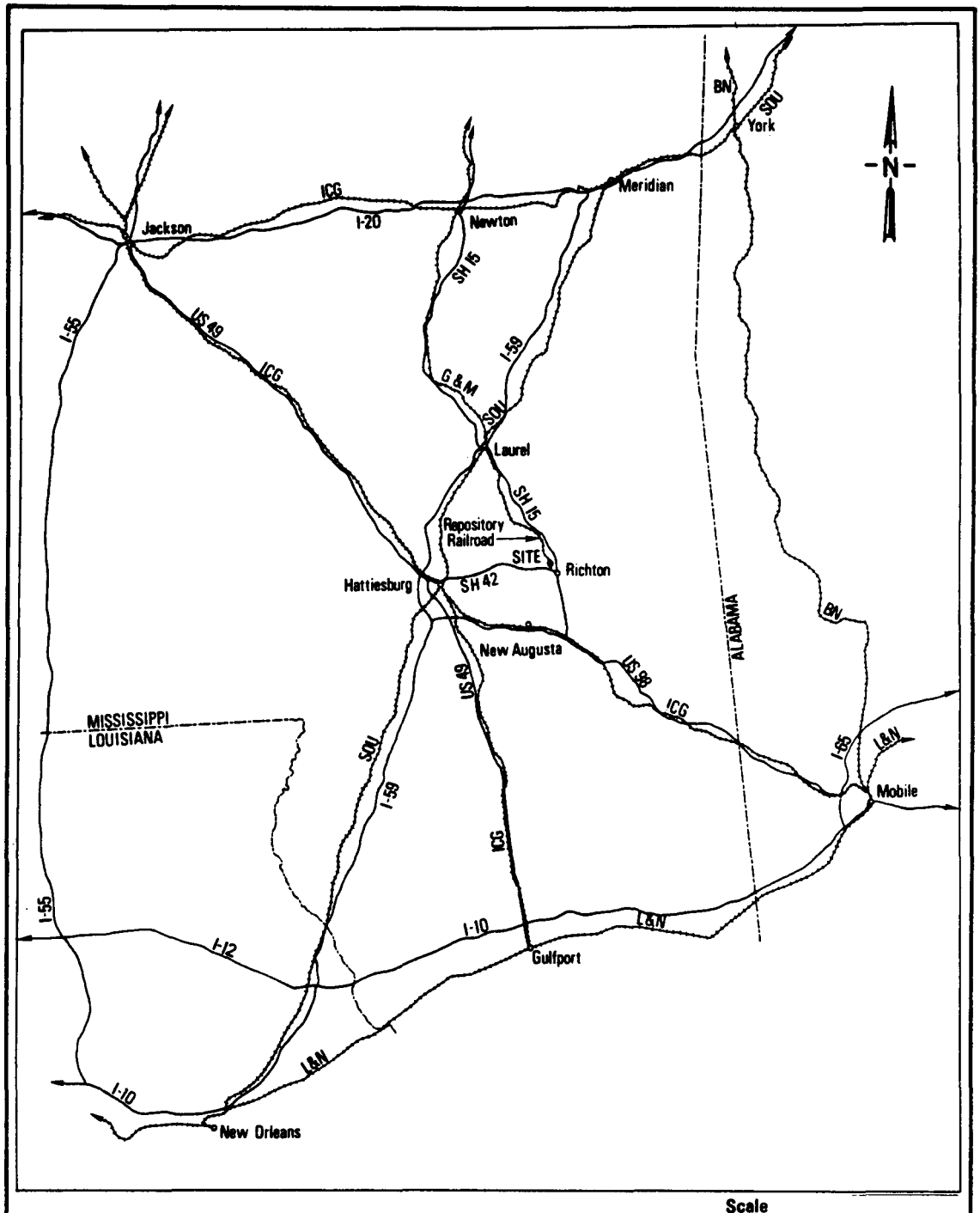
Receipt Form	Transport Mode	
	100% Truck	100% Rail
Authorized System		
100% Spent fuel[a]	12	2
Defense and West Valley HLW[b]	4	1
Total	16	3
Improved Performance System		
Consolidated spent fuel and Associated Wastes[a]	(c)	2[d]
Defense and West Valley wastes[b]	4	1
Total	4	3

(a) Assumes receipts of 3,000 metric tons (3,307 tons) per year of spent fuel during 50 weeks per year, 6 days per week.

(b) Based on peak receipt rate of 1,190 canisters per year, 50 weeks per year, 6 days per week.

(c) Consolidated spent fuel--rail only in dedicated trains.

(d) Receipts will occur via dedicated train, approximately 1 train consisting of 10 cars every five days.



Major Regional Railroads and Highways–
Richton Dome Site

Figure 5-19

A methodology for estimating nuclear waste transport costs and risk on a national basis has recently been developed (see Appendix A). This methodology has been applied to the nine potential sites, and cost and risk estimates on a national basis have been estimated as summarized in Tables 5-12 and 5-13. However, these analyses do not address the relative impact on the region near the potential repository sites. In the following paragraphs, the national risk-estimating methodology will be applied to the region in order to make a preliminary evaluation of the regional impact. It should be pointed out that many of the parameters used in a national evaluation may not apply locally because of site-specific conditions or characteristics. At this time, available data have not permitted a thorough enough evaluation to establish the validity of using the national techniques in a regional analysis. Thus, this analysis should be considered preliminary.

The regional risk calculation considers the Authorized and Improved Performance Systems considered in the national analysis. It also assumes that the entire repository capacity will be shipped on each route analyzed for both truck and rail. Since the goal of this calculation is to conservatively estimate the regional risk, the above assumptions are adequate. The actual fraction to be shipped by rail truck and the fraction which will use specific routes have not been determined at this time.

The risk calculation requires several regional parameters: the population density along the routes; the fraction of travel along each route; and the total route length. In addition, the total number of shipments made along the route must be identified.

Route-specific population density estimates are preliminary at this stage. The analysis used relative data obtained from the City County Data Book (Bureau of the Census, 1983). To characterize the population density along the route, three population classifications were considered. They have been termed urban, suburban, and rural for these transport analyses. These classifications should not be confused with definitions of urban and suburban used in socioeconomic evaluations. Their definitions for the transport analysis are as follows.

The suburban density was estimated by taking all towns and cities of between 2,500 and 100,000 population within a 200-kilometer (125-mile) radius of the Richton Dome site and estimating their average density. This value was used as the suburban density for all routes in the regional analysis. The rural density was based on a route-specific evaluation. For each route, a weighted rural density was calculated using the following procedure. The distance through each county was estimated. Then the rural density in the county was calculated by taking the county population and land area and subtracting from these values the population and land area of any towns and cities, to obtain the rural population and area and hence the rural population density. The average rural density along a route was then calculated by weighting the county data by the fraction of travel through rural areas and summing the weighted data. Urban densities were assumed to be 3,861 people per square kilometer (10,000 people per square mile). This density has been used in the national analyses in Appendix A. The estimated land area occupied by urban zones was obtained by taking the density of any cities with greater than 100,000 inhabitants and finding the number of square miles of urban area that would be needed so that the remaining suburban area density matches the region average suburban value. If the density of the large cities was not significantly different from the suburban value, the city, even though it was large, was classed as suburban. In the region around Richton, both Mobile and Jackson were classed as urban. The results of this calculation for Richton Dome are shown in Table 5-15 in the section of the table labeled "Population Density."

The next step in the regional calculation was to estimate the fraction of travel through each of the population zones on a route-specific basis. The route fraction estimates are shown in Table 5-15 under the heading "Fraction through Populated Zones." RADTRAN-II was used to obtain the unit risk factors. The unit risk factors were then multiplied by the appropriate total vehicle miles traveled to get the impact results given in Table 5-15.

The purpose of the regional risk calculation is to estimate the risk to the people in the site vicinity should the site be chosen as a first repository for high-level nuclear waste. The values presented in Table 5-15 are not presented for the purpose of comparing routes but

Table 5-15. Regional Risk Calculation (Truck Transport), Richton Dome

Route Characteristic	Route #1	Route #2	Route #3
Interstate Highway	I-59/I-20 South and West	I-20 East and I-59 South	I-10 West I-59 North
Distance (kilometers)	236	344	495
Fraction through populated zones (percent)			
Urban	0.0	0.0	1.0
Suburban	3.4	5.8	4.4
Rural	96.6	94.2	94.6
Population Density (persons/km^2)			
Urban	3,861	3,861	3,861
Suburban	524	524	524
Rural	10.9	12.7	16.8
Risk Parameters			
Authorized System			
Nonradiological			
Fatalities	3.0	4.2	6.2
Injuries	36	52	75
Radiological LCFs			
Normal Transport	0.7	1.1	1.6
Accidents	0.0004	0.0008	0.0014
Improved Performance System[(a)]			
Nonradiological			
Fatalities	2.2	2.5	3.0
Injuries	25	29	34
Radiological LCFs			
Normal Transport	0.17	0.25	0.36
Accidents	0.0005	0.0005	0.0005

(a) Includes the risk from dedicated rail shipments to the repository from the MRS.

rather to estimate the spectrum of risks that are projected. The magnitude of the risk number and not the variation caused by using different routes is of interest. Based on the size of the numbers, the incremental risk associated with regional transport is very small compared with other risks to the same population.

5.3.1.3.2 Railroad Transport. It is too early to predict exact rail routes. Competing carriers potentially offering service from the many points of origin to the repository will need to be evaluated by the DOE on the basis of service reliability, safety, and cost before repository start-up. In addition, rail access-route corridors are still under consideration (see Section 5.1.2.2). Four Class 1 rail carriers serve the 200-kilometer (125-mile) region surrounding the Richton Dome site near Richton, Mississippi. These carriers serve the entire southeastern United States and connect with other major systems serving virtually the entire United States. The carriers include the Illinois Central Gulf (ICG) Railroad, the Southern Railway System (now part of Norfolk Southern Corporation), the Burlington Northern (BN) Railroad, and the Louisville and Nashville (L&N), which is part of the Seaboard System

Railroad (now part of CSX Corporation). Eight potential rail routings to the site are listed below:

1. Nuclear waste from the eastern United States can enter the 200-kilometer (125-mile) zone on the southern system through Tuscaloosa, Alabama, and Meridian to Laurel, Mississippi, where it can be transported to the Richton Dome site using the repository railroad.

2. Nuclear waste from the southeastern United States can be shipped on the Seaboard System through Crestview and Pensacola, Florida, to Flomaton, Alabama, where it can be switched to the L&N main line to Mobile, Alabama. At Mobile, Alabama, Seaboard interchanges with the ICG, which can transport the waste to Hattiesburg for interchange with the Southern Railroad. The Southern Railroad can transport the waste to Laurel where it can be transported to the Richton Dome site via the repository railroad.

3. Nuclear waste from western and midwestern states can enter the region via Jackson, Mississippi. Waste from the west can travel the ICG line from Shreveport, Louisiana. Waste from midwestern and northeastern states can travel via Memphis, Tennessee. Waste from Jackson can be routed to Newton, Mississippi, for switching to the Gulf and Mississippi short-line to Laurel. At Laurel, it can be picked up by the repository railroad.

4. Southern Railroad connects with several major western carriers in New Orleans. This traffic could be routed north from New Orleans through Hattiesburg, Mississippi, to Laurel, Mississippi, for interchange with the repository railroad and delivery to the Richton Dome site.

5. The ICG in Jackson connects with western carriers in Shreveport, Louisiana, and Memphis, Tennessee, bringing traffic to Jackson, Mississippi. From Jackson, traffic could be routed to Hattiesburg, Mississippi, for interchange with the Southern Railroad. The Southern Railroad would then transfer the traffic to Laurel, Mississippi, for interchange with the repository railroad and delivery to the Richton Dome site.

6. Traffic from Illinois and the Midwest could use the ICG rail line through Tupelo, Mississippi, to Meridian, Mississippi. At Meridian, the traffic would be interchanged with the Southern Railroad for delivery to Laurel, Mississippi. At Laurel, traffic would be interchanged with the repository railroad for delivery to the site.

7. Nuclear waste from the Midwest could enter the region on the L&N rail line through Montgomery, Alabama. From Montgomery, the traffic could be routed to Mobile and interchange with ICG. The ICG would transfer it to Hattiesburg for interchange with the Southern Railroad which would transfer it to Laurel for interchange with the repository railroad and delivery to the Richton Dome site.

8. The BN system serves the Pacific Northwest and many railroad western points. Nuclear waste traffic on the BN could be brought all the way to Alabama. The traffic could be interchanged with the Southern at York or Boligee, Alabama. From either location, the traffic could proceed to Laurel on Southern and be interchanged with the repository railroad.

Of these eight routes, the first three were analyzed to estimate the range of impacts that would potentially result from the use of regional rail access routes.

The regional risk for rail shipment to the site was evaluated by assuming each route is used to ship all of the waste to the repository. Table 5-16 shows the results of the calculations, which adjust unit risk factors and population densities along the routes. This table provides a summary of the characteristics of the route, expressed in terms of distance traveled in the 200-kilometer (125-mile) radius; the fraction traveled through urban, suburban, and rural zones; and the population density in those zones. It also presents the results of the risk calculation for each of the routes, expressed in terms of absolute risk.

As was the case with highway risks, of concern is the magnitude of the risk value rather than the risk differences among routes. Based on the magnitude of these numbers, the risk of nuclear transport in the region is very small.

5.3.1.3.3 Barge Transport of Spent Fuel. Up to this point the entire discussion of the costs and risks of waste transportation to the repository site has considered truck or rail transport. However, barge transport is discussed in Appendix A. If barge transport were used, intermodal transport would be required. As currently envisioned, the cask could be transferred to a rail car or the entire rail car including the cask would be unloaded from the barge at Memphis, Tennessee, or Mobile, Alabama.

The DOE plans further national logistics, economics, and risk studies of barge transport. These studies will be coordinated with site-specific studies (Section 4.1.3.1.10) during site characterization. However, since shipments using barges would require rail transport locally, the results already presented in Section 5.3.1.3.2 are adequate for EA purposes.

5.3.1.3.4 Additional Regional Concerns. Concerns have been expressed about the effect of slow train speeds because of poor roadbed in the site vicinity. Concerns have also been expressed about consequences of releases from severe transportation accidents, radiation exposure to individuals under normal conditions of transport, and cumulative exposures occurring to people in the site vicinity. The following sections address each of these concerns.

Train Speed. The State of Mississippi was concerned about the speed of trains in the region. Except for the third route, which would use the Newton to Laurel route just recently sold to L. B. Foster and is being operated as the Gulf and Mississippi Railroad, all the route segments are currently in good condition and appear fully able to handle repository traffic with no significant delays. The Gulf and Mississippi rail line would have to be upgraded before being used. In the future, when the DOE contracts with railroads for repository service, the condition of the line will be a consideration in the selection process.

Based on information provided by the Mississippi Public Service Commission, the estimated average rural speeds on the three routes are 96, 40 and 29 kilometers per hour (60, 25, and 18 miles per hour) respectively. Since the rural speed used in the national risk calculation was 64 kilometers per hour (40 miles per hour), a calculation was made to estimate the effect of dividing the velocity by 2. To make this estimate, assumptions regarding the stop time models which indicate how much time the trains will be stopped must be described because exposure to the population is the sum of the exposure while moving and the exposure while stopped. The former changes with velocity.

Table 5-16. Regional Risk Calculation (Rail Transport), Richton Dome

Route Characteristic	Route #1	Route #2	Route #3
Point of Entry	via Meridian	via Mobile	via Jackson
Distance (kilometers)	230	436	268
Fraction through Population Zones (percent)			
Urban	0.0	0.0	1.2
Suburban	7.6	15.3	8.2
Rural	92.4	84.7	90.6
Population Density (persons/km^2)			
Urban	3,861[a]	3,861	3,861
Suburban	524	524	524
Rural	11.1	17.8	13.2
Risk Parameters			
Authorized System			
Nonradiological			
Fatalities	0.19	0.36	0.23
Injuries	2.0	3.8	2.3
Radiological LCFs			
Normal Transport	0.044	0.057	0.046
Accidents	0.004	0.0014	0.0008
Imported Performance System			
Nonradiological			
Fatalities	1.5	1.6	1.5
Injuries	16	17	16
Radiological LCFs			
Normal Transport	0.016	0.020	0.016
Accidents	0.0005	0.0005	0.0006

(a) Dedicated train shipments of consolidated spent fuel and associated wastes were assumed to occur over Route 1. The risk of these shipments was calculated for Route 1 and added to the risk of the defense HLW and West Valley HLW shipments over this route.

The stop model for regular trains used a stop time of 3.3 hours per 100 kilometers (62 miles) of travel while in transit and 30 hours at the closest interchange to the repository. For dedicated trains, the stop time used was 0.36 hours per 100 kilometers (62 miles), and a one-hour stop at the last interchange before the repository. These values are significantly changed from the model used in the draft EA and reflect the results of recent studies which were mentioned as being in progress in the draft. Appendix A provides additional details on the new model for stops.

Because of the shorter duration of time a dedicated train is stopped, a change in the average velocity has a greater effect on the dedicated train radiological risk values. For the regular train case, decreasing the average rural speed of the train from 64 kilometers (40 miles)per hour to 29 kilometers (18 miles) per hour increases the radiological risk by 20 percent. For the dedicated train case, the radiological risk goes up by 40 percent. These increases, while significant, represent a small increase in the risk to the people in the site vicinity.

Radiation Exposures to Individuals From Normal Transport. The previous risk analyses aggregate the radiation exposure and, in turn, health effects to the national and regional population from all nuclear waste transportation activities. This section identifies several activities and routine operations in which individual workers are exposed to radiation. Also included are exposures to individuals in the public domain under conditions which may occur during normal transportation operations. These exposures are summarized in Tables 5-17 and 5-18. Further description of these activities and assumptions made in the calculations of radiation exposure are given in the references cited in Appendix A.

It should be noted that the likelihood of repeated exposure of individuals in the public domain in the vicinity of the repository where such repetitive exposures could conceivably occur is low but has not yet been quantified except as noted in the next paragraph. Detailed studies of repetitive exposures will be done during site characterization activities (Section 4.1.3.1.10). Repetitive exposure to service personnel or other transportation workers will also be examined and necessary procedures and equipment developed, if required, to limit occupational exposures to acceptable levels.

Cumulative Exposure: As waste shipments approach the repository, more waste travels along fewer routes. Thus, one concern to individuals in the region is the cumulative exposure realized by an individual. This exposure is commonly termed the maximum individual dose and is given in the last entry on Table 5-17.

The range of estimates for the maximum individual dose assumes the individual is 30 meters (100 feet) from all shipments and the transport vehicle (truck or rail) moves past the individual at 25 kilometers per hour (15 miles per hour). Over the 25-year repository shipping period, the cumulative individual dose received would range from 40 to 203 millirems.

Annually, the maximum individual exposure values range from 2 to 8 millirem. Assuming the average individual dose is 81 millirems per year from natural background (Section 3.4.7), the maximally exposed individuals would receive an increase above background ranging from 2.0 to 10 percent as a result of waste transport. Additional data on traffic patterns through regional highway and rail systems are needed for more precise analyses of the maximum individual dose in the region. The values given here are believed to be very conservative and actual exposures are expected to be significantly lower.

Radiation Exposure to Individuals and Population Groups Under Accident Conditions. The previous risk analyses aggregate the radiation exposure from accidents and, in turn, health effects to the national and regional population into the overall risk analyses which include both normal and accident exposures. This section identifies several types of severe accidents which could occur, and summarizes the resulting exposures to individuals and population groups in the vicinity of the postulated accidents. Only rail accidents are analyzed because it is assumed that the accident severity and isotopic releases in a truck accident would be less than in a rail accident. Further detail on description of the accident scenarios, assumptions used in the calculations, and resulting radiation dose distribution and pathways to man are given in Appendix A.

Table 5-17. Estimated Radiological Exposures to Members of the Public Sector From a Single Shipment Under Selected Normal Conditions of Transport[a]

Activity Description	Mean Distance from Center of Cask (meters)	Exposure Time[b] (minutes)	Approximate Total Dose (mrem)
Truck Transport			
Caravan			
Passengers in vehicles traveling in adjacent lanes in the same direction as cask vehicle	10	30	1
Traffic Obstruction			
Passengers in stopped vehicles in lanes adjacent to the cask vehicle which have stopped due to traffic obstruction	5	30	3
Residents and Pedestrians			
Slow transit (due to traffic control devices through area with pedestrians)	6	6	0.4
Truck stop for driver's rest. Exposures to residents and passers-by.	40	480[c]	3
Slow transit through area with residents (homes, businesses, etc.)	15	6	0.1
Resident exposed to 100% of shipments	30	25 years	203
Rail Transport			
Caravan			
Passengers in rail cars or highway vehicles traveling in same direction and vicinity as cask vehicle	20	10	0.3
Traffic Obstruction			
Exposures to persons in vicinity of stopped/slowed cask vehicles due to rail traffic obstruction	6	25	2
Residents and Pedestrians			
Slow transit (through station or due to traffic control devices) through area with pedestrians	8	10	0.7

Table 5-17. Estimated Radiological Exposures to Members of the Public Sector From a Single Shipment Under Selected Normal Conditions of Transport[a]

(Page 2 of 2)

Activity Description	Mean Distance from Center of Cask (meters)	Exposure Time[b] (minutes)	Approximate Total Dose (mrem)
	Rail Transport (Continued)		
Residents and Pedestrians (Continued)			
Slow transit through area with residents (homes, businesses, etc.)	20	10	0.2
Train stop for crew's personal needs (food, crew change, first aid, etc.)	50	120	0.7
Resident exposed to 100% of shipments	30	25 years	40

(a) From Appendix A - Authorized System.
(b) Minutes except as noted.
(c) Assumes overnight stay.

Table 5-18. Estimated Radiological Exposures to an Individual Worker for a Single Shipment During Selected Activities Under Normal Conditions of Transport[a]

Activity Description	Mean Distance from Center of Cask (meters)	Exposure Time (minutes)	Approximate Total Dose (mrem)
Truck Servicing and Monitoring			
Refueling (100-gallon capacity)	7	40	2
Tire change or repair to cask trailer	5	50	5
Load inspection/enforcement	3	12	2
State weight scales	5	2	0.2
Train Servicing and Monitoring			
Engine refueling, car changes, train maintenance, etc.	10	120	5
Cask car coupler inspection/maintenance	9	20	1
Axle, wheel or brake inspection/ lubrication/maintenance on cask car	7	30	3
Monitoring			
Cask inspection/enforcement by train, state or federal officials	3	10	2

(a) From Appendix A - Authorized System.

Accident consequences in terms of dose and LCFs to individuals and population groups are given in Tables 5-19 through 5-21 for atmospheric release and land or water contamination.

The accident classes listed are considered to include credible, but extremely severe and unlikely, rail accidents. In the extreme case the rail cask and its air-cooled spent fuel assemblies are assumed to suffer impact rupture, or both impact and burst rupture, or a combined impact and burst rupture accompanied by increased release due to spent fuel oxidation. This is assumed to result from severe mechanical disruption and intense heating from a fire fueled by petroleum or other highly flammable materials. Spent fuel assemblies which are 5 years or older (i.e., have been out of the reactor core for 5 years or more) do not produce sufficient self-heating from radioactive decay to support a rapid oxidation process. Therefore, a large external source of heat, similar to a burning rail tank car of fuel, is needed to create any substantial increase in release above that from impact and burst rupture.

The probability of accidents of the severity assumed in the analysis is very low, and the likelihood of radioactive material releases from a cask in such accidents is even lower. The doses calculated and, in turn, the health effects in terms of LCFs are considered to be very conservative upper bounds to the consequences of extremely severe accidents in both urban and rural settings. No attempt has been made to examine accident scenarios peculiar to a specific site. Such scenarios will be developed and analyzed during site characterization (Section 4.1.3.1.10) if not bounded by the analyses presented in this EA.

5.3.2 Environmental Effects of Improvements to Transport Corridors

The following sections provide an overview of the expected improvements to transportation corridors in the site vicinity, followed by a discussion of the potential environmental effects. The routes in this analysis are used for the purpose of this environmental evaluation; no selection of the preferred routes will be made prior to site characterization.

5.3.2.1 Roadways

Highway access to the Richton Dome site could be provided by three possible routes from I-59 (see Section 5.1.2.2). All three would connect with Mississippi State Highway 15 and would require the construction of approximately 6.4 kilometers (4 miles) of new roadway for access to the site. In addition, relocation of a short section of the county road east of the repository site, improvements to Mississippi State Highway 15, and improvements to other existing roads in the site vicinity may be necessary to support repository operations. Such improvements might include widening and resurfacing of roads and upgrading of bridges. The environmental effects of such improvements, as discussed below, are not expected to be significant.

5.3.2.1.1 Soils. Construction of the new access route will require disturbance of approximately 23 hectares (58 acres) of soils. During the time these soils are exposed to the elements, they will be subject to erosion caused by wind and rainfall. However, gradients will be low, temporary soil erosion controls will be used during construction, and the road surface will be paved and the road shoulders revegetated soon after the soils are exposed. The types of mitigation measures to be employed to control soil loss are discussed in Section 5.2.1.2. Improvements to existing roads may also result in temporary exposure of soils.

5.3.2.1.2 Hydrology. Construction of the new access route will, in general, follow existing contours wherever feasible, and culverts will be provided under the roadway where necessary. Thus, this activity is not expected to alter drainage patterns along the route.

Temporary soil exposure during construction of the new access road and any widening of existing roads will result in an increase of sedimentation in surface runoff. This increase will be mitigated by careful construction techniques (Section 5.2.2.1) to protect downstream water quality. Once road paving and revegetation of shoulders are completed, the water quality of runoff should approximate preconstruction conditions.

Table 5-19. Maximum Individual Radiation Dose Estimates for Rail Cask Accident Involving Release to the Atmosphere[a]

Accident Class	Dose (mrem)[b]			
	Inhalation	Plume Gamma	Ground Gamma	Dust Inhalation
Impact	180	11	12	0.0001
Impact and Burst	6,100	71	91	0.004
Impact, Burst, and Oxidation	9,000	550	710	0.0006

(a) From Appendix A.

(b) Maximum individual dose occurs 70 meters (230 feet) downwind of the release point.

Table 5-20. Fifty-Year Population Dose Estimates for Rail Cask Accident Involving Land Contamination[a]

Accident Class	Urban Area[b]				Rural Area[b]			
	Inhalation	Plume Gamma	Ground Gamma	Total	Inhalation	Plume Gamma	Ground Gamma	Total
Impact								
Dose (man-rem)	3	0.33	940	940	0.005	0.0005	1.4	1.4
Latent cancer fatalities[c]				0.2				0.0003
Impact and Burst								
Dose (man-rem)	110	2.2	13,000	13,000	0.2	0.003	21	21
Latent cancer fatalities[c]				3				0.004
Impact, Burst, and Oxidation								
Dose (man-rem)	150	17	110,000	110,000	0.2	0.03	170	170
Latent cancer fatalities[c]				22				0.04

(a) From Appendix A.

(b) The ground dose is what would be received if each member of the population stayed at the same location for 50 years. The inhalation dose is a 50-year dose commitment from inhalation of the passing plume. Doses are for the population within 80 kilometers (50 miles) of the release point. Cleanup occupational dose not included.

(c) Based on 1 man-rem = 2×10^{-4} latent cancer fatalities.

Table 5-21. Fifty-Year Population Radiation Exposure from a Drinking Water Reservoir Contamination from a Rail Cask Accident[a][b]

Accident Class	Population Dose Effects from Water Ingestion[c]
Impact	180 man-rem 0.04 LCF[b]
Impact and Burst	6,900 man-rem 1.4 LCF[d]
Impact, Burst, and Oxidation	63,000 man-rem 13 LCF[d]

(a) From Appendix A.

(b) The noble gas Kr-85 is omitted because of its negligible uptake by a surface-water body.

(c) A 100-acre/one billion gallon urban reservoir assumed which supplies domestic/agricultural/industrial needs to the surrounding population. Radioactive decay, settling and water filtration are not assumed.

(d) Latent cancer fatality (LCF) estimates are based upon 1 man-rem = 2×10^{-4} LCF.

Improvement of existing bridges and construction of a new bridge at the access road crossing of Beaver Dam Creek will cause some erosion of the creek bed and banks that could result in a temporary degradation of water quality. No effects on ground-water flow patterns or ground-water quality are expected.

5.3.2.1.3 Land Use. This new access road will run primarily through forested land. During site preparation along this corridor, marketable timber will be removed for sale. During the life of the project, this 23-hectare (58-acre) road corridor will be removed from timber production.

The representative access road also passes through two areas of farmland, one immediately northeast of the repository and the other immediately west of Mississippi State Highway 15. As part of the site characterization activities, more detailed route evaluation will be obtained, and negotiations with landowners will be conducted in an attempt to ensure that the final road alignment causes minimal impact to farming.

5.3.2.1.4 Terrestrial and Aquatic Ecosystems. The loss of approximately 23 hectares (58 acres) of forested land caused by construction of the new access road is not expected to significantly affect terrestrial ecosystems. Migration routes of small and large mammals may be altered slightly.

Increased turbidity and sediment loading to streams caused primarily by bridge construction and upgrading may temporarily affect aquatic ecosystems immediately downstream of construction sites. The types of fish species likely to inhabit these streams would experience short-term stress due to increases in sedimentation. Adverse impacts would generally be limited to smothering of benthic organisms for a short distance downstream. Once construction is completed, recolonization of these areas will occur rapidly.

No impacts to threatened or endangered species are expected to occur as a result from road improvements. As described in Section 4.1.3.1, however, a field survey of the road corridors and other potentially disturbed areas will be conducted to verify this.

5.3.2.1.5 Air Quality. Grading and other earthmoving activities will cause increased fugitive emissions during road construction and upgrading. Watering controls will be used as necessary to reduce emissions. After paving and revegetation are completed, fugitive emissions will return to near preconstruction conditions. Diesel equipment will generate primarily hydrocarbon and NO_x emissions for the short period of construction activities. Air impacts from these activities are discussed in Section 5.2.5.

5.3.2.1.6 Aesthetic Conditions. Construction of the new access road will create a corridor through a forested area. Such corridors are common in the region.

5.3.2.1.7 Noise. Road construction activities will cause an increase in existing noise levels. However, the increase will be smaller than that associated with repository site construction (Section 5.2.7), will be short-term in duration, and will not be noticeable much beyond the immediate construction zone.

5.3.2.1.8 Archaeological, Cultural, and Historical Resources. As discussed in Section 3.4.6, the potential for encountering surficial cultural resources in the general area of the new access road is small. However, before road construction, all areas of direct impact will be surveyed for the presence of cultural resources. Survey and resource evaluation methodology will be developed in conjunction with the State Historic Preservation Office (SHPO), and any adverse effects on significant cultural resources will be mitigated (as discussed in Section 5.2.8.1).

5.3.2.2 Railroads

Section 5.1.2.2 provides a description of the proposed railroad route. For purposes of assessing potential environmental impacts, only new construction will be considered in this section. Development of rail access to the Richton Dome site will use approximately

40 kilometers (25 miles) of an existing ICG right-of-way connecting the towns of Laurel and Richton and construction of 2 kilometers (1 mile) on a new right-of-way from the existing ICG right-of-way to the repository site. This segment of new right-of-way will parallel the new access road and will utilize the same bridge across Beaver Dam Creek. The total land requirement for construction of the new rail segment is approximately 4 hectares (9 acres).

Construction of track along the existing right-of-way will disturb the soils and result in temporary fugitive particle emissions and turbidity in surface runoff. However, the right-of-way is presently quite disturbed from recent track and tie removal operations; thus, these effects are not expected to be significantly greater than existing conditions. During construction, noise levels exceeding L_{dn} of 45 dBA are expected within 0.3 kilometer (0.2 mile) on either side of the rail construction. Areas exceeding L_{dn} of 55 dBA are expected to extend less than 0.3 kilometer (0.2 mile) on either side of the rail construction. During construction along the existing right-of-way, impacts on ground water, land use, ecosystems, aesthetics, and archeological, cultural, and historical resources are not expected to be significant.

Construction of the new rail line from the existing right-of-way to the site will result in impacts similar to those described for construction of the new road access (Section 5.3.2.1). However, the geographic extent of impacts will be somewhat less because the rail line is 1.6 kilometers (1 mile) shorter than the road access.

5.3.2.3 Airports

Minor improvements to existing airports serving the Richton Dome vicinity may be required as a result of repository development. The need for and impacts of potential airport improvements will be studied during the site characterization studies phase described in Section 4.1.3.1.10.

5.3.2.4 Waterways

Preliminary studies of barge transportation of nuclear waste to Gulf Coast ports and Memphis, Tennessee, have been made (Appendix A). If this alternative proves viable, further studies of improvements and related impacts will be made during site characterization (Section 4.1.3.1.10).

5.3.3 Effects on Transportation Infrastructure in the Area

This section includes discussion of potential impacts on area transportation networks during project construction, operation, and decommissioning. These potential impacts include those caused by transport of workers, supplies, construction materials, and excess salt, rock, and other uncontaminated wastes. Nuclear waste transportation impacts are discussed in Section 5.3.1.

Repository construction and operation will affect the use, condition, and maintenance and capital cost requirements of transport facilities. Studies to be carried out during site characterization (Section 4.1.3.10) will more precisely determine the nature of impacts on transport facilities; how and to what extent these might be mitigated; and whether improvements are required to accommodate the additional traffic generated by repository construction, operation, and decommissioning.

5.3.3.1 Roadways

The following discussion of potential highway impacts is based on information presented in Section 3.5.

5.3.3.1.1 Construction. Direct construction impacts on highways will be caused by the increase in automobiles transporting employees, truck traffic associated with delivery of construction material and equipment, and the relocation or construction of rights-of-way associated with site development and access.

Table 5-2 shows the personnel requirements for repository construction, operation, and decommissioning. Using this table, one can estimate that the average number of construction workers required is 1,058. The table also shows that the peak-year construction work force averages 1,428. At two workers per car, the average number of daily passenger-vehicle round-trips over the seven-year construction period is 529. During the peak year the average number of daily passenger vehicles is 714.

As stated in Section 5.1.2.3, the total number of truck deliveries required during the seven-year construction period is 24,000, or approximately 14 truck round-trips per day.

Section 5.4.1.1 contains estimates of likely domiciles for in-migrating workers. Using this as a guide to likely domiciles for the entire construction work force, and the traffic volumes previously presented, estimates of traffic increases on area highways are presented in Table 5-22. In Section 5.4.1.1, it is stated that a percent of the in-migrating work force would live outside the incorporated areas. Increases shown in Table 5-22 assume that this percent is split, two-thirds to the Hattiesburg area and one-third to the Laurel area.

The studies to be undertaken, as described in Section 4.1.3.1.10, will assess the impact of these traffic increases compared to highway conditions and capacities, as well as consider traffic mitigating measures such as busing or highway improvements in addition to those that may have been made for site characterization. As stated in Section 3.5, the existing traffic volume-to-capacity ratios for Mississippi State Highways 15 and 42 are generally less than 50 percent. This tends to indicate that no major improvements are required to handle the traffic volume.

Impacts on the town of Richton will be minimized because access to the site will be provided from both Mississippi State Highway 42, for traffic from Hattiesburg, and Mississippi State Highway 15 for traffic from Laurel. Both of these access roads are outside Richton's city limits.

During repository construction, the traffic volumes and domicile patterns previously noted would result in a total of 89.4 million additional vehicle kilometers (55.9 million vehicle miles) over the seven-year construction period. This additional vehicle mileage will increase the predicted number of accidents and resulting injuries and fatalities. Using accident rates for Mississippi State Highways 15 and 42 from the 1981-1983 period, 41 additional accidents and 0.7 fatal accidents are predicted during the seven-year construction period. Using 1983 national rates, the corresponding increases would total 229 and 1.5, respectively.

5.3.3.1.2 Operation. The nature of impacts on highways during operation will be similar to those described in the previous section on construction. As shown in Table 5-2, the peak repository work force will average approximately 1,000 per year. At an estimated two workers per car, the average number of daily passenger vehicle round trips is 500. Trucking will also increase during repository operation. Approximately 270 deliveries per week (54 per day) are required for supplies.

The population distribution for the repository's work force is assumed to be the same as that for repository construction (Section 5.4.1.2). Table 5-23 shows average increases on area highways assuming (1) the population distribution is an indication of likely worker domiciles (except for the 15 percent that live in unincorporated areas that will be handled as discussed for construction), and (2) that truck deliveries are split equally from the north and west (one-half from Hattiesburg, one-half from Laurel).

These traffic volumes are slightly lower than those expected for construction. The studies described in Section 4.1.3.1.10 will determine whether any additional highway improvements are required to accommodate repository operation traffic. One alternative to be studied would be shuttle buses from Hattiesburg, Petal, and Laurel.

During repository operation, the traffic volumes and domicile patterns previously noted would result in 13.4 million additional vehicle kilometers (8.4 million vehicle miles) per

Table 5-22. Traffic Increases During Repository Construction

	1983[1] AADT	Peak Year Average[2] AADT Increase	Peak Year Average[2] Percent Increase	7-Year Average[2] AADT Increase	7-Year Average[2] Percent Increase
SH 42					
Hattiesburg to Runnelstown	3,380-12,520	870	7-26	652	5-19
Runnelstown to Access from SH 42	1,900-2,040	870	43-46	652	32-34
Richton to Access from SH 42	1,690	143	8	108	6
SH 15					
Laurel to Access road from SH 15	1,350-4,510	300	7-22	218	5-16
Richton to Access from SH 15	2,490	143	6	108	4
Access from SH 42	No data	1,013	--	760	--
New Access Road from SH 15	--	443	--	326	--

(1) From Section 3.5; Figure 3-42.

(2) Calculations based on data from Section 5.4.1.1.

Table 5-23. Traffic Increases During Repository Operation

	1983(1) AADT	Average(2) Auto AADT	Truck AADT	Total AADT	Percent Increase Over 1983
SH 42 - Hattiesburg to Runnelstown	3,380-12,520	600	54	654	5-19
SH 42 - Runnelstown to Access Road	1,900-2,040	600	54	654	32-34
SH 42 - Richton to Access Road	1,690	100	--	100	6
SH15 - Laurel to Access Road	1,350-4,510	200	54	254	6-19
SH 15 - Richton to Access Road	2,490	100	--	100	4
Access Road from SH 42	No data	700	54	754	--
New Access Road from SH 15	No data	300	54	354	--

(1) From Section 3.5; Figure 3-42.

(2) Calculations based on data from Section 5.4.1.2.

year. This additional mileage will increase the predicted number of accidents and resulting injuries and fatalities. Using accident rates for Mississippi State Highways 15 and 42 for the 1981-1983 period, 6.0 additional accidents and 0.1 fatal accidents per year are predicted. Using national rates, the corresponding increases would be 34.0 and 0.2. Between 1980 and 1983, 22 accidents, or approximately 7 per year, occurred on Mississippi State Highways 15 and 42. During the same period, 2 fatal accidents occurred on Mississippi State Highway 15; none occurred on Mississippi State Highway 42.

5.3.3.1.3 Decommissioning and Closure. Traffic volumes will decrease slightly during decommissioning and closure. A total of 820 employees per year will be required, which is approximately 20 percent less than that required during operation. Consequently, traffic congestion, road maintenance, and accidents during decommissioning and closure are expected to be less than during operation.

5.3.3.2 Railroads

5.3.3.2.1 Construction. During the repository construction phase, a rail line will be constructed to provide access to the site. An Illinois Central Gulf line, formerly connecting Laurel and Beaumont and passing approximately 3 kilometers (2 miles) east of the site, is now largely abandoned. Constructing a new rail line on this right-of-way between Laurel and the site, a distance of 42 kilometers (26 miles), is a logical rail access route (Section 5.1.2.2). Reconstructing the entire line between Laurel and Beaumont may also have merit if barges are used to transport the waste to a port along the Gulf Coast. From the Gulf Coast port, the casks would then be moved by rail to the repository. This alternative and its impacts will be studied further during site characterization (Section 4.1.3.1.10).

The rail route from Laurel passes through a short section of De Soto National Forest (3-4 miles) and crosses county roads but no State or Federal highways. Upon completion, this line could be used to deliver some of the materials and equipment required for repository construction. This might result in lower highway-related impacts by reducing truck traffic to and from the site. During construction of the rail line, traffic on nearby county roads may experience minor delays or short detours.

5.3.3.2.2 Operation. The major use of the rail line will be outbound salt shipments and occasional inbound shipments of materials or equipment (inbound nuclear waste is discussed in Section 5.3.1).

It is unlikely that total inbound and outbound traffic of all commodities will require an average of more than one daily round-trip train between the repository and the common carrier railroad interchange at Laurel. Hence, congestion at road crossings (all are minor roads) is not expected. The volume of traffic received from or delivered to the common carrier railroads in Laurel may or may not require additional trains to be operated by the railroads. This will depend on the period of time over which salt shipments are made.

Approximately 9 million metric tons (10 million tons) of salt are to be disposed of during repository operations. The disposal site for salt is assumed (Section 5.2.10) to be in Iberia Parish or St. Mary Parish, Louisiana, 482 kilometers (300 miles) from the repository. Salt could be transported either by truck or by rail car. Because of the much greater payload capacity of rail cars (82 to 91 metric tons [90 to 100 tons] versus 21 to 25 metric tons [23 to 27 tons] for trucks), rail transportation would have a much lesser impact in terms of number of loads transported. Also, because of the large tonnage involved (suggesting possible use of lower cost unit train load quantities), rail transport may also be more economical. For these reasons, rail was selected as the representative mode for salt transport. Rail shipments of salt are typically made using covered hopper cars and therefore pose virtually no threat of fugitive salt loss enroute.

Most covered hopper rail cars manufactured in recent years have payload capacities between 86 and 95 metric tons (95 and 105 tons); older cars in the present United States fleet have lower capacities. A conservative estimate of average payload per car is 82 metric tons (90 tons); thus, about 111,000 carloads, slightly over 4,000 per year, would be required for

salt transport. Thus, one unit train per week with up to 100 cars per train could handle the salt disposal requirement. For this traffic volume, it is unlikely that any existing railroad tracks will require improvements; however, further investigation is necessary to confirm this.

Based on the number of accidents that the Southern Railroad and the Southern Pacific Railroad had per million miles in 1984 (U.S. Department of Transportation, 1985), and use of 100-car train loads, the following accident results could be expected:

Total Salt Transported (million tons)	10
Approximate Length of Haul (One Way Rail Miles to Mine Site)	300
Number of Accidents Over Life of Repository	4.8

Because railroad accident data are based on train miles, use of train loads smaller than the 100-car size assumed above would increase the number of train miles and, correspondingly, the number of accidents. Seventy-car trains would, for instance, increase the accident figure shown by 43 percent. The statistically expected 4.8 accidents are based on data that classify accidents as those in which damage exceeds $4,500. The likelihood of a serious accident involving a car body rupture and spillage of salt is much lower than 4.8. Impacts of salt which might escape from the rail car during an accident are discussed in Section 5.2.10.

5.3.3.2.3 Decommissioning and Closure. Rail facilities will remain available and capable of handling transport associated with decommissioning and closure. Such traffic demand is expected to be small. Unless its retention is desired for other purposes, track and track materials can be removed and salvaged upon completion of decommissioning.

5.3.3.3 Airports

5.3.3.3.1 Construction. The air service currently provided to Hattiesburg/Laurel (at Pinebelt Regional Airport) by commercial airlines may need to be expanded to adequately serve increased passenger travel demands. Quantitative estimates of increased travel demands are not presently available.

Should demand for travel into Hattiesburg/Laurel exceed the capacity of the flights now serving the area, it is expected that the airlines would increase the number of flights serving the airport. The impact that additional flights might have on Pinebelt Regional Airport will be assessed during the studies identified in Section 4.1.3.1.10, Transportation and Utilities.

5.3.3.3.2 Operation. During repository operation, demand for repository-related air travel may be less than during construction because the work force is smaller. Therefore, the impacts on Pinebelt Regional Airport will be less.

5.3.3.3.3 Decommissioning and Closure. Impacts on the airport during repository decommissioning will be less than the demand for air travel to and from the area during construction and operation.

5.3.3.4 Waterways

The DOE is studying the operational safety and economics of transporting nuclear waste casks by barge from ports on the East Coast and Great Lakes to ports on the Gulf Coast and Mississippi River (Appendix A). From the Gulf Coast port, the waste would be moved to the repository by rail. Since this alternative would still involve rail shipments to the repository, no additional impacts beyond those discussed for rail operations are expected. However, this alternative will be further studied during site characterization (Section 4.1.3.1.10 and Appendix A).

5.3.4 Utilities

Utility requirements for the repository are discussed in Section 5.1. It is expected that electrical power at the site will be supplied from a 115-kilovolt line that parallels U.S. Highway 98, and is located near Beaumont, Mississippi, approximately 19 kilometers (12 miles) south of Richton. Although a substation exists at Beaumont, a new substation will likely be required to handle repository requirements. A new 23-kilometer (14-mile)-long power line would connect the new substation to the repository site, roughly paralleling Mississippi State Highway 15 (Figure 5-10). Other sources of electrical power may also be used, particularly the 161 kilovolt line located close to the site (Figure 3-44).

Natural gas would be obtained by tapping an existing 41-centimeter (16-inch) pipeline located close to the site. The new gas line would be approximately 3 kilometers (2 miles) long.

Water would be supplied from wells located along Bogue Homo River. Sewage would be treated on site and disposed of in a permitted disposal facility.

5.4 EXPECTED EFFECTS ON SOCIOECONOMIC CONDITIONS

Social and economic effects associated with repository development at the Richton Dome site generally will result from added area employment, migration of populations to the area for employment, project material purchases, secondary economic expansion, and changes in land-use patterns. The influx of persons migrating to the region would result in increased demand for housing and support services such as water, sewerage, sanitation, health care, and police and fire protection. The cost of providing additional services may affect the fiscal operation of communities.

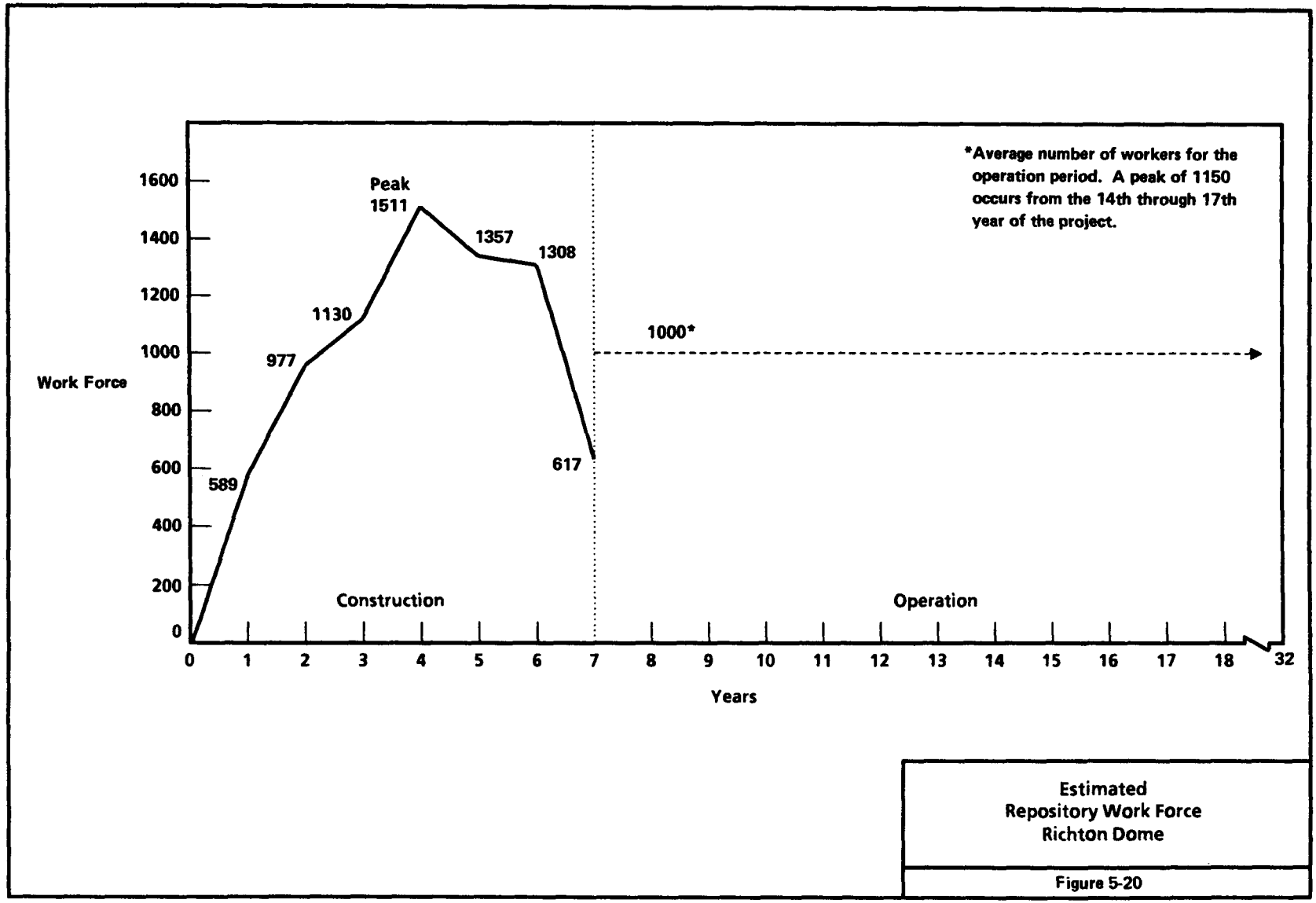
This section discusses a range of potential repository-related impacts on demography, economy, community services, and the fiscal and social environment within an eight-county area surrounding Richton Dome (the socioeconomic study area). Forecasts of impacts are based on currently available socioeconomic data (Section 3.6); project-related data, including labor requirements (Section 5.1); and results of the ONWI Population In-Migration Model (Goldsmith, 1984).

Repository construction will continue for 7 years; peak labor demand will occur in year 4 with a total of 1,511 workers. Project operation will continue from year 8 through year 32, followed by a 24-year caretaker period before decommissioning begins and closure is completed. The operation peak labor demand will occur from the seventh through tenth years of operation, when 1,150 workers will be needed annually. Figure 5-20 shows the labor force requirements for each year of repository construction and operation.

Project-related impacts were estimated using the ONWI Population In-Migration Model, a computerized assessment model that estimates the number of people who will relocate to an area for repository construction and operation. Figure 5-21 illustrates the model operations and logic chart; the input and multipliers used in the model and the basis for each appear in Table 5-24. The definitions of terminology used in the model are shown in Table 5-25. The model calculates the following items for repository construction and operation:

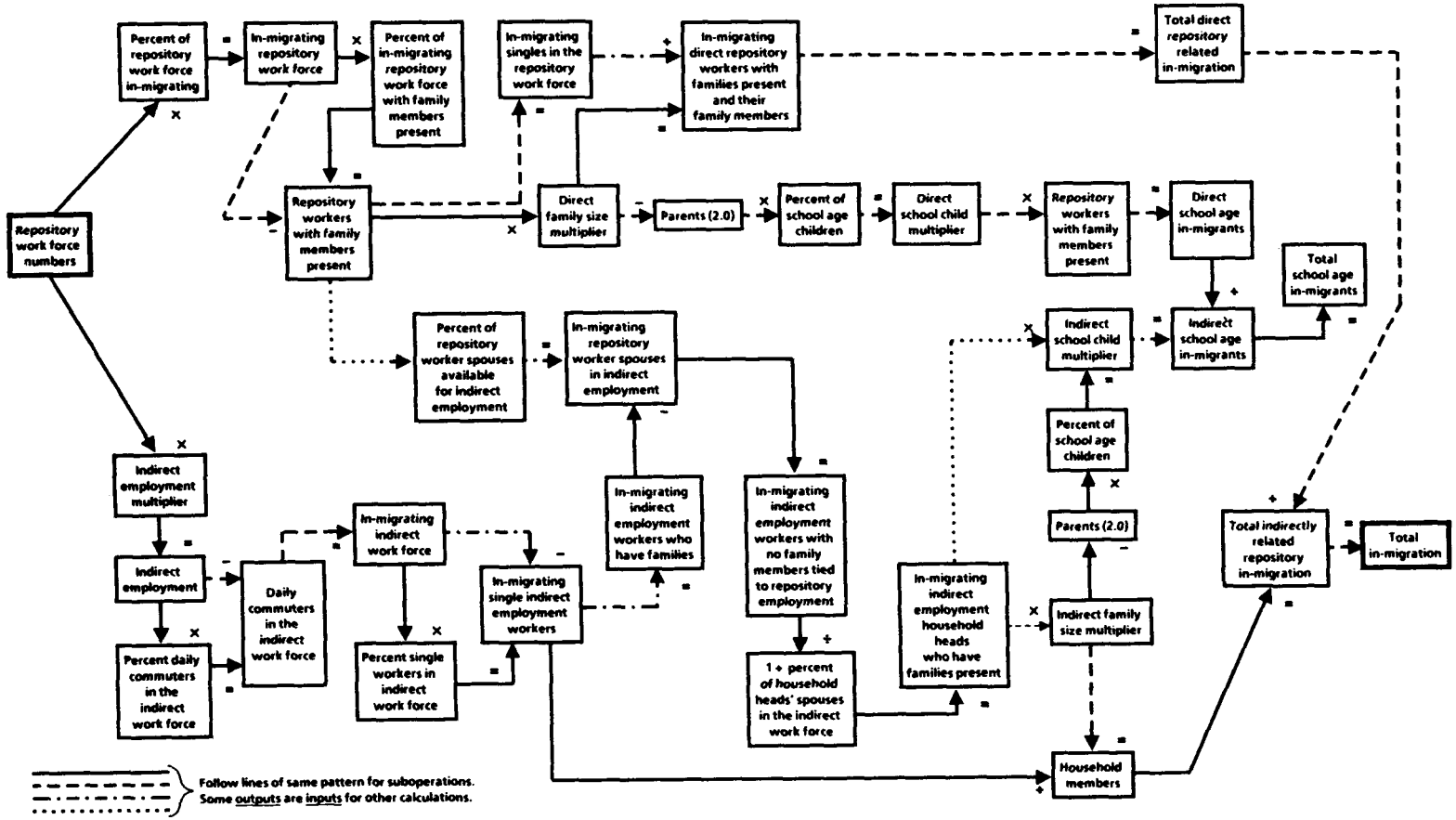
- Direct and indirect in-migration
- Direct and indirect school-age children
- Direct and indirect household heads
- Single-worker in-migration
- Total direct and indirect in-migrating employment.

Direct in-migrants are the repository workers and their families. Indirect in-migrants are repository or consumer-related service workers and their families.



Estimated
Repository Work Force
Richton Dome

Figure 5-20



Source: Goldsmith, 1984.

Population In-Migration Model
Logic of Calculations
Richton Dome

Figure 5-21

Table 5-24. Inputs and Multipliers for the ONWI Population In-Migration Model

	Construction	Operation
A. DIRECT IN-MIGRATION		
Percent of Repository Work Force In-migrating	50.0	45.0
- Available labor force within commuting distance (Section 3.6)		
- Skills of available labor force		
Percent of In-migrating Repository Workers With Family Members Present[a][b]	75.0	80.0
Percent of Repository Worker Spouses Available for Indirect Employment[c]	20.0	40.0
Family Size Multipliers[d]	3.6	3.8
Percent of School Age Children[e]	65.0	65.0
B. INDIRECT IN-MIGRATION		
Indirect Employment Multiplier[a]	0.4	0.9
- Available labor force within commuting distance (Section 3.6)		
- Economic activities in the study area (Section 3.6)		
Percent of Local Hires in the Indirect Work Force	60.0	65.0
- Assumed to be 10 percent higher than the direct work force		
Percent of Single Workers in the Indirect Work Force[f]	35.0	35.0

Table 5-24. Inputs and Multipliers for the ONWI Population In-Migration Model
(Page 2 of 2)

	Construction	Operation
Percent of Indirect Worker Spouses Available for Indirect Employment[e]	40.0	40.0
Family-Size Multipliers[e]	3.3	3.3
Percent of School-Age Children	65.0	65.0
- Same as direct work force		

Sources: (a) Murdock and Leistritz, 1979.
(b) TVA, 1980.
(c) Halstead and Leistritz, 1983.
(d) DOE, 1978.
(e) Bureau of the Census, 1982.
(f) Bureau of Labor Statistics, 1980.

Table 5-25. Population In-Migration Model Terminology

Direct work force	The work force hired for jobs at the repository facilities.
Indirect work force	The work force hired for jobs that are available because of the repository location but are not at the facilities; for example, jobs with repository suppliers, town services, or retail business.
Daily commuters	The local workers hired for direct or indirect jobs. These workers currently reside in surrounding communities.
In-migrants	These workers and their families will relocate on a permanent or temporary basis to communities adjacent to the site. These workers and families are considered to be in-migrants during the construction and operation phase, for as long as they are present. It will be necessary to plan for the housing and service needs of these relocating workers.
In-migrating household heads	The in-migrating workers who will be seeking housing for themselves and their families, if present.
Baseline projections	Future estimates of the population, employment, etc., of a community or larger jurisdiction based on conditions without the planned project.

Note: To avoid double counting, spouses of repository workers that are in the indirect work force are counted only as direct in-migrants.

The key variables determining in-migration include the following:

- The number of repository workers needed each year
- Indirect employment multipliers
- Percent of direct and indirect workers expected to in-migrate
- Direct and indirect family size multipliers (calculates school-age children)
- Repository and direct worker spouses employed in indirect jobs.

These variables were adjusted so a range of impacts could be established for the site. The various multipliers and percentages were chosen based on references, listed in Table 5-24, which reflect research conducted for other large-scale developments in rural settings. The model incorporates information about local labor availability based on existing local employment in construction and mining and on the total study area population and labor force. Also, the level of economic activity in the study area was evaluated to establish realistic, conservative indirect multipliers (Section 3.6).

The changes in inputs and multiplier values for the operations phase are based on the referenced research literature. This literature indicates that during the longer operation phase of a project (1) more workers will relocate with family members; (2) the families that relocate tend to be larger; (3) more local workers are attracted to the long-term job opportunities; and (4) indirect multipliers are higher because of an expanded economy and long-term business opportunities.

The model was designed to project a range of in-migration within which actual in-migration values would lie. The analysis presented here reflects a realistic, conservative case. It assumes no mitigation measures to limit repository-related in-migration, and referenced worker and worker family characteristics that tend to raise in-migration.

The model was validated using the documented impacts resulting from two energy projects. These projects were selected because they were similar to the repository program and because adequate detail was provided in the project monitoring reports on model variables to perform the validation process. The validation is documented in "ONWI Population In-Migration Model" (Goldsmith, 1984). The model was validated for peak-year projection; projections for years other than the peak are not as accurate. Variable sensitivity analysis, scenario hypotheses testing, and testing with historical data from actual facility monitoring reports (as described above) were completed as part of the model's validation and verification.

The repository-related populations were allocated to communities based on a population location (gravity) model. Baseline population projections (Section 3.6) were added to project-related in-migration to determine total population and service demands.

Community service requirements and fiscal impacts on communities were determined based on data presented on existing service capacity in Section 3.6. Potential changes in service capacities (e.g., water, sewer, etc.) and service standards (e.g., police to population ratios) resulting from projected baseline project-related growth were assessed. Impacts on local revenues and expenditures are addressed, as are sources of revenue and mitigation measures.

5.4.1 Population Distribution and Displacement

Changes in regional and local population growth, distribution, and composition during project construction and operation result from changes in the expected population (growth without the repository) coupled with in-migration of direct and indirect project workers and their families. To the extent possible, the work force needed for operation will be drawn from the construction work force to minimize the number of in-migrating workers and their families. In addition, the size of the work force required during operation does not vary greatly from that required for construction because of continuous mining during the operation period.

The expected baseline population growth in the study area through the year 2005 was discussed in Section 3.6. Without the project, by the year 2005, the population of study area

counties is projected to increase 27 percent over the 1980 population. Forrest and Jones Counties are expected to remain the most populous, while George and Stone Counties are expected to have the highest growth rates. Estimates of future growth in Hattiesburg, Petal, Laurel, and Richton were made based on county growth projections.

5.4.1.1 Construction

Estimates of repository related in-migration during construction are presented in Table 5-26. Worker in-migration during peak construction will result in a total population increase of about 2,420 persons. This represents approximately 1 percent increase over the 1995 baseline population of the eight-county study area.

Estimates of where these new employees and their families will live are calculated using a gravity model. The gravity model assumes that two factors (1) population size of a community and (2) distance of the residence from the workplace influence residence selection and thus settlement patterns. The distribution of in-migrating workers within study area cities was predicted using the relationship $Q = K/R^2$, where Q is the likelihood of an in-migrating construction worker residing in any particular community, K is the population of this community, and R is the distance of that community from the work site.

The gravity model projects that 40 percent of the in-migrating population will reside in Hattiesburg, 20 percent in the town of Richton because of its proximity to the site, 15 percent in Laurel, and 10 percent in Petal. During peak repository construction, this will be 967 in-migrants in Hattiesburg (2 percent of the baseline population), 483 persons in Richton (37 percent of the baseline population, 363 persons in Laurel (2 percent of the baseline population, and 242 persons in Petal (3 percent of the baseline population). The remaining in-migrants (15 percent) are distributed to rural areas and other smaller communities in the study area. None of these smaller communities is projected to receive more than 2 percent of the total area in-migrants.

The greatest impact will occur during the first year of construction with the initial influx of in-migrants. The town of Richton will be most affected by in-migration. The community is projected to receive 20 percent of the in-migrants; this represents 37 percent population growth during the peak year of construction, over Richton's projected 1995 baseline population.

Population increases in other small communities and rural areas within the study area are expected to be minimal (363 persons) during peak repository construction. Since the added population is distributed throughout these smaller communities, these surrounding communities should experience minor population increases.

While population size alone is considered for this gravity model, it also reflects other community characteristics that can influence location decisions. For example, the availability of housing and other community facilities (e.g., education, recreational facilities, etc.) is a primary element that attracts new residents to a community and is correlated with population size. Experience on other large-scale industrial projects suggests that availability of services and other amenities will influence population settlement patterns. Consequently, the Hattiesburg/Petal urban area and Laurel would likely attract the majority of in-migrating populations. Other demographic effects of in-migrating workers during project development are likely to be an increased number of young adults in the area and a more diverse direct and indirect work force.

5.4.1.2 Operation

In-migration expected during repository operation will initially represent a slight decrease over the in-migration during the last year of construction, followed by an increase in in-migration during the seventh year of operation and then a decline in in-migration after the tenth year of operation (Table 5-27). Worker in-migration will create a total population increase of 1,968 persons within the eight-county study area during the seventh through tenth years of operation. This represents less than a one percent increase over the projected

Table 5-26. Estimated In-Migration During Construction Phase, Richton Dome

Year	Direct In-migration[a]			Indirect In-migration[a]			Total Yearly Increment[a]	Cumulative Total
	Single Workers	Married Workers	Family Members	Single Workers	Married Workers	Family Members		
1	70	220	580	30	10	30	940	940
2	50	150	370	30	10	10	620	1560
3	20	60	160	0	0	10	250	1810
4	50	140	360	30	10	20	610	2420
5	(20)	(60)	(150)	(10)	0	(10)	(250)	2170
6	(10)	(20)	(50)	0	0	0	(80)	2090
7	(90)	(260)	(670)	(30)	(20)	(30)	(1100)	990

Note: Numbers rounded to nearest 10.

[a] Increments between years; ( ) denotes a decrease.

Source: Goldsmith, 1984.

Table 5-27. Estimated In-Migration During Operations Phase, Richton Dome

Year	Direct In-migration[b]			Indirect In-migration[b]			Total Increment[b]	Cumulative Total
	Single Workers	Married Workers	Family Members	Single Workers	Married Workers	Family Members		
8-13[a]	10	130	400	80	30	70	720	1710
14-17	10	50	150	20	10	20	260	1970
18-32	(10)	(50)	(150)	(20)	(10)	(20)	(260)	1710

Note: Numbers rounded to nearest 10.

(a) The increments and cumulative totals for years 8 to 13 are based on the figures in Table 5-26 for the last year of construction.

(b) Increments between years; ( ) denotes a decrease.

Source: Goldsmith, 1984.

baseline population in year 2005. The expected in-migration into Hattiesburg during peak operation will represent less than 2 percent increase (787 in-migrants) over the baseline population for the year 2005; the population of Petal will increase 2 percent (197 in-migrants); Laurel will increase 1 percent (295 in-migrants); and Richton will increase 28 percent (394 in-migrants). The same population distribution to communities as calculated for the construction phase is assumed.

5.4.1.3 Decommissioning and Closure

During the 24-year caretaker period, the work force at the repository will decline to an average work force of 230. Out-migration should increase unless other employment opportunities are created. During the 5-year decommissioning period, the repository work force will increase to an average work force of 820. In-migration should increase as decommissioning workers and their families move to the study area. Following closure and the end of significant permanent employment at the repository, out-migration should take place as workers move to other areas to find employment.

5.4.1.4 Displacement of Residents

Residents displaced by project activities will be eligible for assistance. The specific location of the controlled area within the nominated site will determine the number of residents who must be relocated. The DOE is required under the "Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970" (42 USC Sections 4601 et seq.) to compensate individuals, partnerships, corporations, and associations who are to be displaced because the Federal government has acquired their property. Under this act, the acquiring agency must offer fair market value for the property. The act encourages Federal departments, such as the DOE, to make every reasonable effort to acquire real property expeditiously by negotiation, or offer just compensation, which must be at least as much as the DOE's appraisal of the property's fair market value.

5.4.2 Economic Conditions

The local and regional economy of the study area will change during project construction. Local employment opportunities will expand because jobs will be directly and indirectly created by repository construction. Local wage rates and purchases of local goods and services will also increase. Minor displacement in forestry, agriculture, and mining activities associated with the site will occur.

5.4.2.1 Employment

Repository construction will generate employment in the study area cities and in the region by directly and indirectly creating jobs. The increase in jobs available may encourage young people to remain within local communities to take advantage of these employment opportunities.

Hiring a large number of local craftsmen and white collar employees may create inflationary pressure in study-area labor markets. Some employees may be attracted from their current employment if there is a higher wage differential at the repository site.

5.4.2.1.1 Construction. The ONWI Population In-Migration Model (Goldsmith, 1984) assumes that 50 percent (760) of the jobs in the peak direct construction work force will be available to existing workers in the region and 60 percent (360) of the jobs in the peak indirect work force will be available to local workers. Employment during peak repository construction will thus generate jobs for 1,120 workers in the study area. Table 5-28 projects direct and indirect employment for local and in-migrating populations. The actual number of local hires will depend on the number of workers and types of skills available within the study area.

5.4.2.1.2 Operation. The ONWI Population In-Migration Model (Goldsmith, 1984) assumes that, of the peak direct operation work force, 55 percent of the workers (630) will be local,

Table 5-28. Estimated Work Force During Construction Phase, Richton Dome

Year	Direct Employment[a]		Indirect Employment[a]		Total Yearly Increment[a]	Total Cumulative Increase
	Local	In-Migrating	Local	In-Migrating		
1	300	300	140	90	830	830
2	190	190	100	60	540	1370
3	80	80	30	20	210	1580
4	190	190	90	70	540	2120
5	(80)	(80)	(30)	(30)	(220)	1900
6	(30)	(20)	(10)	(10)	(70)	1830
7	(340)	(350)	(170)	(110)	(970)	860

Note: Numbers rounded to nearest 10.

[a]Increments between years; ( ) denotes a decrease in work force.

Source: Goldsmith, 1984.

and of the peak indirect workers, 65 percent (670) will be local. At peak operation, 1,300 jobs may be available to local workers. Table 5-29 projects direct and indirect employment for local and in-migrating populations during the operation phase.

It is expected that many of these jobs will be filled by residents of Hattiesburg, Petal, and Laurel, where more workers with required skills are likely to be available. The operation work force will include heavy equipment operators, mechanics, craftspersons, and technicians. Local hiring will be emphasized to help build a stable work force. Vocational training for repository positions will also provide additional opportunities for local hiring.

5.4.2.1.3 Decommissioning and Closure. Following the repository operation phase (from the 7th to 32nd year of the project), a caretaker period of approximately 24 years is expected. Following operation, the average work force level will decrease to about 230. These employees will primarily be responsible for security and monitoring activities. The caretaker period's reduced repository employment will probably result in increased area unemployment. The extent to which regional unemployment will increase depends on the extent of out-migration, the extent that mitigating measures have been implemented, and the availability of other jobs in the area.

The decommissioning period will follow the caretaker period. During this five-year period, employment at the repository will increase to an average of 820 persons per year. Area unemployment should decrease in response to increased employment opportunities at the repository. Requirements for craft workers will predominate during decommissioning. After decommissioning and closure are completed, significant repository employment should end and unemployment is likely to increase.

5.4.2.2 Economic Activity

Changes in economic activity in study-area cities and in the region will be caused by purchases of local materials and services, purchases of personal goods and services by new residents, and wages paid to new residents.

Procurement of materials for the repository will rely upon local, regional, and national suppliers. The economic base of the area will expand as materials and services are purchased. The degree of expansion within local economies will depend on the availability of necessary suppliers; if large industrial manufacturers or business suppliers are not available within the study area, purchases will be made outside the area and consequently will not directly contribute to local economic expansion.

5.4.2.2.1 Construction. Based on experience with other large construction projects, it is estimated that 5 percent of repository purchases will be made locally. The estimated cost of materials purchased locally is about 37 million dollars during the 7-year construction period. In addition to purchases directly related to construction, purchases by in-migrating workers and families will contribute to an increase in sales within the study area. This analysis assumes that this secondary multiplier for the purchase of local goods and services is 1.4; that is, for each dollar spent locally for direct repository purchases, another 40 cents will be generated from indirect or secondary purchases. Thus, assuming direct repository purchases of 37 million dollars, the total projected increase in dollar volume of local purchases during construction is 52 million dollars, which represents an annual increase of 0.5 percent from the total 1982 sales for the area (Section 3.6).

The increased employment will provide higher incomes for many employed workers, but it may also increase labor competition for some sectors of the local economy. If growth is substantial, new large-volume stores attracted to the area could cause cost competition with existing local retailers. A potential increase in the area cost of living would most affect people on fixed incomes, particularly if rents and food prices increase.

5.4.2.2.2 Operation. The economy of study area cities and counties would likely continue to expand during project operation. As business activity expands during project construction, more materials needed for project operation should be available for purchase

Table 5-29. Estimated Work Force During Operations Phase, Richton Dome

Year	Direct Employment[b]		Indirect Employment[b]		Total Increment[b]	Total Cumulative Increase
	Local	In-Migrating	Local	In-Migrating		
8-13[a]	240	140	440	220	1040	1900
14-17	80	80	90	40	290	2190
18-33	(80)	(80)	(90)	(40)	(290)	1900

Note: Numbers rounded to nearest 10.

[a]The increments and cumulative totals for years 8-13 are based on the data, in Table 5-28, for the last year of construction.

[b]Increments between years; ( ) denotes a decrease.

Source: Goldsmith, 1984.

locally. Personal goods and services will also continue to be purchased by in-migrating workers and their families.

As with project construction, a certain amount of the approximately $3-billion operation cost will be recirculated in the local economy through purchase of equipment and materials and work purchase of local goods and services. The amount of local purchases during project operation has not yet been estimated.

5.4.2.2.3 Decommissioning and Closure. Following repository operation, some communities may experience economic dislocations to the degree that their economies are more dependent on the operation of the repository. This decline during the caretaker period may precipitate secondary impacts such as a decrease in consumer spending; as consumer spending decreases, demand for secondary goods and services will decline and the revenues derived from them will likewise decline.

An increase in area unemployment and decrease in personal income may result from reduced employment at the repository. A decline in employment, and subsequently, in population as the unemployed out-migrate from the region, can create an excess supply of housing and municipal services. The rental values of properties, housing prices, and income derived from services may decline for a few years. Repository construction and operation will also have generated economic growth and diversification of the area. In addition, new employment opportunities may be available to repository workers as a result of acquired skills and experience in repository operation. Out-migration may also occur and reduce unemployment during the repository caretaker period.

The long project operation period should provide communities time to develop and implement programs to mitigate social and economic impacts. The DOE could provide the technical assistance to State and local government for this effort.

The increase in employment and local repository purchases will increase economic activity during the 5-year decommissioning period. Although it is expected that local service sector business will expand, many will be unwilling to make significant new investments due to the short length of the decommissioning period. After closure, a decline in local economic activity should occur following the decline in repository employment and repository purchases.

5.4.2.3 Displacement of Regional Economic Activity

About 2,222 hectares (5,489 acres) of land will be required in the Richton Dome area for repository construction, operation, and subsurface protection. This will result in the loss of 0.15 percent of forest land in Perry County. Any businesses displaced by project activities will be eligible for government assistance similar to that provided to displaced residents.

Changes in land use in the site vicinity and neighboring communities can affect economic activity if agricultural land is replaced by project-related residential and commercial development. This could also result in additional funds to local governments because developed land is usually taxed at a higher rate than land used for agriculture. It is difficult to assess potential effects on land value near the site. Land values could increase as industrial development replaces agricultural activities. Also, as the demand for housing increases to accommodate in-migrating populations in Hattiesburg, Petal, Laurel, and Richton, land values in these communities could increase.

However, land values may decrease depending on community attitudes toward project development. If the repository is perceived as a negative influence, it may discourage other new industrial development and investment in the local trade and service sectors. This effect may be alleviated through encouragement of facility-related development and local business expansion.

5.4.3 Community Services

Workers and their families who in-migrate to the study area during project construction and operation will create an increased demand for housing, potable water, sewage disposal, solid waste disposal, schools, police and fire protection, recreation facilities, hospitals, and other health-related services. These requirements and the potential effects on the local and regional infrastructure are described below. The service requirement level indicated includes both direct and indirect workers.

Projected community service needs with and without the project were estimated (Tables 5-30 and 5-31). In determining these community service needs, it was assumed that any existing excess capacity will not be used for facility-related needs. Baseline population requirements were estimated using the same service standards as those used to estimate facility-related population requirements.

Even though national service standards or averages were used in all calculations except housing needs, it must be recognized that such levels (ratio of service per capita) may or may not be suitable for an individual community. National service standards are used in this analysis so that a comparison from site to site can be made. Local service levels vary, as discussed in Section 3.6.3, and a local level of service may be preferred by a specific community. The use of a particular service level affects the amount of excess capacity that would be absorbed by baseline growth. The appropriate level of community services to be maintained though impact assistance is considered to be a point of negotiation between the DOE and the State.

Project impacts are estimated for peak years of construction and operation. The largest increase in facilities and personnel will be required during the first year of construction, but the highest level of service will occur during peak operation.

Impacts on community services will, for the most part, occur during the project's construction stage. Although community services will be required during the project operation phase, many of these services should have been substantially upgraded during project construction, with only minimal changes needed for project operation.

The demands for services such as housing would increase during the initial years of decommissioning when workers would be temporarily locating in the area. This phase is far into the future and it is difficult to predict whether the excess capacity present at the end of the operation phase will be present and capable of handling the additional public service demands created by the decommissioning phase.

5.4.3.1 Housing

The in-migrating work force may cause some pressure on housing and rental prices in the study area. However, the impact would be minimal due to the expected place of residence for the in-migrating work force and the pressure that will result from expected baseline populations in study area communities through the years 1996 and 2006 (Section 3.6.1).

The total new housing units needed to accommodate future populations will depend on the housing needs of the projected baseline population and the housing needs of new households in-migrating to the area during project construction and operation. Forecasted baseline housing needs were based on projected populations for the study area through the years 1996 and 2006 and on the average household size in 1980.

Projections of housing units needed by in-migrating population during project construction and operation are determined based upon estimates of in-migrating households, including those with families and singles. Estimates of in-migrant households for each year of project construction and operation are shown in Tables 5-26 and 5-27, respectively.

The types of housing to meet increased needs could include single family dwellings, multifamily units, and temporary housing. Accommodations for families and singles may include homes, mobile homes, apartments, and motel rooms.

Table 5-30. Projected Baseline and Project-Related Service Requirements During Peak Construction (1995), Richton Dome

Item	Hattiesburg		Petal		Laurel		Richton	
	Baseline	Project Related	Baseline	Project Related	Baseline	Project Related	Baseline	Project Related
Additional population	5,411	967	1,104	242	2,853	363	105	483
Additional housing required[a]	2,147	349	397	87	1,081	131	37	174
Education								
Number of school-age children	866	246	140	62	514	92	23	123
Additional teachers required[b]	46	13	7	3	27	5	1	6
Protective Services								
Additional municipal police required[c]	11	2	2	1	6	1	0	1
Additional paid firefighters required[d]	4	1	1	0	2	0	0	0
Health[e]								
Additional physicians required	5	1	1	0	3	0	0	0
Additional hospital beds required	27	5	6	1	14	2	1	2
Water								
Additional municipal water needs, (thousands of gallons/day)[f]	812	145	166	36	428	55	16	73
Sewage								
Additional effluent[g] (thousands of gallons/day)	541	97	110	24	285	36	11	48
Recreation								
Additional neighborhood parks (acres)[h]	5	1	1	0	3	0	0	1
Additional children's playgrounds (acres)[i]		0		0		0		0

Note: All numbers are rounded to the nearest whole number.

(a) Baseline housing figures are estimated from 1980 average household size; project-related housing from data for households in Goldsmith (1984).
(b) Based on 1981-82 student/teacher ratio of 19:1 (National Center for Education Statistics, 1983).
(c) Based on police/population ratio of 2:1,000 (Federal Bureau of Investigation, 1984). This includes local law enforcement, state police, and highway patrol officers.
(d) Based on firefighters/dwelling ratio of 2:1,000 (Stenehjem and Metzger, 1976).
(e) Based on physicians/population ratio of 0.99/1,000 and hospital beds/population of 5/1,000 (National Center for Health Statistics, 1983).
(f) Based on 150 gallons per day per person (International City Management Association, 1979).
(g) Based on 100 gallons per day per person (International City Management Association, 1979).
(h) Based on 1 acre per 1,000 population (International City Management Association, 1979).
(i) Based on 1 acre per 600 children-playground (International City Management Association, 1979).

Table 5-31. Projected Baseline and Project-Related Service Requirements During Peak Operation (2005), Richton Dome

Item	Hattiesburg		Petal		Laurel		Richton	
	Baseline	Project Related	Baseline	Project Related	Baseline	Project Related	Baseline	Project Related
Additional population	10,091	787	2,074	197	4,813	295	215	394
Housing required[a]	4,004	278	746	70	1,823	104	76	139
Education								
Number of school-age children	1,615	211	415	53	866	79	47	105
Additional teachers required[b]	85	11	22	3	46	4	2	6
Protective Services Required								
Additional municipal police[c]	20	2	4	0	10	1	0	1
Additional paid firefighters[d]	8	1	2	0	4	0	0	0
Health Requirements[e]								
Additional physicians	10	1	2	0	5	0	0	0
Additional hospital beds	50	4	10	1	24	1	1	2
Water								
Additional municipal water needs, (thousands of gallons/day)[f]	1,514	118	311	30	722	44	32	59
Sewage								
Additional effluent (thousands gallons/day)[g]	1,009	79	207	20	481	30	22	39
Recreation								
Additional neighborhood parks (acres)[h]	10	1	2	0	5	0	0	0
Additional childrens' playgrounds (acres)[i]		1		0		0		0

Note: All numbers are rounded to the nearest whole number.

(a) Baseline housing figures are estimated from 1980 average household size; project-related housing from data for households in Goldsmith (1984).
(b) Based on 1981-82 student/teacher ratio of 19:1 (National Center for Education Statistics, 1983).
(c) Based on police/population ratio of 2:1,000 (Federal Bureau of Investigation, 1984). This includes local law enforcement, state police, and highway patrol officers.
(d) Based on firefighters/dwelling ratio of 2:1,000 (Stenehjem and Metzger, 1976).
(e) Based on physicians/population ratio of 0.99/1,000 and hospital beds/population of 5/1,000 (National Center for Health Statistics, 1983).
(f) Based on 150 gallons per day per person (International City Management Association, 1979).
(g) Based on 100 gallons per day per person (International City Management Association, 1979).
(h) Based on 1 acre per 1,000 population (International City Management Association, 1979).
(i) Based on 1 acre per 600 children-playground (International City Management Association, 1979).

Workers and their families who in-migrate into the study region during project operation will require additional housing and other community services, since more in-migrating workers and families are expected during peak project operation than during peak project construction. However, many of these services should have been substantially upgraded during project construction, with only minimal changes needed during project operation. Table 5-31 summarizes maximum community service requirements during peak operations.

Total housing units needed to accommodate in-migrating operation workers and their families will depend on the housing needs of the projected baseline population and the housing needs of new households in-migrating into the study area during project operation.

Total additional project-related households expected during peak operation will be 591. The number of singles in-migrating is expected to decrease during operation. However, 8 percent fewer families are expected to in-migrate during project operation. Hence, fewer single-family units will be required during project operation. In addition, since fewer multi-family and mobile home units will be needed during project operation, a surplus of multi-family and mobile home units may be available to operation phase families generally desiring single-family units.

5.4.3.2 Education

Estimates of the maximum number of school-age in-migrants expected during repository construction and operation are presented in Tables 5-30 and 5-31, respectively. The expected place of residence of these in-migrants is also shown. The number of additional teachers required was projected based on national 1981-82 student-teacher ratio. The greatest number of school-age children will occur in the fourth year of construction. Projected peak construction in-migration in the four study area communities will include 523 students. This will require 27 additional teachers. During peak operation, the 448 additional school-age children will require 24 teachers.

5.4.3.3 Protective and Community Services

To determine baseline and future needs, two municipal police officers per 1,000 population was assumed (based on national standards). For the project-related growth during peak repository development, a maximum of 5 additional municipal police will be required (Table 5-30). County police officers provide assistance to each community, and the number of these officers is also expected to increase in the future. Increased traffic congestion can also result in traffic control problems requiring additional personnel.

To meet project-related growth during peak operations, one additional firefighter will be required in Hattiesburg. Since fire protection at the repository will be provided by the contractor, the repository will have little or no effect on fire services in the surrounding communities.

Increased and specialized services will be required by police and fire services to implement effective emergency preparedness plans, which will be developed for each proposed site.

5.4.3.4 Health Services

Needs for additional physicians and hospital beds were estimated based on national health standards (NHS). Maximum project-related growth (at peak construction) will require an additional 5 beds in Hattiesburg, 1 bed in Petal, 2 beds in Laurel, and 2 beds in Richton (Table 5-30).

Repository operation will also require additional health and safety maintenance programs. Emergency preparedness plans and personnel trained in emergency procedures will be needed in communities near the repository and along waste transportation routes. The DOE will help communities develop and implement emergency plans and train personnel. Special health care personnel and facilities will also be required to monitor worker exposure to radioactive materials.

5.4.3.5 Water Supply and Sewage Treatment

The additional requirements to meet baseline needs and peak projected construction- and operation-related in-migration in Hattiesburg, Petal, Laurel, and Richton are shown in Tables 5-30 and 5-31. These water and sewer capacity requirements were projected using national standards of 0.66 cubic meter (150 gallons) per day per person for water and 0.44 cubic meter (100 gallons) per day per person of effluent discharge.

5.4.3.6 Recreation

It is likely that some additional facilities will be necessary to provide recreational opportunities to in-migrating workers and their families, particularly in the smaller study area communities that lack the level and diversity of facilities available in the larger urban areas (e.g., Hattiesburg and Laurel). Increased visitor use of De Soto National Forest by in-migrants may also result in a need for additional camping and picnicking facilities.

The projected additional neighborhood park areas needed to meet baseline and maximum repository in-migration were estimated using national standards of 0.4 hectare (1 acre) per 1,000 additional population (Tables 5-30 and 5-31).

5.4.4 Social Conditions

Predictions of probable social impacts are qualitative, based on expectations of social interaction and behavior. Generally, local social impacts can be expected to result from rapid and significant changes in population in individual communities. Regional impacts occur when most or all communities in an area experience rapid change. The degree of local or regional impact is influenced by lifestyle differences or similarities among the composition of entering, exiting, and existing population groups, and associated changes to the economic and community service sectors. Data on population characteristics of the existing population are valuable for assessing potential social impacts. Table 3-40 (Section 3.6.1.4) presents a breakdown of the population for the study area by age, sex, and race.

5.4.4.1 Construction

The largest increases in population associated with this project are expected to occur during the first few years of repository construction (Section 5.4.1.1), with the peak cumulative increase occurring in year 1995. According to the gravity model projections, Hattiesburg would receive 967 repository-related in-migrants, which represents a 2 percent change above the baseline projection for that year. Petal would receive 242 repository-related in-migrants (less than 3 percent change). Laurel would receive 363 repository-related in-migrants (less than 2 percent change) and Richton would receive 483 repository-related in-migrants (37 percent change). The potential repository-related population growth for Richton could lead to social changes in the community.

Because of the temporary nature of some of the construction tasks, some differences in lifestyle can be expected between the long-term resident population and workers who temporarily relocate to the area. Experience at large-scale energy development projects in the western United States has shown that many construction workers will choose to live in mobile homes or temporary housing for the duration of their jobs, often creating new mobile home parks to accommodate this new but temporary population. There will be some differing values and attitudes; however, social programs can be developed to promote interaction between new and long-time residents and to help reduce initial conflict. Programs can be instituted to preserve local heritage and promote an understanding of local heritage to new residents. Better access to social services and aid for the disadvantaged, such as elderly and low-income housing, may be primary goals of the NWPA-negotiated local mitigation measures. Emergency preparedness planning and public information may go a long way to alleviate health fears and their impact on the quality of life. Also, construction personnel expecting to be employed for the entire construction period will be more likely to find permanent housing and establish lifestyles in keeping with the existing regional lifestyle.

Large population in-migrations are often considered to be the impetus for community lifestyle changes. A measure of the propensity of a community to accommodate large population in-migrations and associated lifestyle changes is the relationship between the native population level and the in-migrant population level. In this context the native population equates to those persons born in the state of their residence.

The potential for the largest lifestyle impact will occur in Richton. Based upon in-migration estimates, it is estimated that in a conservative case, where all in-migrants would be non-natives, the native population of Richton could be reduced from a baseline of about 89 percent to about 65 percent during peak construction and operation. This compares to a state average native population of about 79 percent and a national average of about 68 percent.

The native population base of Hattiesburg, Petal, and Laurel is not estimated to be as heavily impacted as Richton's. During peak construction, the native population of Hattiesburg will be reduced from a baseline of about 74 percent to 73.0 percent; the native population of Petal will be reduced from a baseline of about 80 percent to 78 percent; and the native population of Laurel will be reduced from a baseline of about 84 percent to 82 percent. As stated in Section 3.6.4, in the culture of the Richton area religion is an important part of daily life. Most people are members of conservative Protestant churches and their way of life is heavily influenced by their religious beliefs. The beliefs or behavior patterns of in-migrants may be different from those of long-term residents; differences such as these may lead to conflict between these groups.

Some of the construction workers will leave during the construction period, since it can be expected that some of this work force will move to the region only for the duration of the construction phase and not seek other employment when project work assignments end. In addition, because some of the construction and operation jobs require overlapping skills, a certain proportion of the construction personnel will become operations personnel and will settle in the area as long-term residents.

5.4.4.2 Operation

New residents moving to the area to work during the operations phase are likely to blend reasonably well into the regional lifestyle. Persons choosing to relocate to the area for jobs at the repository will choose to do so in part because the area and its lifestyle make it an attractive place to make a home. Although these new residents may come from diverse backgrounds, their presence will not necessarily change the values, interests, and attitudes of the resident population. Although population change will be greater in Richton (as described above), the 7-year construction period will have given newcomers and long-term residents time to adjust to each others' differences.

Operation activities, despite associated new population growth in the early years, are not expected to have significant effects on social conditions. By the time the repository begins operation, it will be a well-established element of the community, and associated population change will be less drastic than that experienced with construction activities. Because of the long-term nature of the facility, any new project-related residents are likely to be long-term as well and, therefore, likely to blend into existing lifestyles.

5.4.4.3 Decommissioning and Closure

Although the caretaker period will result in a loss of jobs to the region, this project phase is long term. Workers displaced during this period will either find new employment elsewhere in the region or leave the area to seek employment. Out-migration is expected to occur over several years and not be disruptive to the larger communities. Smaller communities may need some assistance in stimulating other economic activity.

Decommissioning will result in in-migration associated with an increase in the average work force during the five year period. As in the construction phase, some differences in lifestyle can be expected between the long-term resident population and workers who

temporarily relocate to the area. Following closure, out-migration should occur. If the local economy is sufficiently diverse, other economic activities may take the place of the repository and provide continuity for area communities. Therefore, social impacts would be minimized.

5.4.5 Fiscal Conditions and Government Structure

Project construction and operation will result in added revenues and costs to study area cities and to the region. Estimated revenues and costs are discussed below.

5.4.5.1 Construction

Construction of the repository will create an increase in revenue from property taxes, sales taxes, and user fees. Intergovernmental transfers may or may not increase depending on the method of calculating the amount of the transfer and the impact of project related growth on the formula.

Additional intergovernmental transfers related to repository development are designed to offset the negative property tax impacts and provide assistance to impacted state and local jurisdictions. The 1982 Nuclear Waste Policy Act (42 USC Sections 10101-10226) requires the DOE to provide grants-equal-to-tax payments to State and general units of local governments in which a candidate site for characterization is approved by the President. Payments will be made during (1) the site characterization phase, (2) the repository construction phase, and (3) the repository operation phase. These payments would continue until activities at the site are terminated. These funds are not earmarked for specific community projects. Section 4.2.2 contains a more detailed discussion of the grants-equal-to-taxes program.

The DOE shall provide grants to the State to (1) review activities and determine economic, social, public health and safety, or environmental impacts; (2) develop impact assistance requests; (3) monitor, test, or evaluate site characterization activities; (4) inform residents of activities; and (5) request information and make comments to the Secretary of the DOE. The States are required to submit their analysis of the impacts of a repository to the Secretary of the DOE when site characterization activities are completed and before a site is recommended to the President for a repository. The analysis will then serve as a basis for the State's impact assistance requests.

Technical and financial assistance will be provided to any host state requesting such assistance within six months following issuance of a construction authorization from the NRC. The DOE must seek to enter into an agreement with the State on the amount of financial and technical impact assistance to be provided and on procedures to be followed in providing such assistance. To receive these payments, the State must submit an evaluation of the likely social, economic, public health and safety, and environmental impacts to the Secretary of the DOE. Funds could be used to improve community services (DOE, 1985, DOE/RW-0005, p. 139). In addition, school districts in the area, affected by increased Federal activities, could apply for funds through the School Assistance in Federally Affected Areas for School Construction and Operation program (Office of Management and Budget, 1983).

Cities, counties, and special districts have authority to levy and collect property taxes. Property tax revenue will increase in those jurisdictions where workers choose to settle and residential and commercial real estate development occurs, thus increasing the amount of taxable property. Per capita revenue may increase depending on the value of the property added to the tax base.

Construction of the repository will increase the income in the area, resulting in greater sales tax revenues from this source. Sales tax revenues will also increase from repository supplies that are purchased locally.

User fees are related to specific services such as water supply or wastewater collection and treatment, and, therefore, the revenue collected will depend on the demand for these services. If demand increases proportionally with population growth, then total revenues will

increase, but fee per capita will not. Variances between demand for services and population growth will cause different changes in the total revenue and fee per capita.

Cities, counties, and special districts have the power to issue bonds for capital projects, subject to certain limitations on tax rates and total amount of indebtedness. The types of bonds include tax bonds, if a majority of the voters approve; bonds secured by the operating revenues of the facility constructed with the bond proceeds; and certifications of obligation to pay for the construction of public works. Certificates of obligation may be repaid by taxes, revenues, or a combination thereof.

The additional population and new development associated with construction of a large facility often lead to significant increases in local tax revenues, user fees, and property taxes. These additional revenues often serve as a source for much-needed service improvements, such as new schools and water and sewer systems. Problems may arise, however, in the timing of revenue collection in relation to public service costs and in the distribution of costs and revenues between jurisdictions.

New service demands may arise immediately during project construction, and many of the revenues necessary to meet those front-end capital improvement costs may not be available until project operation. It may be necessary to provide front-end financing to local jurisdictions to pay for required new services in anticipation of expected project revenues. Problems result when resources that generate government income are located in one government jurisdiction while service impacts created by new residents occur in another jurisdiction.

Additional governmental employees will be required to provide the new or expanded services and facilities. This will increase employment opportunities, as well as contribute to increased project-related costs to local governments.

Fiscal impacts are expected to be minimized by Federal assistance, as provided for in the NWPA (Section 116).

5.4.5.2 Operation

Governmental revenue sources would be influenced by the same factors that influenced them during repository construction, although the magnitude of the changes may be different. Property tax revenues would increase due to the project increase in home ownership. These revenues would fluctuate in the transition from construction to operations because of changes in work force size and characteristics. Other factors discussed under construction impacts would probably remain the same. The DOE grants equal to taxes would continue and may increase revenues depending on how the repository is assessed.

User fees are related to specific services and would fluctuate as the population fluctuates. The same factors discussed under construction impacts would influence user fees during repository operations.

Bonding requirements would probably drop, since most of the demand for new facilities would have been met during the construction period. There will be replacement requirements as the useful life of the various facilities is exhausted. These requirements would be part of the communities' service planning and budgeting process.

Changes in expenditures are subject to the same factors discussed for repository construction. Service requirements will fluctuate with changes in total population and in the demographic characteristics. They may result in periods of over- or underutilized capacity. Since the peak operational work force is greater than peak construction, expenditures may be more. The differences between construction and operation work force family characteristics may require expansion of some services, such as water and sewer lines and schools.

5.4.5.3 Decommissioning and Closure

Revenues to state and local governments will decrease as operations phase down and the repository enters the caretaker period. Out-migration of unemployed repository workers in the short term may create a greater than normal housing vacancy rate, resulting in a reduction of new home construction. Thus, residential property tax income could stabilize or decline if home values also decline. The extent of this effect will depend upon levels of other economic activity in the region.

User fees are related to specific services. Per capita costs for these services may increase if repository workers leave, since fixed costs will have to be paid by fewer users. Municipal bonding requirements would drop, since excess municipal facility capacity results from out-migration. However, DOE grants equal to tax payments will continue to be made.

Changes in expenditures are subject to the same factors discussed for repository construction. Service requirements will decline if unemployed repository workers leave the area. This may result in excess capacity and reductions in expenditures to reduce capacity.

Following the caretaker period, there should be an upswing in revenues as workers move to the area during decommissioning. Residential property tax income, revenue from user fees for community services and sales tax revenues should all increase. At the end of decommissioning, government revenues would probably decline as workers and their families move to other areas and major project expeditures end.

5.5 SUMMARY OF IMPACTS ON THE RICHTON DOME STUDY AREA

Repository development activities including repository construction, operation, decommissioning, and closure have the potential to cause various levels of impacts. Table 5-32 summarizes the regional and local impacts of locating a repository at Richton Dome.

Impacts are discussed in terms of their duration, intensity, or significance. The use of mitigation measures is noted in determining intensity of the impact. As applicable, location of the impact is also identified.

Table 5-32. Summary of Repository Impacts, Richton Dome

I. Repository Construction

Primary Activities are as follows:

Development of offsite utility and transportation access corridors, development of onsite transportation and utility infrastructure, establishment of a water supply, site preparation and grading, construction/erection of repository surface facilities, development of shafts and underground facilities, storage of mined materials including salt, transport of personnel and materials to and at the site, surface and subsurface use restrictions, and population in-migration.

Summary of Impacts

1. Soils (Section 5.2.1.1)

   a. About 280 hectares (700 acres) of soil will be subject to increased erosion, mixing of soil horizons, reduced fertility, and disturbance of local topography and drainage patterns during construction of repository facilities and access/utility corridors.

   b. Deposition of windblown salt is expected to be insignificant beyond the site boundary. Use of engineered control measures and leak detection systems under the lined storage pile will prevent significant soil contamination due to leaching or runoff.

2. Mineral Resources (Section 5.2.1.2)

   Exclusion of controlled area from mineral and hydrocarbon resource development will have minimal local and regional effects, because resources are not unique and are readily available in the region.

3. Surface Water (Section 5.2.2.1.1)

   a. Local and temporary increases in sediment loads will occur until completion of sedimentation ponds.

   b. Project water requirements will be met primarily from offsite wells; consequently, no surface water will be withdrawn or consumed.

   c. No impacts on the 100-year floodplain will occur because none of the proposed surface facilities will lie within the 100-year floodplain.

   d. No significant degradation of water quality from windblown salt is expected. Based on expected salt deposition rates, increases in salinity will be less than 1 milligram per liter at any adjacent stream. This represents minor changes in water quality.

Table 5-32. Summary of Repository Impacts, Richton Dome
(Page 2 of 13)

I. Repository Construction

4. Ground Water (Section 5.2.2.2)

   a. No significant drawdown interferences to local water supply wells are expected because the estimated saturated thickness of aquifers would decrease by 49 meters (16 feet) by the year 2000.

   b. Ground-water-quality impacts due to infiltration of precipitation through salt-contaminated soils are expected to be minor because of low wind deposition of salt outside the repository area.

   c. Design measures and construction techniques will prevent contamination between aquifers; wells will be monitored and sampled and remedial measures (grouting or pumping) implemented if cross-contamination is detected.

5. Land Use (Section 5.2.3.1)

   a. Impacts to commercial forestry are expected to be minor; loss of forest land represents only a small portion (0.15 percent) of the total forest land in Perry County. Much of this land has recently been cleared.

   b. Salt-related impacts will be insignificant because the majority of windblown salt particulates will remain within the construction area.

   c. Repository construction is not expected to change the nature or use of the De Soto National Forest, Leaf Wilderness Area, or Black Creek Wilderness Area.

   d. Some residences within the proposed controlled area will have to be relocated to other available areas. Displaced residents and landowners will be compensated for relocation.

   e. Richton will be unable to expand residential, commercial, or industrial development into controlled zone. Alternative areas for such development are currently available. The present character of the controlled area will not change since the DOE does not plan to develop the area.

6. Terrestrial Biota (Section 5.2.4.1.1)

   a. Minimum loss of vegetation and wildlife habitat and some mortality of small sedentary wildlife will occur due to land clearing for repository and access routes; much of the site area has recently been cleared. There may be a temporary increase in competition for food and cover as bird and mammal species move into adjoining habitat.

Table 5-32. Summary of Repository Impacts, Richton Dome
(Page 3 of 13)

I. Repository Construction

b. Minor impacts to biota in proximity to construction areas will occur from vehicle movements, increased noise, and human presence.

7. Aquatic Biota (Section 5.2.4.2.1)

a. There will be a loss of 7.5 hectares (18.5 acres) of ephemeral wetlands; approximately 5.1 hectares (12.7 acres) will be reestablished following channel diversion.

b. Loss of aquatic flora and fauna will occur in relocated drainages; however, no fish or other important aquatic species are expected to be present in these drainages.

c. No significant impacts on aquatic biota will result from increased salinity in surface waters because the projected 1 milligram per liter increases in salinity will be below harmful levels for fish.

8. Threatened and Endangered Species (Section 5.2.4.3)

a. Repository construction is not expected to significantly impact threatened or endangered species because of lack of habitat caused by clearcutting.

b. Access and utility routes could potentially affect threatened or endangered species in the area; surveys wll be performed prior to construction and, if necessary, measures taken (e.g., access re-routing, scheduling of activities to avoid critical periods) to avoid impacts.

9. Air Quality (Section 5.2.5.2)

a. Concentrations of air pollutants from the facility are projected to be less than National Ambient Air Quality Standards (NAAQS).

b. Wind erosion of the salt pile will be negligible due to natural crusting or covering of the pile.

10. Aesthetics (Section 5.2.6.1)

Tall structures may be visible for short periods of time from an area on Mississippi State Highway 42 located about 2.4 kilometers (1.5 miles) south of the restricted area, but will probably not be visible from Mississippi State Highway 15.

Table 5-32. Summary of Repository Impacts, Richton Dome
(Page 4 of 13)

I. Repository Construction
11. Noise (Section 5.2.7.1)
a. Noise impacts are expected to be insignificant because no sensitive receptors are located within 1.4 kilometers (0.9 miles) of the surface facility (potential zone of noise impacts); and because projected increases in noise from repository construction are below 55 dBA 1.4 kilometers (0.9 miles) from the center of construction activities.
b. Noise from surface blasting will be temporary, occurring over a period of 4 to 12 days.
12. Archaeological, Cultural, and Historic Resources (Section 5.2.8.1)
a. No significant impacts are expected because no known archaeological, cultural, or historical sites occur in the project area and the potential for locating significant sites is low because of prior disturbance.
b. Potential indirect impacts on unrecorded sites that may be located will be mitigated in accordance with agreements developed in continuing consultations between the DOE and the SHPO and Advisory Council.
13. Transportation (Section 5.3.3)
a. Minor and temporary increases in traffic congestion and traffic delays will occur from increased truck and passenger traffic along Mississippi State Highways 42 and 15.
b. Insignificant increase is predicted in number of vehicular accidents because of increased project-related traffic.
c. Minor delays and short detours to road traffic may occur during rail line construction.
14. Utilities (Section 5.3.4)
a. Existing utility capacities will be sufficient to handle construction needs.
b. No impacts on waste treatment facilities are expected because waste treatment will be handled on site.

Table 5-32. Summary of Repository Impacts, Richton Dome
(Page 5 of 13)

I. Repository Construction

15. Population (Section 5.4.1.1)

a. In-migration during peak construction will result in a total increase of 2,420 persons (workers and families) in the area.

b. In-migration is projected to be 967 persons (40 percent) to Hattiesburg, 483 persons (20 percent) to Richton, 242 persons (10 percent) to Petal, and 363 persons (15 percent) to Laurel.

16. Employment (Section 5.4.2.1)

The repository will generate a peak of 2,120 direct and indirect jobs, which includes a total of 1,120 local direct and indirect jobs.

17. Economic Activity (Section 5.4.2.2)

a. The total projected increase in dollar volume of local purchases is $52 million.

b. Businesses displaced by project activities will be eligible for government assistance.

18. Community Services (Section 5.4.3)

Population in-migration will require an increase in community services, including 741 housing units, 27 teachers, 5 police officers, 1 physician, 10 hospital beds, 300 thousand gallons of water, 205 thousand gallons of sewage treatment, and 2 acres of parks.

19. Social Conditions (Section 5.4.4.1)

The population change in Hattiesburg, Petal and Laurel will be less than or equal to 2 percent of the existing populations. This would cause no social change in these communities. Richton will have a 37-percent change in population; this may cause some social change in Richton.

20. Fiscal Condition and Government Structure (Section 5.4.5)

a. Revenues from property taxes, sales taxes and user fees will increase.

b. Impact mitigation payments will be used to finance needed services.

c. Additional municipal staff may be needed in the town of Richton.

Table 5-32. Summary of Repository Impacts, Richton Dome
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II. Repository Operation

Primary activities are as follows:

Transport and handling of nuclear wastes, other surface facilities operations, salt storage, water and energy use, transport of personnel and nonwaste materials to and at the site, surface and subsurface use restrictions, population in-migration.

Summary of Impacts

1. Soils (Section 5.2.1.2.2)

   a. Control measures designed to stabilize soils will reduce erosion rates to near predisturbance levels.

   b. Use of engineered control measures and leak detection systems under the lined storage pile will prevent significant impacts from soil contamination due to leaching or runoff.

   c. Deposition of wind-borne salt is expected to be insignificant beyond the site boundary.

2. Mineral Resources (Section 5.2.1.2)

   No significant impact will occur because of continued exclusion of resources from development within the controlled area.

3. Surface-Water Quality (Section 5.2.2.1.2)

   a. Minimal soil erosion and turbidity in surface waters is expected because exposed soils will be stabilized and revegetated.

   b. Because the projected windblown salt emissions are low, no significant increase in salinity to nearby creeks is anticipated.

4. Ground-Water Quality (Section 5.2.2.2.2)

   a. No significant disruption of ground-water flow patterns.

   b. Ground-water withdrawals will produce minor drawdowns of up to several feet at supply wells within 16 kilometers (10 miles) of the repository.

   c. Insignificant impacts on ground-water quality are expected because of the low levels of wind-deposited salt on site.

Table 5-32. Summary of Repository Impacts, Richton Dome
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II. Repository Operation
5. Land Use (Section 5.2.3.2)
a. The DOE will control land uses within the controlled area for the 50 years of repository operation.
b. Impacts on agriculture and forest land will be similar to those during repository construction; loss of forest land for the repository represents only 0.15 percent of the total forest land in Perry County.
c. Insignificant impacts on forest and crop productivity are expected because of the small area to be impacted by salt piles; the area affected by salt deposition will be contained on site.
6. Terrestrial Biota (Section 5.2.4.1.2)
a. Continued minor disturbance to wildlife will occur from vehicular activities, noise, lights, and increased human presence in areas adjacent to the surface facilities.
b. Some increases in impacts to wildlife (e.g., roadkills, hunting pressure) are expected from influx of repository workers and their use of parks and wildlife refuges in the region. Mitigation measures (e.g., worker awareness, restrictions on recreational activities) will be implemented.
c. Some wildlife habitat will be regained on reclaimed areas of rights-of-way and landscaped portions of the repository.
d. Vegetation impacts from windblown salt will only occur immediately adjacent to the salt pile.
7. Aquatic Biota (Section 5.2.4.2.2)
a. No significant impacts on aquatic biota are expected; surface-water resources and associated aquatic biota will not be affected because ground waters will supply repository operation needs.
b. No significant impacts to aquatic biota are anticipated from salt deposition because the projected 1 milligram per liter increases in salinity will be below harmful levels for fish.
8. Threatened and Endangered Species (Section 5.2.4.3.2)
No impacts to threatened or endangered species from repository operation are expected because of lack of habitat caused by clearcutting.

Table 5-32. Summary of Repository Impacts, Richton Dome
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II. Repository Operation
9. Air Quality (Section 5.2.5.2)
a. Wind erosion of the salt pile will be negligible due to natural crusting and/or covering of the pile and the small working face.
b. Modeling results indicate the NAAQS requirements will be met.
10. Aesthetic Conditions (Section 5.2.6.2)
Repository operations activities are potentially visible from limited areas on Mississippi State Highway 42; impacts are expected to be insignificant because of short duration of visibility to travelers on the highway, and because buildings and structures will be arranged and painted to blend with the surrounding environment where possible.
11. Noise (Section 5.2.7.3)
No significant noise impacts are expected because no sensitive receptors are located within 1.0 kilometer (0.6 mile) of the surface facility (the potential noise impact zone) and because projected noise levels are below 55 dBA 1.3 kilometers (0.8 mile) from the repository.
12. Archaeological, Cultural, and Historic Resources (Section 5.2.8.2)
No direct impacts are expected.
13. Nuclear Waste Transportation (Section 5.3.1)
a. Estimated radiological health effects from nuclear waste transport are expected to result in 6.3 (assumes 100 percent truck transport) to less than one (assumes 100 percent rail transport) latent cancer fatalities to present and future generations.
b. Estimated non-radiological fatalities resulting from traffic accidents range from 6.7 (100 percent rail) to 21 (100 percent truck).
c. The regional maximum individual exposure values range from 1 to 4 millirem per year, or about 1 to 5 percent of background.

Table 5-32. Summary of Repository Impacts, Richton Dome
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II. Repository Operation
14. Transportation (Section 5.3.3)
a. Minor increases in traffic congestion during peak hours are expected from increased passenger traffic along Mississippi State Highways 42 and 15; additional highway improvements may be required to accommodate repository operation traffic.
b. Increase in predicted number of vehicular accidents (6 additional accidents and 0.1 fatal accidents per year) may occur due to increased traffic volume.
c. Congestion at road crossings is not expected because of rail shipments.
15. Utilities (Section 5.3.4)
a. No significant impacts on utilities are expected, because existing utility capacities will be sufficient to handle operational needs.
b. No impacts on waste treatment facilities are expected because waste treatment will be handled on site.
16. Population (Section 5.4.1.2)
a. In-migration during peak operation will result in a total increase of 1,970 persons (workers and families) in the area.
b. In-migration is projected to be 787 persons (40 percent) to Hattiesburg, 394 persons (20 percent) to Richton, 197 persons (10 percent) to Petal, and 295 persons (15 percent) to Laurel.
17. Employment (Section 5.4.2.1)
The repository will generate a peak of 2,190 direct and indirect jobs. There is estimated to be a total of 1,702 local direct and indirect jobs.
18. Salt Management and Disposal (Section 5.2.10)
a. Windblown salt deposition is expected to be 1.0 kilogram per hectare (0.9 pound per acre) per year at 0.8 kilometer (0.5 mile), which is within the controlled area.
b. Minimal impact to soil productivity is expected from windblown salt deposition, because the majority of any salt deposition will be within the controlled area.

Table 5-32. Summary of Repository Impacts, Richton Dome
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II. Repository Operation

c. Potential degradation of the water quality of the adjacent streams and water bodies by windblown salt will be small.

d. Changes in ground-water quality due to infiltration of precipitation through soils contaminated by windblown salt will be minor.

e. No adverse effects on vegetation are expected, because the majority of any salt deposition will be within the controlled area.

f. Impacts resulting from accidental transportation spills on land will be localized and short-term, because of implementation of emergency cleanup procedures.

19. Economic Activities (Section 5.4.2.2)

Both repository and work force purchases will increase the economic activity in the area.

20. Community Services (Section 5.4.3)

Population in-migration will require the following community services in the peak year of 2006. Population in-migration will require an increase in community services including 591 housing units, 24 teachers, 4 police officers, 1 physician, 8 hospital beds, 251 thousand gallons of water, 168 thousand gallons of sewage treatment, and 1 acre of parks.

21. Social Conditions (Section 5.4.4.2)

Assimilation of new residents will be less of a problem than during construction because of (1) the changes that have already occurred during construction and (2) the long-term presence of new residents.

22. Fiscal Conditions and Government Structure (Section 5.4.5)

a. Revenue from property taxes, sales taxes, and user fees is projected to increase.

b. Impact mitigation funds will be used to finance needed services.

Table 5-32. Summary of Repository Impacts, Richton Dome
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III. Repository Decommissioning/Closure

Primary activities are as follows:

Dismantling of surface facilities, shaft backfilling, site regrading and revegetation, transport of personnel and materials to, from, and at the site, and population out-migration.

Summary of Impacts

1. Soils (Section 5.2.1.2.3)

   Temporary increase in soil erosion rates will result from regrading and restoration of site to original contours. Site restoration will ultimately reduce erosion rates to preconstruction levels.

2. Mineral Resources (Section 5.2.1.2)

   No significant impact will occur because of continued exclusion of resources from development in the controlled area.

3. Surface Water (Section 5.2.2.1.3)

   a. Local and temporary increase in sedimentation and turbidity will occur in surface waters because of regrading and limited salt contamination during salt transport for backfilling.

   b. No significant impacts on surface-water resources are expected.

4. Ground Water (Section 5.2.2.2.3)

   Minimal impacts to ground-water systems are expected because potential surface sources of contamination will be removed from the site.

5. Land Use (Section 5.2.3.3)

   Restrictions on surface and subsurface uses will continue.

6. Terrestrial Biota (Section 5.2.4.1.3)

   a. Minor impacts may occur from continued noise, lights, and human presence.

   b. Reclamation and revegetation will restore wildlife habitats and wildlife should repopulate the area.

Table 5-32. Summary of Repository Impacts, Richton Dome
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III. Repository Decommissioning/Closure
7. Aquatic Biota (Section 5.2.4.2.3) Aquatic biota will be protected from sediment runoff by sediment basins that will be maintained during decommissioning.
8. Threatened and Endangered Species (Section 5.2.4.3.3) No adverse impacts to threatened and endangered species are expected.
9. Air Quality (Section 5.2.5.3) Impacts are not expected to exceed those modeled for repository construction and operation.
10. Aesthetic Resources (Section 5.2.6.3) a. No additional impacts are expected; visible repository structures will be dismantled and the landscape graded and revegetated to blend with surrounding topography. b. Aesthetic impacts of postclosure monuments or markers will depend on design and type of passive prevention barrier selected.
11. Noise (Section 5.2.7.3) Noise impacts are not expected to exceed those identified for repository construction.
12. Cultural Resources (Section 5.2.8.3) No direct impacts are expected because no additional land will be disturbed.
13. Transportation (Section 5.3.3) No significant impacts are expected as traffic volume will decrease during decommissioning and closure.
14. Utilities (Section 5.3.4) No additional impacts on utilities are expected.

Table 5-32. Summary of Repository Impacts, Richton Dome
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III. Repository Decommissioning/Closure

15. Population (Section 5.4.1)

    a. Some potential out-migration may occur during the caretaker period and following closure, depending on the effect of repository work force reduction on indirect employment and the type of other job opportunities in the area.

    b. Some in-migration will occur during decommissioning as some workers move to the area.

16. Employment (Section 5.4.3.2)

    Potential decrease in employment.

17. Economic Activities (Section 5.4.2.2)

    Potential decrease in economic activity.

18. Community Services (Section 5.4.3)

    a. Out-migration due to a decline in repository employment may result in an excess supply of housing and community services during the caretaker period and following closure.

    b. In-migration during decommissioning may strain local services and cause housing shortages in some communities.

19. Social Conditions (Section 5.4.4.3)

    a. No sudden changes to social structure are expected during the caretaker period because population changes will probably occur over a long period.

    b. Some social impacts may be expected due to rapid population change during decommissioning.

20. Fiscal Conditions and Government Structure (Section 5.4.5)

    a. Tax revenues may decrease during the caretaker period and following closure. As service requirements decrease, user fees will be reduced; however, facility operation costs may not decrease significantly.

    b. Tax revenues, service requirements, and user fees will increase during decommissioning.

5.6 CHAPTER 5 REFERENCES

5.6.1 References Listed by Author

Battelle's Pacific Northwest Laboratories, 1979. Environmental Aspects of Commercial Radioactive Waste Management, Vol. 1, DOE/ET-0029, prepared for U.S. Department of Energy, Washington, DC.

Battelle's Pacific Northwest Laboratories, 1979. Environmental Aspects of Commercial Radioactive Waste Management, Vol. 2, DOE/ET-0029, prepared for U.S. Department of Energy, Washington DC.

Battelle's Pacific Northwest Laboratories, 1979. Environmental Aspects of Commercial Radioactive Waste Management, Vol. 3, DOE/ET-0029, prepared for U.S. Department of Energy, Washington, DC.

Bechtel Group, Inc., 1983. Salt Disposal: Paradox Basin, Utah, ONWI-453, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Bechtel National, Inc., 1982. Environmental Characterization Report for the Gulf Interior Region, Mississippi Study Area, ONWI-193, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Bechtel National, Inc., 1985a. Richton Dome Noise Analysis, draft letter report, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Bechtel National Inc., 1985b. Richton Dome Air Quality Analysis, draft letter report, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Bernstein, L., and H. E. Howard, 1958. "Physiology of Salt Tolerance," Annual Review of Plant Physiology, Vol. 9, pp. 25-46.

Berry, W. E., 1983. Durability of Marker Materials for Nuclear Waste Isolation Sites, ONWI-474, prepared by Battelle Columbus Laboratories for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

BGI, see Bechtel Group, Inc.

BNI, see Bechtel National, Inc.

Bohn, Russel, Thomas Cuscino, Jr., and Chatten Cowherd, Jr., 1978. Fugitive Emissions from Integrated Iron and Steel Plants, EPA-600/2-78-050, prepared for U.S. Environmental Protection Agency by Midwest Research Institute, Kansas City, MO.

Bowers, J. F., J. R. Bjorklund, and C. S. Cheney, 1979. Industrial Source Complex (ISC) Dispersion Model User's Guide, Vol. 1, EPA-450/4-79-030, prepared for Source Receptor Analysis Branch, U.S. Environmental Protection Agency, Research Triangle Park, NC, by H. E. Cramer Company, Inc., University of Utah Research Park, Salt Lake City, UT.

Brooks, Kanand, Jr., 1985. Letter from Brooks, Soil Conservation Service, to B. White, Salt Repository Project Office, U.S. Department of Energy, with Farmland Conversion Impact Rating form, March 14.

Bureau of Labor Statistics, 1980. Handbook of Labor Statistics, Bulletin 2070, U.S. Department of Labor, Washington, DC, pp. 108-109.

Bureau of the Census, 1982. Statistical Abstract of the United States 1982-83, 103d edn., U.S. Department of Commerce, Washington, DC, pp. 26, 43, 147, and 383.

Bureau of the Census, 1983. 1980 Census of Population, General Population Characteristics, Mississippi, PC80-1-C26, U.S. Department of Commerce, Washington, DC.

Buschena, Cynthia, and Edward Sucoff, 1980. Six-Year Growth of Trees and Shrubs Along Minnesota Roads, Especially as Affected by Deicing Salts, Report No. FHWA/MN-80/7, Minnesota Department of Transportation, Research and Development Office, St. Paul, MN.

California Department of Transportation, 1975. Use of Deicing Salt on California State Highways, Final Environmental Impact Report, State Clearinghouse Number 75060298.

Chen, C. P., and G. E. Raines, 1985. Technical Basis for High-Level Waste Repository Land Control Requirements (Palo Duro Basin, Paradox Basin, and Richton Dome), draft, prepared for the U.S. Department of Energy by Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Committee on Biological Effects of Ionizing Radiation, 1980. The Effects on Population of Exposures to Low Levels of Ionizing Radiation, National Academy Press, Washington, DC.

D'Appolonia Consulting Engineers, 1976. Preliminary State-of-the-Art Survey: Mining Techniques for Salt and Other Rock Types, Y/OWI/SUB-76/16515, prepared for U.S. Energy Research and Development Administration, Washington, DC.

DOE, see U.S. Department of Energy.

EO, see Section 5.6, Federal Regulations and Statutes and Executive Orders.

EPA, see U.S. Environmental Protection Agency.

Eschen, V. G., 1985. Letter from Eschen, Stearns Catalytic Corporation, to Norm Henderson, Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, about personnel for basic repository, August 14.

ETC, see The Earth Technology Corporation.

Federal Bureau of Investigation, 1984. Crime in the United States, Uniform Crime Reports for the United States, 1983, U.S. Department of Justice, Washington, DC.

Fish and Wildlife Service, 1983. National Wetlands Inventory Maps, Rhodes, Richton, Beaumont Quadrangles, Office of Biological Services, U.S. Department of the Interior, Atlanta, GA.

Fluor Technology, Inc., 1985. Evaluation of Exploratory Shaft Facility Impacts on Repository, S.O.W. 4.4.2.1, Engineering Design Study, Revisions to report, Irvin, CA, abstract.

FWS, see Fish and Wildlife Service.

Goldman, Larry E., 1985. Letter from Goldman, Field Supervisor, Fish and Wildlife Service, to S. E. Pomeroy, Battelle Columbus Laboratories, Columbus, OH, about existence of wetlands, July 10.

Goldsmith, Stanley, 1984. ONWI Population In-Migration Model (attachment for inclusion in salt site statutory environmental assessment documents), letter report from Goldsmith, Office of Nuclear Waste Isolation, Battelle Memorial Institute, to T. J. Taylor, Salt Repository Project Office, U.S. Department of Energy, Columbus, OH, May 30.

Hale, Allan, 1973. "Salt Water Vapor Discharges and the Environment," in A. H. Coogan, ed., Fourth International Symposium on Salt, Northern Ohio Geological Society, Inc., Cleveland, OH, pp. 387-389.

Halstead, John M., and F. Larry Leistritz, 1983. Impacts of Energy Development on Secondary Labor Markets: A Study of Seven Western Counties, Agricultural Economics Report No. 178, North Dakota State University, Fargo, ND.

Hepner, J., and P. Nault, 1984. Telephone conversations between Hepner and Nault, coordinators, U.S. Fish and Wildlife Service, National Wetlands Inventory, Atlanta, GA, and K. Marcus, The Earth Technology Corporation, about wetland inventories, October 1 and 3.

Hoffman, Glenn J., and Jewell L. Meyer, 1982. "Reclamation of Salt-Affected Soils in California," Proceedings of the First Thematic Conference on Remote Sensing of Arid and Semi-Arid Lands (January, 1982, Cairo, Egypt), pp. 147, 149, 151, 153, 155, 157, and 159.

Hutchinson, F. E., 1973. "Effect of Deicing Salts Applied to Highways on the Contiguous Environment," in A. H. Coogan, ed., Fourth International Symposium on Salt, Northern Ohio Geological Society, Inc., Cleveland, OH, pp. 427-434.

Hutchinson, F. E., and B. E. Olson, 1967. "The Relationship of Road Salt Applications to Sodium and Chloride Ion Levels in the Soil Bordering Major Highways," Environmental Considerations in Use of Deicing Chemicals, Highway Research Record, No. 193, National Research Council, pp. 1-7.

INTERA Environmental Consultants, Inc., 1978. Radiological Waste Storage Analysis, prepared for Sandia Laboratories, Albuquerque, NM.

International City Management Association, 1979. The Practice of Local Government Planning, Washington, DC.

Jenkins, D. M., 1984. Memo from Jenkins, Battelle Columbus Laboratories, to T. Thomas, Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, about treatment of rainwater runoff from salt piles, October 10.

Jenks, G. H., and H. C. Claiborne, 1981. Brine Migration in Salt and Its Implications in the Geologic Disposal of Nuclear Waste, ORNL-5818, prepared for U.S. Department of Energy by Oak Ridge National Laboratory, Union Carbide Corporation, Oak Ridge, TN.

Kaplan, Maureen F., 1982. Archaeological Data as a Basis for Repository Marker Design, ONWI-354, prepared by The Analytic Sciences Corporation for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Kelsall, P. C., J. B. Case, D. Meyer, J. G. Franzone, and W. E. Coons, 1985. Schematic Designs for Penetration Seals for a Repository in Richton Dome, BMI/ONWI-562, prepared by IT Corporation for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Langill, R. F., 1983. Preliminary Investigation of Deep Well Disposal of Excess Repository Salt, prepared by Richard F. Langill and Associates, Inc., for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, January, in preparation.

Leopold, A. C., and R. P. Willing, 1984. "Evidence for Toxicity Effects of Salt on Membranes," Salinity Tolerance in Plants - Strategies for Crop Improvement, John Wiley & Sons, Inc., New York, NY, pp. 67-76.

Little, S., J. J. Mohr, and L. L. Spicer, 1958. "Salt-Water Storm Damage to Loblolly Pine Forests," Journal of Forestry, January, pp. 27-28.

Loken, Marc C., Gary D. Callahan, Darrell K. Svalstad, and Ralph A. Wagner, 1984. Thermomechanical Analyses of Conceptual Repository Designs for the Paradox and Permian Basins, prepared by RE/SPEC Inc. for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, in preparation.

Loyacano, H. A., Jr., 1967. "Acute and Chronic Effects of Salinity on Two Populations of Red Swamp Crawfish," Louisiana State University, Baton Rouge, LA.

Maas, E. V., and G. J. Hoffman, 1977. "Crop Salt Tolerance--Current Assessment," Journal of the Irrigation and Drainage Division, Proceedings of the American Society of Civil Engineers, Vol. 103, No. IR2, pp. 115-134.

Maryland Department of Natural Resources, 1978. Power Plant Cumulative Environmental Impact Report, PPSP-CEIR-2, Maryland Power Plant Siting Program, Annapolis, MD.

McSweeney, T. I., R. W. Peterson, and R. Gupta, 1984. "The Costs and Impacts of Transporting Nuclear Waste to Candidate Repository Sites," Proceedings of the 1983 Civilian Radioactive Waste Management Information Meeting, CONF-83-1217, Office of Civilian Radioactive Waste Management, U.S. Department of Energy, Washington, DC, pp. 351-361.

Murdock, Steve H., and F. Larry Leistritz, 1979. Energy Development in the Western United States, Impact on Rural Areas, Praeger Special Studies, Praeger Scientific, New York, NY, pp. 93-100 and 109-111.

National Center for Education Statistics, 1983. Digest of Education Statistics 1983-84, U.S. Department of Education, Washington, DC.

National Center for Health Statistics, 1983. Health - United States, 1981, U.S. Department of Health and Human Services, Washington, DC.

National Safety Council, 1984. Accident Facts, 1984 edn., Chicago, IL, pp. 40-79.

Neff, J. O., 1984. Personal communication between Neff, Salt Repository Project Office, U.S. Department of Energy, and Charles Baxter, U.S. Fish and Wildlife Service, Vicksburg, MS, October 10.

Newcome, Roy, Jr., compiler, 1971. Results of Aquifer Tests in Mississippi, U.S. Geological Survey Bulletin 71-2, prepared by the Water Resources Division with the Mississippi Board of Water Commissioners, Jackson, MS.

Newcome, Roy, Jr., 1975. The Miocene Aquifer System in Mississippi, U.S. Geological Survey Water-Resources Investigations 46-75, U.S. Department of the Interior, prepared with the Mississippi Board of Water Commissioners, Jackson, MS.

NUS Corporation, 1984. Alternative Methods to Manage Waste Salt From Repository Excavation in the Deaf Smith County and Swisher County Locations, Texas: A Scoping Study, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH (August 1984 draft), in preparation.

Oak Ridge National Laboratory, 1983. Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics, DOE/NE-0017/2, prepared for U.S. Department of Energy, Washington, DC.

Office of Management and Budget, 1983. "School Assistance in Federally Affected Areas," 1983 Catalog of Federal Domestic Assistance, Executive Office of the President, Washington, DC, pp. 816-818.

Office of Nuclear Waste Isolation, 1986. Evaluation of Air Quality and Noise Impact Assessments - Richton Dome. Battelle Memorial Institute, Columbus, OH, in preparation.

ONWI, see Office of Nuclear Waste Isolation.

Parsons-Redpath, 1984. Preliminary Salt Control Plan, prepared for U.S. Department of Energy by Parsons-Redpath, Columbus, OH, in preparation.

Rhoades, J. D., 1982. Reclamation and Management of Salt-Affected Soils After Drainage, paper prepared for Soil and Water Management Seminar, November 29 - December 2, 1982, Lethbridge, Alberta, Canada.

Russell, J. E., 1979. Areal Thermal Loading Recommendations for Nuclear Waste Repositories in Salt, Y/OWI/TM-37, prepared for the U.S. Department of Energy by the Office of Waste Isolation, Union Carbide Corporation, Nuclear Division, Oak Ridge, TN.

Scharpf, R. F., and M. D. Srago, 1974. Conifer Damage and Death Associated With the Use of Highway Deicing Salt in the Lake Tahoe Basin of California and Nevada, Forest Pest Control, Technical Report 1, Forest Service, U.S. Department of Agriculture, Washington, DC.

Scheriff, M. A., 1983. Correspondence from Scheriff to V. G. Eschen, both of Stearns-Roger Services, Inc., about candidate underground mines for disposal of excess salt from proposed nuclear waste repositories located in Mississippi, Texas, and Utah, March 4.

Schraufnagel, F. H., 1967. "Pollution Aspects Associated with Chemical Deicing," Environmental Considerations in Use of Deicing Chemicals, Highway Research Record No. 193, National Research Council, pp. 22-33.

Schultz, Theodore J., 1978. "Synthesis of Social Surveys on Noise Annoyance," Journal of the Acoustical Society of America, Vol. 64, No. 2, pp. 377-405.

Scott, R., 1984. Letter from Scott, Stearns-Roger Services, Inc., to C. DaMassa, Bechtel National, Inc., San Francisco, CA, enclosing field notes and photos, March 29.

Shows, T. N., W. L. Broussard, and C. P. Humphreys, Jr., 1966. Water for Industrial Development in Forrest, Greene, Jones, Perry, and Wayne Counties, Mississippi, Mississippi Research and Development Center, prepared by Water Resources Division, U.S. Geological Survey, U.S. Department of the Interior, Jackson, MS.

Simpson, P. W., J. R. Newman, M. A. Keirn, R. M. Matter, and P. A. Guthrie, 1982. Manual of Stream Channelization Impacts on Fish and Wildlife, FWS/OBS-82/24, Fish and Wildlife Service, Office of Biological Services, U.S. Department of the Interior, Washington, DC.

Siskind, D. E., M. S. Stagg, J. W. Kopp, and C. H. Dowding, 1980. Structure Response and Damage Produced by Ground Vibration From Surface Mine Blasting, Report of Investigations 8507, Bureau of Mines, U.S. Department of the Interior, Washington, DC.

Sneed, Charley, 1985. Dome outline revision for Richton Dome, drawings transmitted by Sneed, Stearns Catalytic Corporation, to N. C. Henderson, Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, August 30.

Southern Mississippi Planning & Development District, 1974. Richton, Mississippi Comprehensive Plan: A Guide for Community Growth, Gulfport, MS.

Stearns Catalytic Corporation, 1984a. Basic Repository EA Design Basis, Gulf Interior Region, Richton Dome Site, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, in preparation.

Stearns Catalytic Corporation, 1984b. Preliminary Access Route and Cost Study Analyses for Seven Candidate Salt Sites, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, in preparation.

Stenehjem, Erik, and James Metzger, 1976. A Framework for Projecting Employment and Population Changes Accompanying Energy Development, ANL/AA-14, Vols. I and II, prepared for U.S. Department of Energy by Argonne National Laboratory, Argonne, IL.

Tennessee Valley Authority, 1980. Yellow Creek Nuclear Plant Socioeconomic Monitoring and Mitigation Report, YCNP-SMR 4, Knoxville, TN.

The Earth Technology Corporation, 1985. Gravity Modeling Study, Richton Dome, Mississippi, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, September, in preparation.

Theis, Charles V., 1935. "The Relation Between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well Using Ground Water Storage," American Geophysical Union Transactions, pp. 519-524.

Thomas, Michael, 1984. Letter report from Thomas, NUS Corporation, to Harry Smail, Office of Nuclear Waste Isolation, regarding land reclamation and revegetation plan, Permian Basin Sites, May.

TVA, see Tennessee Valley Authority.

U.S. Atomic Energy Commission, 1975. Operational Accidents and Radiation Exposure Experience Within the United States Atomic Energy Commission, WASH-1192 (revised), Washington, DC.

U.S. Department of Energy, 1978. Socioeconomic Impact Assessment: A Methodology Applied to Synthetic Fuels HCP/L2516-01, Washington, DC, pp. 15-21.

U.S. Department of Energy, 1980. Final Environmental Impact Statement, Management of Commercially Generated Radioactive Waste, DOE/EIS-0046F, Vol. 3, Summary, Public Comments and Hearing Board Report, Washington, DC.

U.S. Department of Energy, 1980. Final Environmental Impact Statement, Waste Isolation Pilot Plant, DOE/EIS-0026, Washington, DC.

U.S. Department of Energy, 1981. Technical Conservatism in the Design of a Spent Fuel Repository in a Generic Bedded Salt Stratigraphy, DOE/NWTS-147(2), Office of NWTS Integration, Battelle Memorial Institute, Columbus, OH.

U.S. Department of Energy, 1984. Generic Requirements for a Mined Geologic Disposal System, DOE/NE/44301-1, prepared by Roy F. Weston Inc. for Office of Civilian Radioactive Waste Management, Washington, D.C.

U.S. Department of Energy, 1985. Mission Plan for the Civilian Radioactive Waste Management Program, Vol. I of III, DOE/RW-0005, Office of Civilian Radioactive Waste Management, Washington, DC.

U.S. Department of Transportation, 1979. Restoration of Fish Habitat in Relocated Streams, FHWA-IP-79-3, Federal Highway Administration, Washington DC.

U.S. Department of Transportation, 1985. Accident/Incident Bulletin, No. 153, Federal Railroad Administration, Office of Safety, Washington, DC, p. 55.

U.S. Environmental Protection Agency, 1971. "National Primary and Secondary Ambient Air Quality Standards" (42 CFR Part 410), Federal Register, Vol. 36, No. 84, pp. 8186-8201.

U.S. Environmental Protection Agency, 1974. Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, EPA/ONAC 550/9-74, Washington, DC.

U.S. Environmental Protection Agency, 1983. Compilation of Air Pollutant Emission Factors, 3rd edn., suppl. 14 (including suppls. 1-7, 1977), PB83-250720, Research Triangle Park, NC.

U.S. Geological Survey, 1973. Rhodes, Mississippi, Quadrangle Map, Scale 1:24,000, U.S. Department of the Interior, Reston, VA.

U.S. Geological Survey, 1982a. Ovett, Miss., Quadrangle Map, N3122.5-W8900/7.5, Scale 1:24,000, U.S. Department of the Interior, Reston, VA.

U.S. Geological Survey, 1982b. Richton, Miss., Quadrangle Map, N3115-W8852.5/7.5, Scale 1:24,000, U.S. Department of the Interior, Reston, VA.

U.S. Geological Survey, 1982c. Water Resources Data for Mississippi - Water Year 1981, Water-Data Report MS-81-1, in cooperation with the Mississippi Department of Natural Resources and other agencies, U.S. Department of the Interior, Jackson, MS.

U.S. Geological Survey, 1982d. Ovett SE, Mississippi, Quadrangle Map, Scale 1:24,000, U.S. Department of the Interior, Reston VA.

Ver Planck, William E., 1958. Salt in California, Bulletin 175, Division of Mines, California Department of Natural Resources, San Francisco, CA.

Wadleigh, Cecil H., and Mildred S. Sherman, 1978. "Sodium Chloride in Plant Nutrition," Sodium Chloride, D. W. Kaufmann, ed., ACS Monograph No. 145, American Chemical Society, Washington, DC, pp. 470-483.

Wagner, Ralph A., Marc C. Loken, and Hans Y. Tammemagi, 1985. Preliminary Thermomechanical Analyses of a Conceptual Nuclear Waste Repository at Four Salt Sites, BMI/ONWI-512, prepared by RE/SPEC Inc. for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, in preparation.

Watters, B. G., 1959. "Transmission Loss of Some Masonry Walls," The Journal of the Acoustical Society of America, Vol. 31, No. 7, New York, NY, pp. 898-911.

Westinghouse Electric Corporation, 1983. Engineered Waste Package Conceptual Design: Defense High-Level Waste (Form 1), Commercial High-Level Waste (Form 1), and Spent Fuel (Form 2) Disposal in Salt, ONWI-438, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Wiedenfeld, Robert Phillip, 1978. Effects of Evaporative Salt Water Cooling Towers on Salt Spray and Salt Deposition on Surrounding Soils, Ph.D. Dissertation, Texas A&M University, College Station, TX.

5.6.2 Federal Regulations and Statutes and Executive Orders

10 CFR Part 60, Disposal of High-Level Radioactive Wastes in Geologic Repositories; Technical Criteria.

10 CFR Part 960, Nuclear Waste Policy Act of 1982; General Guidelines for the Recommendation of Sites for the Nuclear Waste Repositories; Final Siting Guidelines.

10 CFR Part 961, Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste.

10 CFR Part 1022, Floodplain/Wetlands Environmental Review Requirements.

14 CFR Part 77, Objects Affecting Navigable Airspace.

29 CFR Part 1910, regulations under the Occupational Safety and Health Act of 1970, as amended.

29 CFR Part 1926, Safety and Health Regulations for Construction.

30 CFR Part 57, Part IV, Safety Standards for Gassy Metal and Non-metal Mines; Proposed Rule, June 4, 1985.

30 CFR Part 57, Safety and Health Standards - Metal and Non-metal Underground Mines, revised July 1, 1984.

36 CFR Part 60, National Register of Historic Places.

36 CFR 251.53, Authorities.

40 CFR Part 50, National Primary and Secondary Ambient Air Quality Standards.

40 CFR 51.24, regulations under the Clean Air Act, as amended (42 USC Secs. 7401-7642).

40 CFR 52.21, regulations under the Clean Air Act, as amended (42 USC Secs. 7401-7642).

40 CFR Part 191, Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes; Final Rule, September 19, 1985.

49 CFR 177.825, Routing and Training Requirements for Radioactive Materials.

Bald and Golden Eagle Protection Act, 16 USC Secs. 668-668d.

Coastal Barrier Resources Act, 16 USC Secs. 3501-3510.

Endangered Species Act of 1973, 16 USC Secs. 1531-1543.

Farmland Protection Policy Act, 7 USC Secs. 4201-4209.

Federal Land Policy and Management Act of 1976, 43 USC Secs. 1701-1782.

Fish and Wildlife Coordination Act, 16 USC Secs. 661-666c.

Mine Safety and Health Act of 1977, 30 USC Secs. 801 et seq.

National Forest Organic Legislation, 16 USC Sec. 475.

Noise Control Act of 1972, Quiet Communities Act of 1978, 42 USC Secs. 4901-4918.

Nuclear Waste Policy Act of 1982, 42 USC Secs. 10101-10226.

Occupational Safety and Health Act of 1970, with supplement, 29 USC Secs. 651-673.

Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, 42 USC Secs. 4601 et seq.

Wilderness Act, 16 USC Secs. 1131-1136.

EO 11990, Protection of Wetlands, May 24, 1977.

5.6.3 State of Mississippi Laws

Air Pollution Control Regulations (identical to 40 CFR Part 52), MAPCR, APC-S-2, 1982.

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