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SUMMARY CHARACTERIZATION AND RECOMMENDATION OF STUDY AREAS FOR THE GULF INTERIOR REGION

November, 1980

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PREPARED FOR:
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OFFICE OF NUCLEAR WASTE ISOLATION (ONWI)
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ABSTRACT

This report is published as a product of the National Waste Terminal Storage (NWTS) program. The objective of this program is the development of terminal waste storage facilities in deep, stable geologic formations for high-level nuclear wastes, including spent fuel elements from commercial power reactors and transuranic nuclear waste for which the federal government is responsible.

Pertinent environmental and geological information for the Gulf Interior Region (GIR) is summarized, including physical, biological, and cultural characteristics of the region. The screening procedure used to select study areas within the GIR is described. Three areas containing eight salt domes are recommended for further study: Louisiana Study Area, Mississippi Study Area, and Texas Study Area.

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1.0 INTRODUCTION

This report is published as a product of the National Waste Terminal Storage (NWTS) Program. The objective of this program is the development of terminal waste storage facilities in deep, stable geologic formations for high-level nuclear wastes, including spent fuel elements from commercial power reactors and transuranic nuclear waste for which the federal government is responsible. Figure 1-1 illustrates the Gulf Interior Region, encompassing portions of Texas, Louisiana, and Mississippi, to which this report pertains.

In efforts to develop the technology for geologic disposal of high-level nuclear wastes, the United States Department of Energy (DOE) contracted with Battelle Memorial Institute (BMI) in 1978. The Office of Nuclear Waste Isolation (ONWI), established within the Project Management Division of BMI, subsequently contracted with a Geologic Project Manager (GPM) and a Regulatory Project Manager (RPM) to perform technical studies.

Criteria for selecting salt domes were provided by NUS (1978), Brunton and McClain (1977), and Brunton et al. (1978). ONWI also developed repository-related criteria applicable to any media for nuclear waste disposal, published in NWTS Criteria for the Geologic Disposal of Nuclear Wastes: Site Qualification Criteria (ONWI-33(2)). Abbreviated definitions of these criteria follow:

1. Site Geometry - The repository site shall be located in a geologic environment with geometry adequate for repositiory placement.

2. Tectonic Environment - The repository site shall be located such that credible tectonic events can be shown to cause no unacceptable reduction in repositiry performance.

3. Subsurface Hydrology and Geochemistry - The repository site shall have subsurface hydrologic and geochemical characteristics compatible with waste isolation.

4. Surface Hydrology - The repository site shall be located so that the surficial hydrological system, both during anticipated climatic cycles and during extreme natural phenomena, will not cause unacceptable adverse impact on repository performance.

5. Geologic Characteristcs - The repository site shall have geologic characteristics compatible with waste isolation.

6. Surface Topography - The repository site and its surrounding area shall possess surface characteristics which are compatible with waste disposal.

7. Human Intrusion - The repository site shall be located so that likelihood or consequences of past or future human intrusion will cause no unacceptable adverse impact to repository performance.

8. Proximity to Population Centers - The repository site shall have characteristics that tend to minimize the risk to the population from potential radiation exposure.

9. Environment - The repository site shall be located with due consideration to potential environmental impacts, present land use conflicts, and ambient environmental conditions.

10. Social, Political, and Economic - The repository shall be sited with due consideration to social, political, and economic impacts on communities affected by the repository.

Since these criteria are general, they are applicable to any repository system and comprise only a portion of the total criteria for a given repository facility. More specific criteria (specifications) are applied at each step in the siting process.

Figure 1-2 outlines the major steps in the site characterization and selection process and illustrates how geologic and environmental inputs are integrated into the decision process. The sequence of characterization involves three major phases:

<u>Regional Studies</u> - Formation-wide surveys, over broad multi-state regions, resulting in selection of study areas

<u>Area Studies</u> - More detailed studies of approximately 2,600-square-kilometer (1,000-square-mile) areas within the regions that appear to have favorable characteristics for repository sites. These studies result in selection of locations for further study

<u>Location Studies</u> - Detailed surveys of approximately 80-square-kilometer (30-square-mile) areas to identify potential sites

These three phases lead to a sequence of steps resulting in eventual licensing of a nuclear waste repository site or sites.

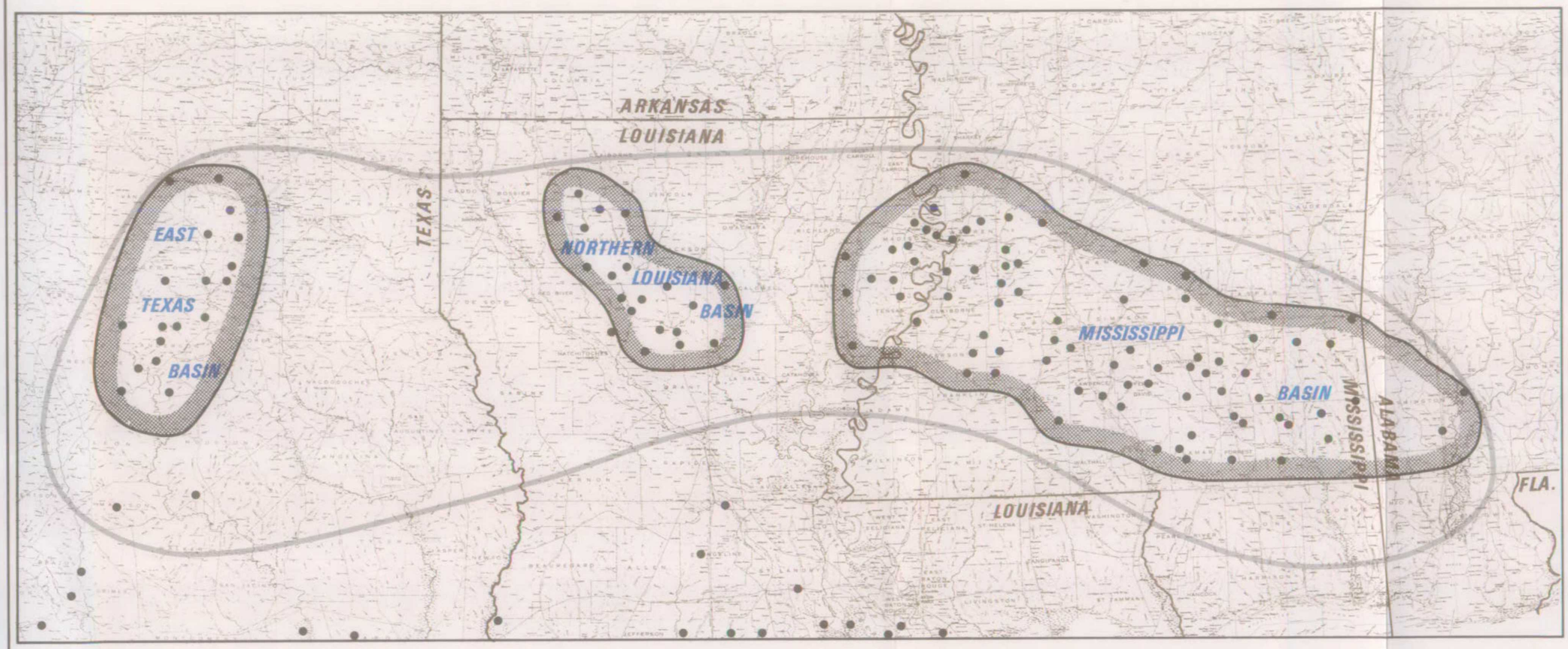
Law Engineering Testing Company is the Geologic Project Manager (GPM) for the Gulf Interior Region (GIR). Their geologic studies provide the information needed to evaluate selected salt domes as

potential repositories from the standpoint of engineering feasibility, safety, public health, and resource conflicts (Criteria 1-7). The geologic information is reported in Geologic Evaluation of Gulf Coast Salt Domes (Law Engineering Testing Co., 1978).

Bechtel National, Inc. (BNI) is the Regulatory Project Manager (RPM) for the GIR. Bechtel's environmental characterizations are intended to ensure that data on ecological, socioeconomic, and other environmental factors required by the National Environmental Policy Act (NEPA) of 1969 are considered (Criteria 7-10). BNI's findings are published in Regional Environmental Characterization Report for the Gulf Interior Region and Surrounding Territory (ONWI-67).

This report was prepared to summarize environmental and geologic information developed during the regional studies and to recommend areas potentially favorable for further, more detailed study. The report is organized as follows: in Section 2.0 the areas recommended for further study are identified; in Section 3.0 the screening process is described; the physical, cultural, and biological characteristics of the region are summarized in Section 4.0; and the methodology by which the study areas were recommended, based on regional characteristics, is outlined in Section 5.0.

Both the GPM and RPM will conduct area studies, developing more detailed information than is found in the present regional studies. Those studies will be summarized and locations (domes) in the GIR will be identified for characterization in the location phase of the NWTS program. Subsequently, candidate sites will be identified and placed in a site bank. After site banking, the GPM may conduct, as required, a detailed site characterization for input to a license application. The first repository site will be selected when four to five sites have been banked in different geologic media. Media currently under consideration include salt domes, bedded salt, basalt, tuff, and granite.



EXPLANATION

GULF INTERIOR REGION

Salt dome

Gulf Interior salt dome basins

REFERENCE:
Tectonic Map of the Gulf Coast Region, U.S.A., A.A.P.G., 1972

0 20 40 60 80 KM
0 10 20 30 40 50 MI
SCALE

SALT DOMES OF THE GULF INTERIOR REGION

Figure 1-1

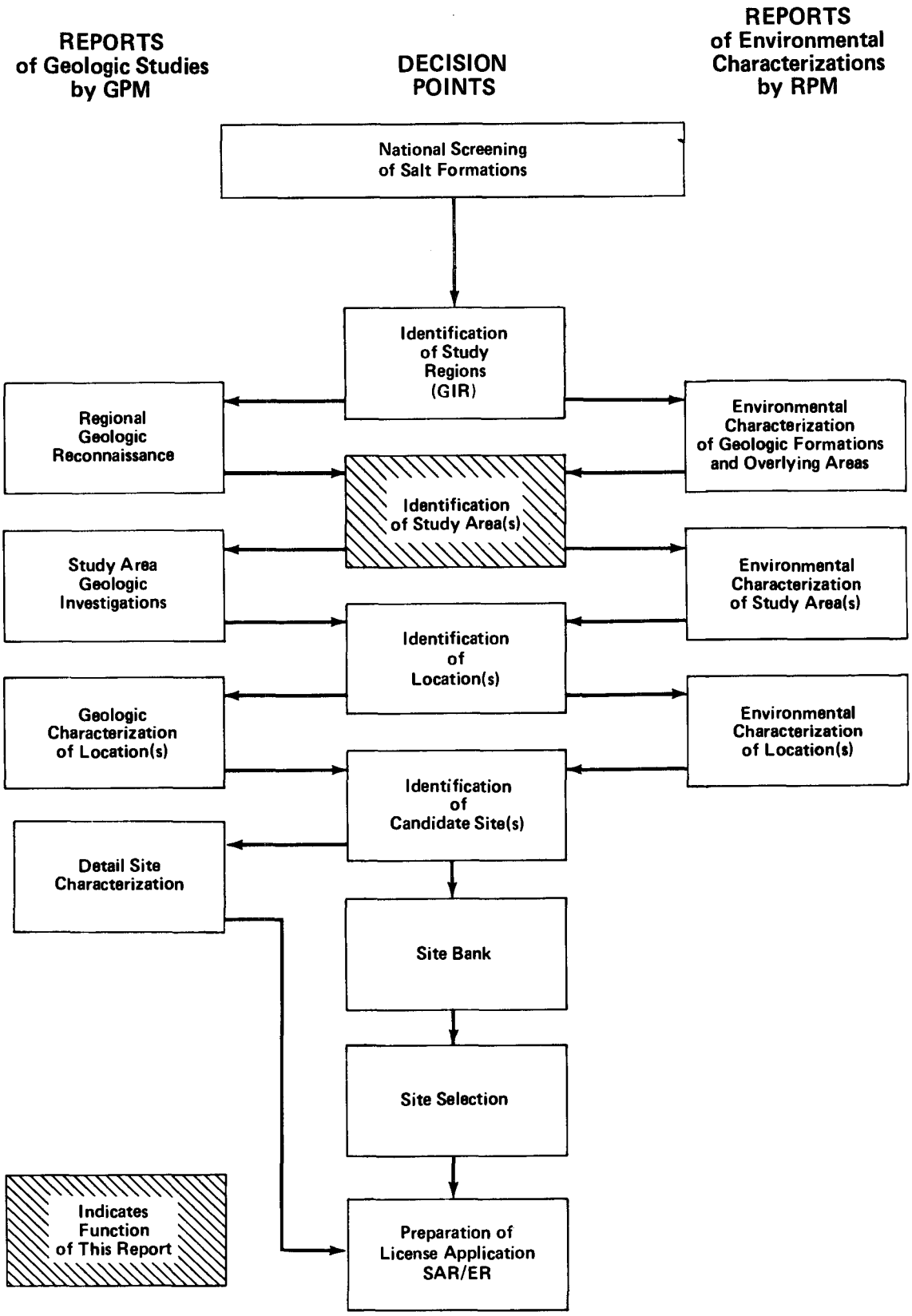


Figure 1-2 SITE CHARACTERIZATION AND SELECTION PROCESS

1.1 NEED FOR STORAGE OF NUCLEAR WASTES

The nuclear power industry in the United States is based almost solely on the operation of light-water reactors (LWRs). The LWR fuel cycle is shown diagrammatically in Figure 1-2. Uranium ore is first mined and milled to produce uranium concentrate. Since the fissionable isotope of uranium, U-235, constitutes only about 0.7 percent of natural uranium, and LWRs require uranium with about 3 percent of U-235 for operation, the concentrate is next converted to uranium hexafluoride (UF_6), the chemical form of uranium required as feed material for a gaseous diffusion isotopic enrichment plant. The enrichment plant produces uranium that is enriched to about 3 percent in the fissionable U-235 isotope; the by-product (U-238) uranium tails, reduced in U-235, are stockpiled. The enriched product is converted to uranium oxide and fabricated first into fuel pellets and then sealed in zirconium alloy tubes (fuel rods).

After about 3 years in the LWR, spent fuel elements are removed and stored under water at the LWR site in spent fuel pools. Storage in these pools provides time for the radioactive decay of shorter-lived fission products and reduction in levels of decay heat generated. The spent fuel may then be either reprocessed or stored permanently.

Reprocessing, shown by the dashed line in Figure 1-2, has been eliminated as an option for the present by U.S. Government policy. Therefore, permanent storage must be provided for the nuclear wastes that have been and continue to be generated by nuclear plants and nuclear fuel preparation facilities.

Proposed terminal waste disposal, indicated by the dotted line in Figure 1-3, is the goal of the NWTS program.

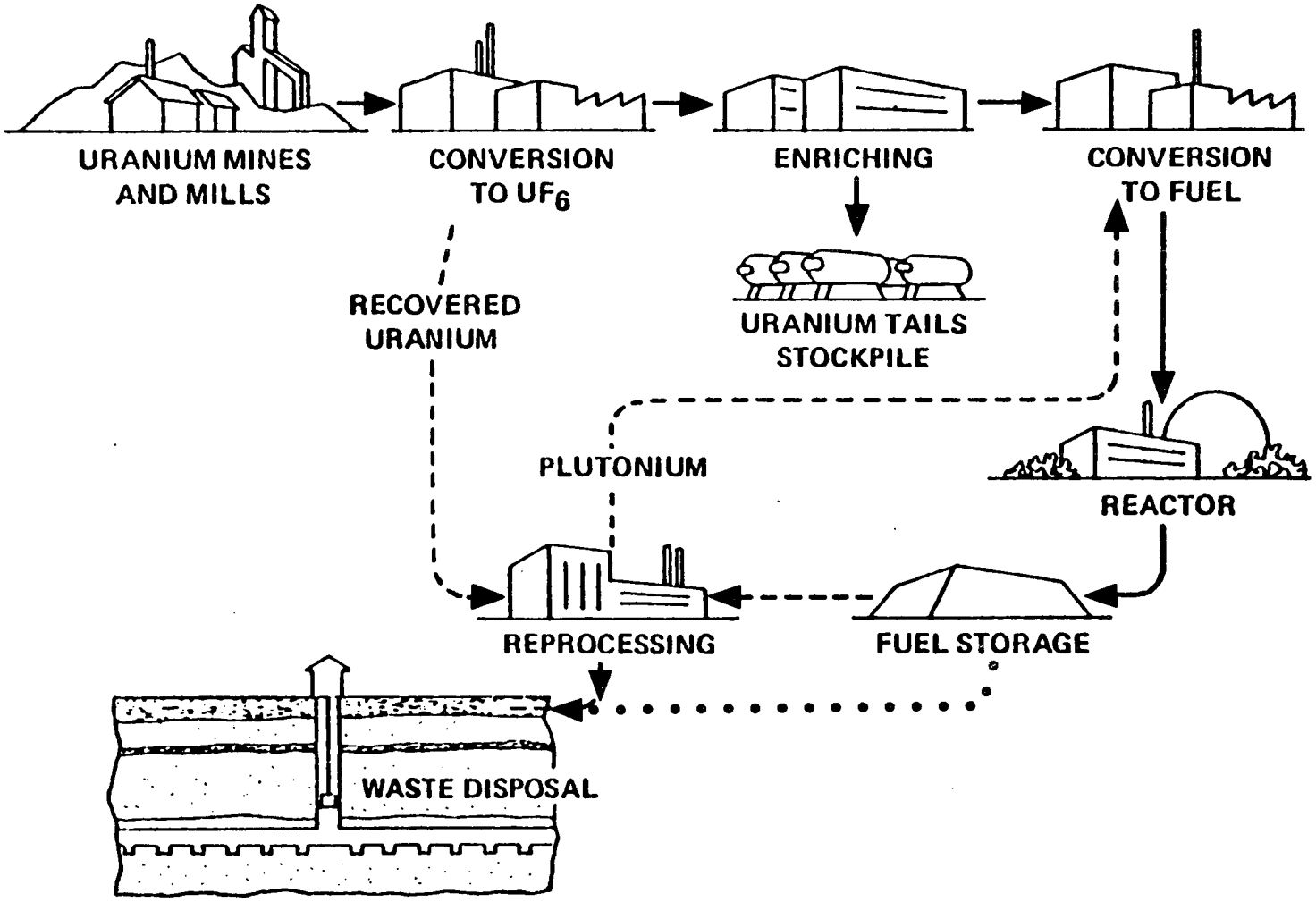


Figure 1-3 THE LIGHT-WATER REACTOR NUCLEAR FUEL CYCLE

1.2 DEVELOPMENT OF THE TECHNOLOGY OF NUCLEAR WASTE TERMINAL STORAGE IN SALT DEPOSIT FORMATIONS

In response to a request from the Atomic Energy Commission (AEC), the National Academy of Sciences - National Research Council (NAS-NRC) established in 1955 a committee of geologists to consider the possibilities of disposing of high-level radioactive wastes in the United States. The committee issued a report (National Academy of Sciences, 1957) that stated:

> The most promising method of disposal of high-level waste at the present time seems to be in salt deposits. The great advantage here is that no water can pass through salt. Fractures are self-healing. Abandoned salt mines or cavities are, in essence, long-enduring tanks.
>
> The second most promising method seems to be in forming a silicate brick or slag which would hold all elements of the waste in virtually insoluble blocks. These could be stored in sheds on the surface in arid areas or in dry mines.

Research and development efforts have predominantly followed these two parallel paths in the intervening 23 years: development of insoluble matrices for waste and verification of the suitability of salt deposits for waste isolation.

In the search for insoluble bonding matrices for waste, a form of borosilicate glass has been developed that shows promise of retardation of the solution of waste for extended periods in the event of exposure to ground water. However, this waste form requires that the spent fuel receive further processing after removal from the reactor. Such additional processing is not presently planned in the United States, but other nations, including France and England, do plan to reprocess spent fuel and utilize more stable waste forms.

The suitability of salt deposits as a geologic medium for waste disposal was extensively investigated in both laboratory and field experiments by the Oak Ridge National Laboratory beginning in 1957. Factors investigated included thermal properties, such as thermal conductivity, heat capacity, and thermal expansion coefficients; structural and mechanical properties, such as stress-strain relationships, creep behavior, and elastic and plastic moduli; trapped moisture effects; and radiation effects on salt crystal structure and brine inclusions. All of these properties indicated that a repository in salt could be designed to provide the required degree of waste containment (Bradshaw and McClain, 1971).

The early work on salt had been directed at determining its suitability for the isolation of high-activity wastes in liquid form. In late 1961, the NAS-NRC Committee, having reviewed progress in waste solidification as well as the salt investigations, recommended that the program be reoriented to

focus on the storage of solidified, packaged wastes in those formations (National Academy of Sciences, 1961).

Field experiments, known as Project Salt Vault, were carried out at an inactive salt mine in Lyons, Kansas, beginning in the early 1960s; these experiments included the determination of in-situ salt properties, demonstration of emplacement equipment, demonstration of salt stability under effects of heat and radiation from emplaced irradiated fuel elements and electric heaters, and, overall, "the feasibility and safety of handling highly radioactive materials in an underground environment" (Bradshaw and McClain, 1971).

Based on successful experimental results from Project Salt Vault, it was proposed to establish the facility as a pilot demonstration repository to handle prospective solidified commercial high-level waste and a large volume of low-level plutonium-contaminated debris from a fire at the AEC weapon facility at Rocky Flats, Colorado (U.S. Nuclear Regulatory Commission, 1976).

The safety of using the mine for this purpose was questioned by some geologists in Kansas and elsewhere (U.S. Atomic Energy Commission, 1971). The 1972 AEC Authorization Bill was then amended by Congress to allow work to continue on conceptual design and certain safety tests but also to require that periodic progress reports be made to Congress and that the implementation of the Waste Repository Project be contingent on its certification by an advisory committee. Later, the operator of a solution mining project in a salt mine located a few miles south of the Lyons site reported the unexplained loss of approximately 175,000 gallons of water during the course of his mining operations. The implications of the possible effects of this water on the salt formation together with difficulties associated with locating and plugging old oil and gas wells, raised sufficient concern about the integrity of the potential repository to result in the cancellation of the project in February 1972. However, geologic exploratory work with respect to bedded salt formations continued at other locations in Kansas and New Mexico.

In May 1976, the U.S. Energy Research and Development Administration (ERDA) issued an extensive evaluation of technical alternatives for the management of radioactive wastes from the commercial nuclear fuel cycle (ERDA, 1976). This assessment concluded that, of the alternatives examined for the management of high-level wastes, emplacement of solidified wastes in deep geologic formations was the option having the highest probability of acceptable use in a reasonable time frame. The alternatives have not been permanently foreclosed, but their potential use will require extensive additions to the technical information base as well as time for development and assessment.

As a result of Presidential policy statements in October 1976 and April 1977, geologic exploratory work is being concentrated in

states where promising salt deposits are located and in hard rock formations at the Nevada Test Site near Las Vegas, Nevada, and at the Hanford site near Richland, Washington (Cooley, 1977).

In 1978 the President established the Interagency Review Group on Nuclear Waste Management (IRG), composed of representatives from fourteen federal agencies, the White House, and regulatory and cabinet-level agencies that have a role in the energy and nuclear waste areas. IRG was to develop a strategy for dealing with the waste management problem. The final IRG report, issued in March 1979, recommended that initial emphasis be given to the mined geologic repository concept with an evaluation of a number of different sites in various types of rock formations, extensive testing of repository performance prior to final commitment, and full compliance with NEPA. The IRG also urged continued exploration of alternative disposal concepts, expanded public knowledge of the program to increase public interaction, and the establishment of a State Planning Council to represent public interests and concerns at both state and local levels (IRG, 1979).

In February 1980, President Carter announced his comprehensive Nuclear Waste Management Policy (Presidential Message to Congress, 1980). The primary objective of the policy is to isolate existing and future high-level waste (HLW) in mined geologic repositories in order to protect the biosphere and public health and safety. The U.S. Department of Energy (DOE) is responsible for program management. The Nuclear Regulatory Commission (NRC) will have the authority to license the repository site and facility once DOE selects a site and applies for a license to construct and ultimately operate the repository. The State Planning Council, established in the President's February 1980 policy statement, will advise the Congress and the President (and the DOE) of concerns and issues affecting state, tribal, and local governments.

On October 25, 1979, the NRC issued a Notice of Proposed Rulemaking regarding its confidence whether methods of safe disposal of high-level nuclear wastes will be available when they are needed. The DOE responded on November 23, 1979, with a Notice of Intent to be a Full Participant in the rulemaking proceeding. Their mutual goal for the subsequent proceeding on April 15, 1980, was:

> ... to assess generically the degree of assurance now available that radioactive waste can be safely disposed of, to determine when such disposal or off-site storage will be available, and to determine whether radioactive wastes can be safely stored on-site past the expiration of existing facility licenses until off-site disposal or storage is available (U.S. Department of Energy, 1980).

It was concluded at the proceeding that, although there is no technical reason spent nuclear fuel cannot be stored at reactor sites for extended periods of time, additional storage facilities

offsite are desirable due to shortage of onsite storage capacity. The knowledge and capability to provide such facilities are currently available, so that storage and safe disposal offsite should be possible by the mid-1980s. It was also concluded that a repository could be in operation as early as 1997 or as late as 2006, depending on whether the repository would be located in bedded or dome salt or in hard rock, such as granite, which would require a longer time period before construction could begin.

The NWTS program is an integral part of this federal effort to provide terminal storage of high-level nuclear waste.

1.3 DEVELOPMENT OF OTHER WASTE DISPOSAL CONCEPTS

The use of other options for radioactive waste disposal has not been foreclosed, but their development and assessment are expected to require long lead times and extensive additions to the technical information base (Cooley, 1977). A generic environmental impact statement (EIS), issued in draft form in April 1979 (DOE, 1979), described other waste disposal concepts currently being analyzed. These include:

- Disposal in a very deep hole
- Subseabed disposal
- Disposal in a rock melt cavity
- Disposal in space
- Disposal in rock forms other than salt

The deep hole concept relies on using a very deep shaft in strong, unfractured rock such as crystalline rock, or some deep sedimentary basins. The hole would be 5,000 to 10,000 meters (14,000 to 27,000 feet) deep and would utilize its great depth to prevent the escape of nuclear material to the biosphere.

In the subseabed disposal concept, shielded waste containers would be dropped from ships to become embedded in sea-floor sediments. The clay sediments considered for this concept are found in the vast, remote abyssal hill regions in the centers of tectonic plates, for example, the central North Pacific. These areas are biologically unproductive and geologically stable.

The rock melting concept would involve the emplacement of unshielded waste containers in a deep underground hole or cavity. After sealing the hole, heat generated by radioactive decay would cause melting of the surrounding rock. In time the waste-rock solution would solidify, trapping the radioactive material in a relatively insoluble matrix deep underground.

The dominant attraction of disposal of nuclear waste in space is the promise of permanent separation of waste from the human environment. The currently favored concept is to use the space shuttle to lift shielded waste containers into earth orbit, then to emplace the containers in a stable solar orbit.

Disposal in rock forms other than salt would employ a repository similar in design to that described for salt. Other geologic media currently being considered are tuff, basalt, granite, and shale. Differences in design of repositories in other rock forms are necessary to deal with different requirements for water removal, structural support, and heat dispersion.

1.4 CONCEPTUAL REPOSITORY DESIGN, CONSTRUCTION, AND OPERATION

Although the descriptions that follow are primarily for encapsulated spent fuel, the same general processes and procedures would be followed for vitrified and encapsulated wastes derived from a reprocessing industry. It is anticipated that the nuclear waste will be received over a period of several decades and must be isolated in a safe and environmentally acceptable manner. Current concepts call for encanistering and terminal storage at the same site. A conceptual design for such a facility located in a salt dome has been prepared (BNI, 1979).

1.4.1 Conceptual Repository Design and Construction

Figure 1-4 shows an overall view of the surface facilities and a cut-away view of a portion of the subsurface facilities at a conceptual waste repository in a salt dome. The principal surface facility building is the waste handling building (25 on Figure 1-4) built over the waste transfer shaft (37). Here in separate areas for spent fuel and transuranic waste (TRU), rail and truck shipments of waste are received, unloaded, and prepared for transfer to the terminal storage areas approximately 610 meters (2,100 feet) underground.

Auxiliary facilities include four additional shafts (36, 38, 39 40) with combined functions for men and material handling (38), underground ventilation (36), development exhaust (39), and repository exhaust (40). There is a boiler house for heating and process steam (17); an electrical substation (28); an administration building (32); a security building (26); a maintenance building (8); a warehouse (10); water and sewage treatment plant (16); and other support and utility facilities necessary for the operation of the repository. All surface structures, constituting the only visible evidence of the repository, would be confined to an area of approximately 160 hectares (400 acres). The underground emplacement area may extend over as much as about 800 hectares (2,000 acres or about 3 square miles). Assumed storage level is 600 meters (2,000 feet) below the ground surface (BNI, 1979.)

Salt excavated during underground development will be brought to the surface and stockpiled during early stages and later transferred directly from the underground development area to the emplacement area to be used as backfill. In a typical design, about 21 million tons of salt would be excavated. Of this, about 4 million tons will be stored in a surface stockpile for eventual use as backfill. About 9 million additional tons will be directly used for backfill without being brought to the surface. The remaining 8 million tons will be shipped offsite for disposal in landfills, existing mines, or the sea.

Facilities at the repository would be designed to protect operating personnel and the public from radiation and contamination hazards and to contain the radioactive materials during both normal operations and emergency or accident

situations. Facilities containing radioactive materials would be designed to maintain their containment integrity under flood, earthquake, and tornado conditions.

The waste handling building contains the facilities and equipment necessary to receive and handle spent fuel. It can be modified to handle reprocessed waste. Spent fuel assemblies are unloaded from shipping casks and transferred under water to a shielded cell where the assemblies are placed in canisters for disposal. The canister integrity is checked and then the canisters are lowered through the waste shaft to the emplacement level and moved to their final location with a shielded transporter.

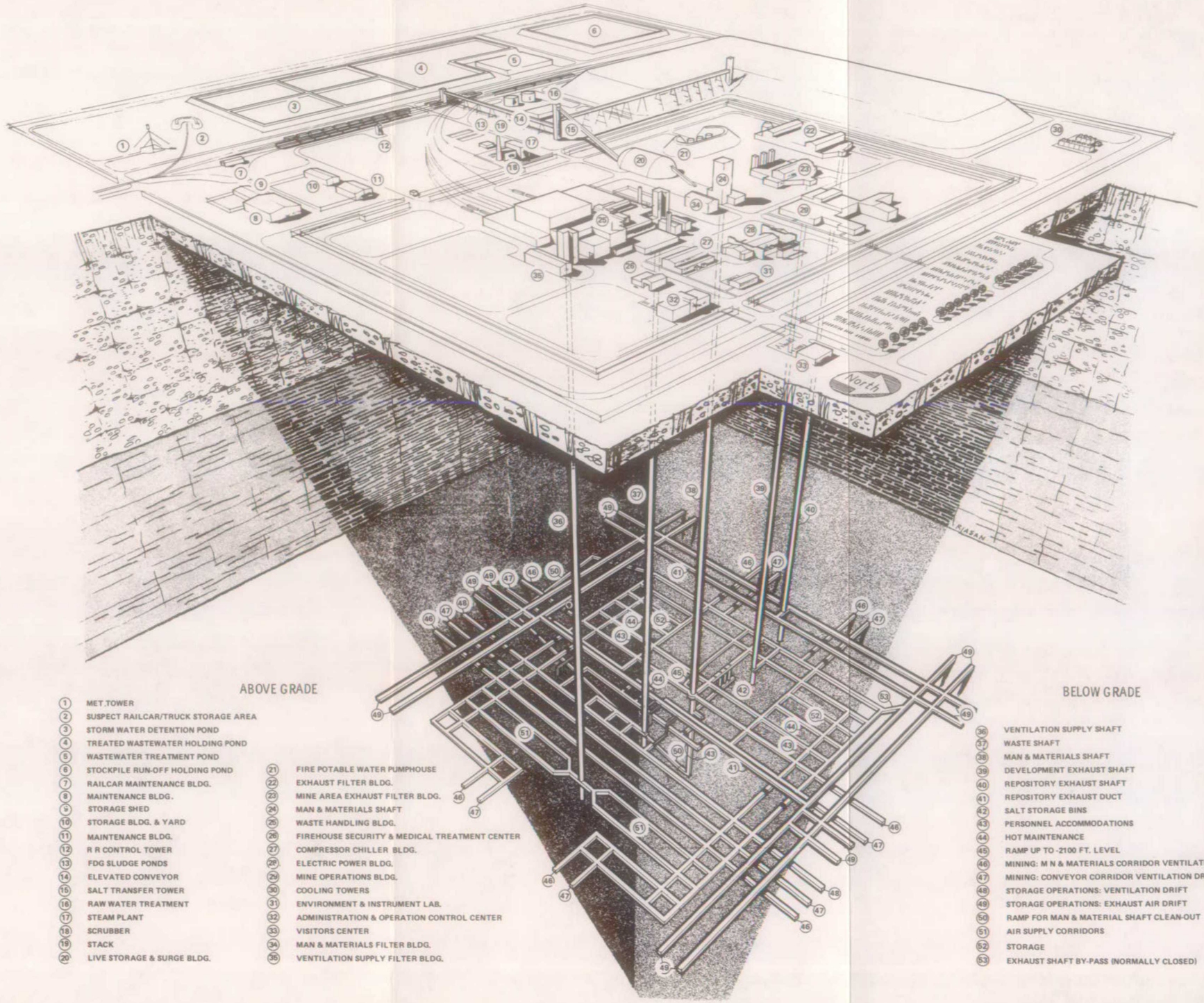
Spent fuel canisters are placed in predrilled storage holes with one of the two types of storage hole designs. The first is the lined hole which is used to assure retrievability during the first five years of emplacement. A removable concrete plug is placed over the canister to provide shielding while allowing access for retrieval. The second is the unlined hole. A gap is left between the canister and the salt to allow for creep. The canister is covered with salt.

TRU solidified in drums is shipped in containers to the facility. An overhead bridge crane is used for offloading from the carrier, and electric forklifts unload the drums. Following inspection, damaged TRU drums that may possibly leak contaminants are overpacked, and contaminated drums are decontaminated with a demineralized water spray. After all procedures have been completed, the drums are lowered into the waste shaft designed to carry the canister transfer casks. In the underground shaft station, they are unloaded, placed on pallets, and transported to the storage area by a special forklift-type transporter where they are stacked two-high on the floor using standard practices.

1.4.2 Repository Operation

The repository will be initially operated in a mode that allows retrievability of the waste; that is, all the rooms will be kept open and the waste so emplaced that it can be removed from the repository with relative ease if circumstances develop that require this action. Once the initial phase is satisfactorily completed, operations performed to maintain retrievability will cease and storage rooms will be backfilled with compatible materials after the radioactive waste is emplaced. When the repository is full, the surface facilities will be decommissioned. All shafts and other access to the underground will be plugged and sealed. Active surveillance will be maintained for an additional period, after which monitoring will be continued, as required, to confirm that waste isolation is indeed maintained.

Total fee simple rights, as well as subterranean mineral and water rights, to an area covering between 7,700 and 8,500 hectares (19,000 and 21,000 acres) may be acquired by the Department of Energy. This will ensure the safety of the



ABOVE GRADE

1. MET.TOWER
2. SUSPECT RAILCAR/TRUCK STORAGE AREA
3. STORM WATER DETENTION POND
4. TREATED WASTEWATER HOLDING POND
5. WASTEWATER TREATMENT POND
6. STOCKPILE RUN-OFF HOLDING POND
7. RAILCAR MAINTENANCE BLDG.
8. MAINTENANCE BLDG.
9. STORAGE SHED
10. STORAGE BLDG. & YARD
11. MAINTENANCE BLDG.
12. R R CONTROL TOWER
13. FDG SLUDGE PONDS
14. ELEVATED CONVEYOR
15. SALT TRANSFER TOWER
16. RAW WATER TREATMENT
17. STEAM PLANT
18. SCRUBBER
19. STACK
20. LIVE STORAGE & SURGE BLDG.
21. FIRE POTABLE WATER PUMPHOUSE
22. EXHAUST FILTER BLDG.
23. MINE AREA EXHAUST FILTER BLDG.
24. MAN & MATERIALS SHAFT
25. WASTE HANDLING BLDG.
26. FIREHOUSE SECURITY & MEDICAL TREATMENT CENTER
27. COMPRESSOR CHILLER BLDG.
28. ELECTRIC POWER BLDG.
29. MINE OPERATIONS BLDG.
30. COOLING TOWERS
31. ENVIRONMENT & INSTRUMENT LAB.
32. ADMINISTRATION & OPERATION CONTROL CENTER
33. VISITORS CENTER
34. MAN & MATERIALS FILTER BLDG.
35. VENTILATION SUPPLY FILTER BLDG.

BELOW GRADE

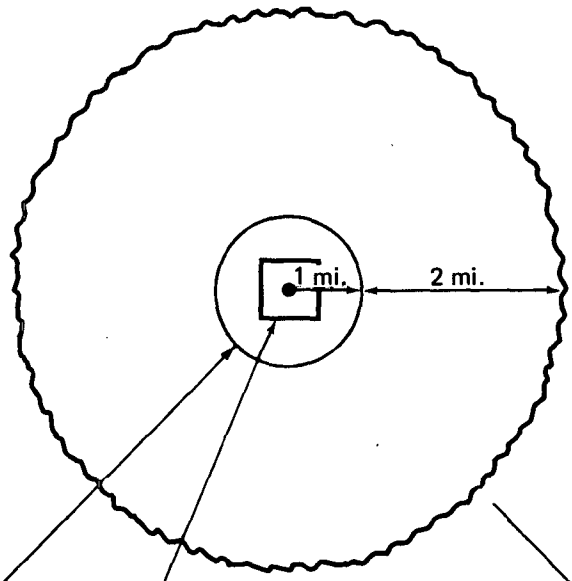
36. VENTILATION SUPPLY SHAFT
37. WASTE SHAFT
38. MAN & MATERIALS SHAFT
39. DEVELOPMENT EXHAUST SHAFT
40. REPOSITORY EXHAUST SHAFT
41. REPOSITORY EXHAUST DUCT
42. SALT STORAGE BINS
43. PERSONNEL ACCOMMODATIONS
44. HOT MAINTENANCE
45. RAMP UP TO -2100 FT. LEVEL
46. MINING: M N & MATERIALS CORRIDOR VENTILATION DRIFT
47. MINING: CONVEYOR CORRIDOR VENTILATION DRIFT
48. STORAGE OPERATIONS: VENTILATION DRIFT
49. STORAGE OPERATIONS: EXHAUST AIR DRIFT
50. RAMP FOR MAN & MATERIAL SHAFT CLEAN-OUT
51. AIR SUPPLY CORRIDORS
52. STORAGE
53. EXHAUST SHAFT BY-PASS (NORMALLY CLOSED)

Source: Bechtel National Inc., 1979

Figure 1-4 OVERALL SCHEMATIC OF WASTE REPOSITORY IN A SALT DOME

repository by preventing drilling, mining, or other activities that could conceivably breach the storage formation. However, selective surface rights for this area might be leased for grazing, farming, or other uses. (Figure 1-5 depicts idealized controlled zones for a waste repository in a salt dome.)

A typical repository would operate over a period of 30 years. It is estimated that peak employment during repository construction would reach 1,600 and during repository operation would range from 1,100 to 1,250 employees.



CENTRAL AREA – 400 ACRES CONTAINS ALL SURFACE FACILITIES. FENCED.

INNER CONTROLLED AREA – 2,000 ACRES 1-MILE RADIUS FROM CENTER (OR LAND AREA CORRESPONDING TO EXTENT OF SALT DOME). NO DRILLING OR MINING.

OUTER CONTROLLED AREA – 2-MILE ANNULUS FROM INNER CONTROLLED AREA. NO DRILLING OR MINING. SELECTIVE LEASING OF SURFACE RIGHTS.

CENTRAL AREA, INNER CONTROLLED AREA, AND OUTER CONTROLLED AREA TOTAL 19,000 - 21,000 ACRES, DEPENDING ON DOME AND ACTUAL LOCATION OF REPOSITORY.

NOTE: 1 ACRE = 0.405 HECTARE.

Sources: Bechtel National, Inc., 1979
ONWI-67
Stearns-Roger, 1979

Figure 1-5 IDEALIZED CONTROLLED ZONES FOR WASTE REPOSITORY IN A SALT DOME

2.0 RECOMMENDATIONS

2.1 IDENTIFICATION OF STUDY AREAS

Based on the Regional Characterization Studies, three study areas, incorporating the eight domes listed below, are recommended for further evaluation under the Area Characterization program. The recommended study areas are shown in Figures 2-1, 2-2, and 2-3 and include the following domes of interest (listed alphabetically by state):

- Rayburn's Dome, LA
- Vacherie Dome, LA
- Cypress Creek Dome, MS
- Lampton Dome, MS
- Richton Dome, MS
- Keechi Dome, TX
- Oakwood Dome, TX
- Palestine Dome, TX

These preliminary outlines approximate the dome configuration at 914 meters (3,000 feet) below the ground surface. The results of the geologic and environmental screening programs conducted by the GPM and RPM, as described in Sections 3.0 and 5.1 of this report, indicate the favorability of the three recommended areas for more detailed evaluation under the Area Characterization program. It should be noted that other portions of the GIR which are not recommended for further study at this time may be reconsidered in the future. Similarly, some or all of the eight domes recommended above may be deleted from the program as additional data is accumulated. Section 2.2 briefly outlines the anticipated scope of the Area Characterization study program.

2.2 AREA CHARACTERIZATION PROGRAM

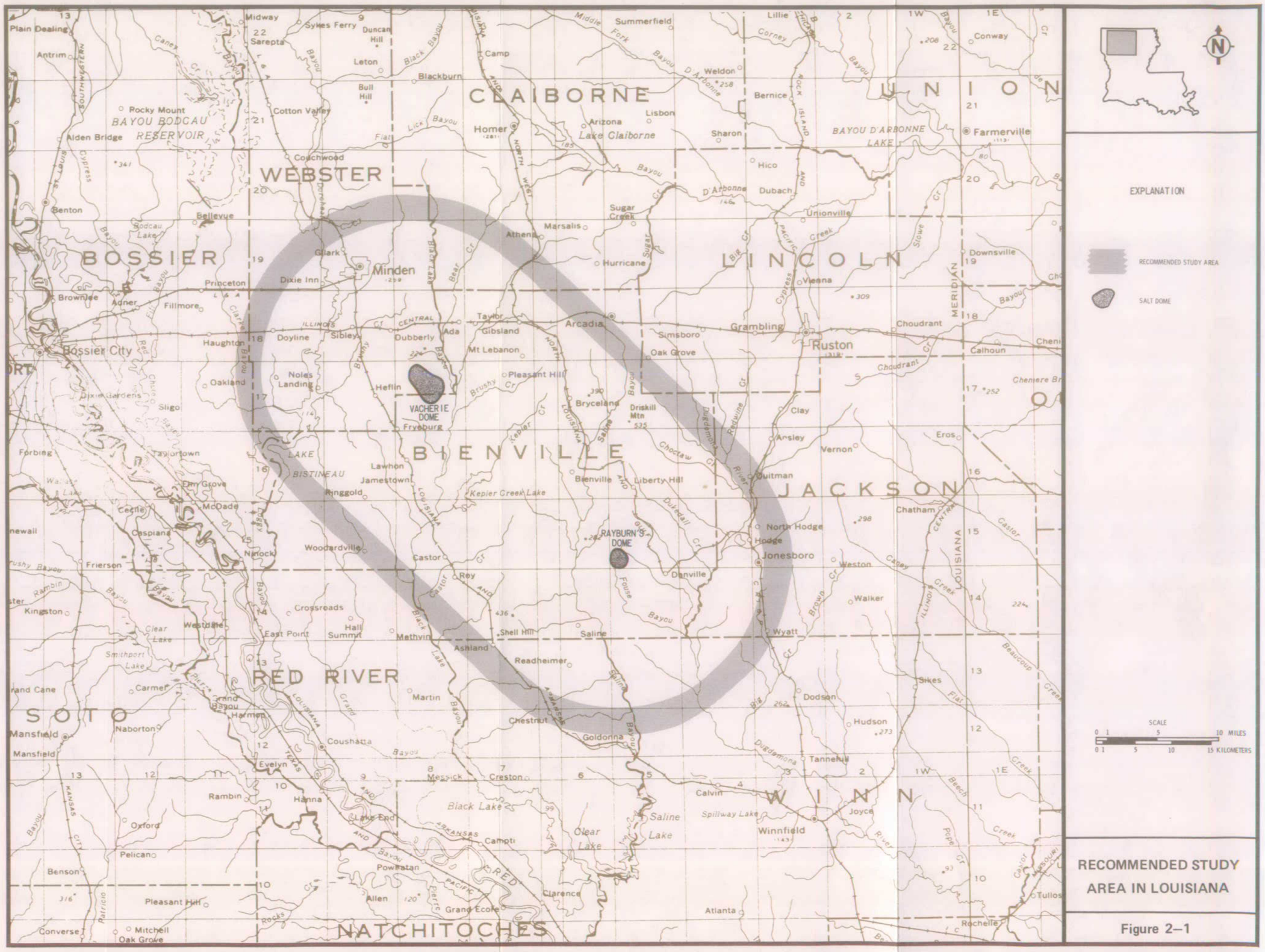
Published nongeological plans for the NWTS program (NUS, 1978) were designed primarily for bedded salt deposits which extend over continuous geographical areas of many thousands of square miles. The next step in the planned nongeological screening sequence would normally be to undertake studies of 2,600-square-km (1000-square-mile) areas (Area Characterization) within the regions in order to identify potentially suitable repository locations (48 square km or 30 square miles). The Gulf Interior Region is unique, however, in that the considered geologic host rock appears as salt domes that occupy only minor and discrete

portions of any 2,600-square-km (1000-square-mile) area. Consequently, for some technical disciplines the size of the areas to be studied during the Area Characterization step may conform more closely with the actual area of the salt domes. For some disciplines, an 80- to 260-square-km (30- to 100-square-mile) study area may suffice.

In the nongeological studies, emphasis will be placed on determining the relationships, if any, between the eight potentially acceptable domes and the locations of:

- Surface water and floodplains
- Urban areas
- Conflicting land uses
- Potentially interactive uses
- Transportation
- Sensitive wildlife habitats

The geological and ground water aspects of the Area Characterization will be conducted by the GPM, and nongeological aspects will be undertaken by the RPM. Near the conclusion of the RPM and GPM Area Characterization, ONWI will prepare a summary report that will recommend locations (domes) for detailed study during the Location Characterization phase of the NWTS program.



RECOMMENDED STUDY AREA IN LOUISIANA

Figure 2–1

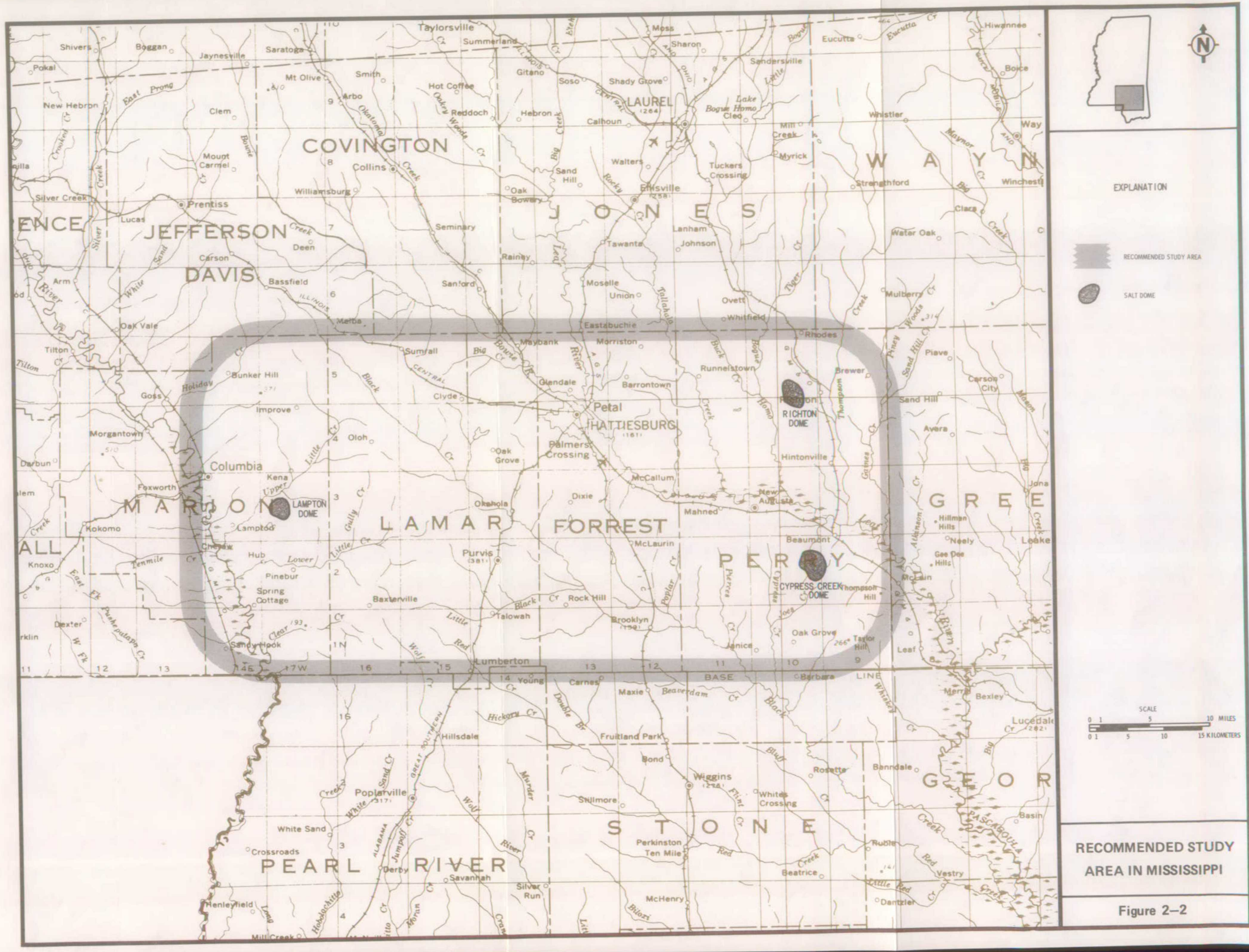
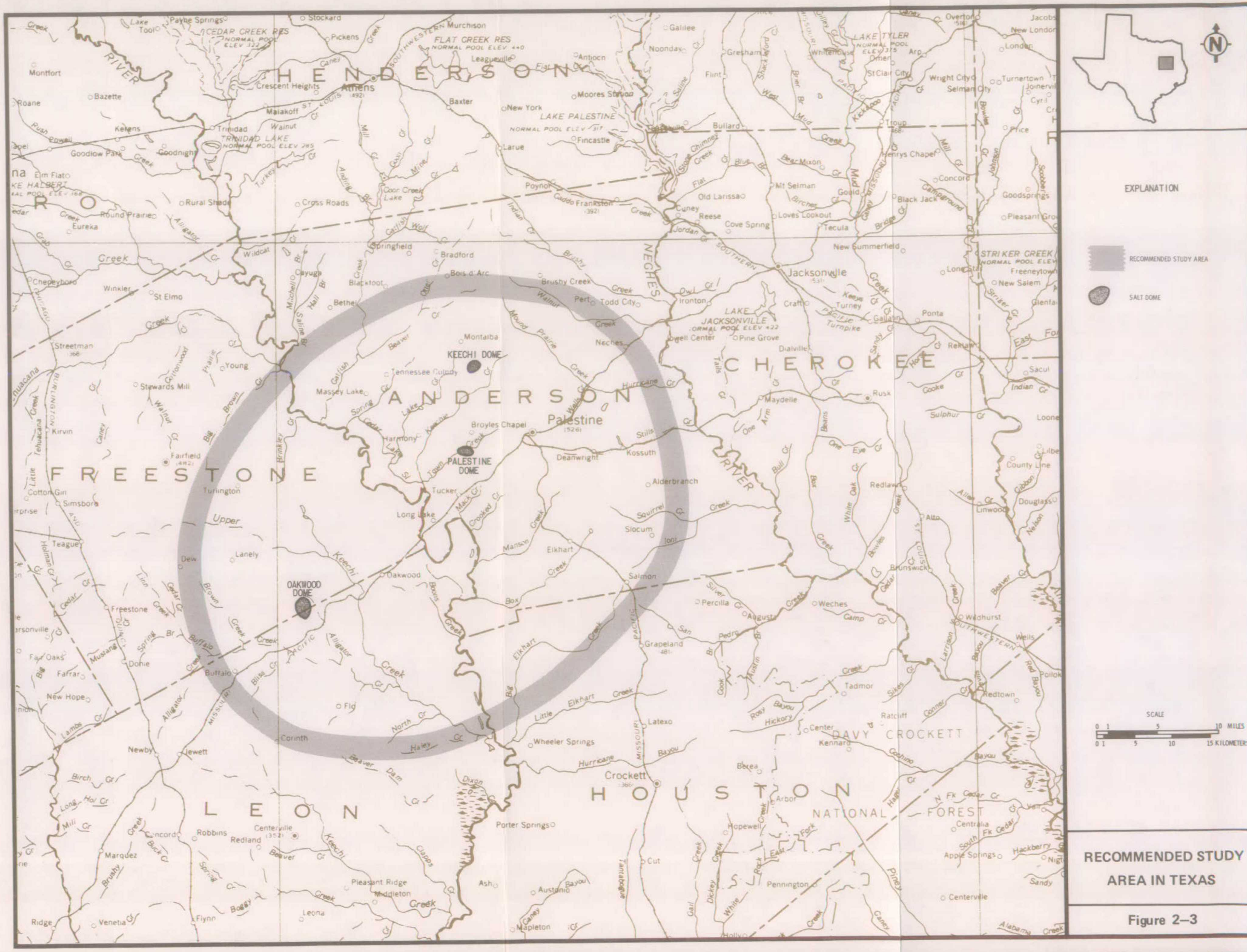

EXPLANATION
RECOMMENDED STUDY AREA
SALT DOME
SCALE
0 1 5 10 MILES
0 1 5 10 15 KILOMETERS
COVINGTON
JEFFERSON DAVIS
JONES
WAYNE
MARION
LAMAR
FORREST
PERRY
GREENE
STONE
PEARL RIVER
GEORGE
LAUREL
HATTIESBURG
Columbia
Prentiss
Collins
Mount Carmel
Seminary
Sandy Hook
Lumberton
Purvis
Petal
Richton
Baxterville
Hillsdale
Poplarville
Leaf
Lucedale
LAMPTON DOME
RICHTON DOME
CYPRESS CREEK DOME
BASE LINE
RECOMMENDED STUDY AREA IN MISSISSIPPI

Figure 2–2



RECOMMENDED STUDY AREA IN TEXAS

Figure 2–3

3.0 MAJOR STEPS IN THE SCREENING PROCESS

The major steps in the screening procedure that were used to identify potentially acceptable nuclear waste repository study areas in the Gulf Interior Region are described in the following paragraphs.

Rock salt was recommended by the National Academy of Sciences and other scientific sources as a base medium for a suitable isolation system for the long-term storage of nuclear wastes (Hess et al., 1957; National Academy of Sciences, 1970; and the American Physical Society, 1978). The endorsement of salt is due to a number of characteristics and properties (Anderson et al., 1973; Angina, 1977; Cohen, 1977; Marsily et al., 1977) including the following:

- Salt is abundant. Large areas of the continental United States are underlain by thick beds of fairly pure salt at reasonable depths.
- Salt is structurally strong. The compressive strength of rock salt approaches that of concrete.
- Salt has good radiation-shielding properties.
- Salt is relatively easy to mine.
- There are many existing, inactive, and abandoned salt mines present in the United States which are being used to study the conditions that will likely occur at candidate salt dome repositories. Existing salt mines are not being considered as nuclear waste repositories.
- Salt has good thermal properties. Its ability to transmit heat away from the waste is generally better than that of other rock types.
- Salt has a high inherent plasticity. This characteristic results in a tendency for fractures to "heal" by flowage and recrystallization; thus, impervious deposits tend to remain intact over long periods of time.
- Salt is considered to be very impermeable to water.
- The relatively old (100 million years) age of the salt domes is evidence that ground water flow has not significantly affected salt domes for that period of time.

The principal areas of the United States underlain by rock salt at a reasonable depth and thickness were designated as study regions. These study regions are:

- The Salina Basin bedded salt in Michigan, northeastern Ohio, western Pennsylvania, and western New York
- The Permian Basin bedded salt in western Kansas, Oklahoma, west Texas, and eastern New Mexico
- The Paradox Basin bedded salt in eastern Utah and western Colorado
- A large area of the Gulf Coastal Plain and the adjacent offshore area in Texas, Louisiana, and Mississippi that is underlain by more than 500 salt dome structures.

This report is concerned only with this last area, the Gulf Interior Region of the Gulf Coastal Plain, as defined by Anderson et al., 1973, in USGS 4339-2.

Within the Gulf Coastal Plain and adjacent offshore area in Texas, Louisiana, and Mississippi, there are more than 500 salt domes, with 263 known or suspected salt domes onshore. These onshore domes were evaluated by the USGS (Anderson et al., 1973) and 36 domes were identified as "potentially acceptable" (Table 3-1). The USGS screening criteria were based on a maximum depth to salt of less than 2,000 feet and a lack of previous use by industry (oil, gas, sulfur, etc.). The USGS concentrated on onshore salt domes 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).

Following this study by USGS, further studies were conducted by the Office of Waste Isolation (OWI). OWI, a Union Carbide Corporation, was the predecessor to ONWI at Battelle. OWI selected 125 domes in interior basins for further study. Additional research-oriented studies were conducted by Netherland, Sewell & Assoc. (1975, 1976), Ledbetter, Kaiser and Ripperger (1975), Martinez et al. (1975, 1976, 1977), Frederick F. Mellen (1976) and Kreitler et al. (1978). The studies by NSAI (1975) and Mellen (1976) provided important background data but made no attempt to recommend any domes for further study. Most of these studies are delineated in Table 3-1. In addition, USGS District Offices participated in the program. The results of these studies were subsequently used in the GIR regional characterization screening evaluation.

In the present study, only the 125 onshore salt domes within the interior salt basins were evaluated (Figure 1-1 and Table 5-1).

Criteria and screening specifications were developed. The generalized criteria serve as standards for preparation of the more detailed specifications used in the regional, area, and location studies to be implemented. The initial site identification screening criteria have been developed by the Union Carbide Office of Waste Isolation and published as

"Geological Criteria for Radioactive Waste Repositories" (Brunton and McClain, 1977), "Screening Specifications for Gulf Coast Salt Domes" (Brunton et al., 1978) and "Nongeologic Criteria for Radioactive Waste Repositories" (NUS, 1978).

Plans for the Regional Characterization Study were prepared and published as "Plans for Environmental Surveys of Salt Domes and Enclosing Formations and Overlying Areas of the Gulf Interior Basin" for Texas (NUS, 1978a), Louisiana (NUS,1978b), and Mississippi (NUS, 1978c).

Data were collected for the Regional Characterization Reports. Geological and hydrological data characterizing the GIR were compiled by the GPM from available information and previous studies. Nongeological data characterizing the GIR were compiled by the RPM from available information.

The Regional Screening Specifications (Brunton et al., 1978; NUS, 1978) were applied to the data collected for the Regional Characterization reports (Law Engineering Testing Co., 1978; ONWI-67) to identify study areas within the GIR for more detailed investigation. The procedure for selecting the study areas in the GIR is presented in Subsection 5.1.

A process similar to that described above will be used in the Area Characterization program for identifying locations to be recommended for further study (see Subsection 2.2).

TABLE 3-1.
Salt Domes Within the Gulf Interior Region Investigated and Identified for Further Study

	(USGS)* Anderson et al. 1973	NSAI 1975	NSAI 1976	(LSU-IES) Martinez, et al. 1975, 1976, 1977	(TBEG)** Kreitler et al. 1978
NORTHEAST & SOUTH TEXAS BASINS					
Bullard	X	O	X		O
Palestine	X	O	O		X
Brooks	X	O			O
Grand Saline	O				O
Steen	X	O	O		O
Butler					O
Whitehouse	X	O	X		O
Keechi	X	O	X		X
Palangana	O				
Mt. Sylvan	X	O	O		O
Gyp Hill	X				
East Tyler	O				O
Oakwood	O				X
Hainesville	O				O
Piedras Pintas	O				
Bethel	O				O
Boggy Creek	O				O
Day	O				O
Brushy Creek	O				O
Kittrell	O				O
LaRue	O				O
Concord	O				O
Moca	O				
Dilworth Ranch	O				
Elkhart	O				O
Pescadito	O				
TEXAS COASTAL BASIN					
Davis Hill	X				
Gulf	X				
Hawkinsville	X				
Hockley	X				
Hoskins Mound	X				
Long Point	X				
NORTH LOUISIANA BASIN					
Rayburns	X	O		X	
Kings	X	O		O	
Winnfield	X	O		O	
Cedar Creek	X	O		O	
Vacherie	X	O		X	
Drakes	O			O	
Gibsland	O			O	
Protho	X	O		X	
Prices	X	O		O	
Arcadia	O			O	
Minden	O			O	
Bistineau	O			O	
Coochie Brake	O			O	
Chestnut	O			O	
Milam	O			O	
Chester	O			O	
Sikes	O			O	
Packton	O			O	
Castor Creek	X	O		O	
			Mellen 1976		
MISSISSIPPI BASIN					
McIntosh	O				
Richton	O		O		
Crowville	X				
Tatum	X	O	O		
Lampton	X	O	O		
Petal	O		O		
Gilbert	X				
Hazelhurst	X	O	O		
Arm	X	O	O		
McLaurin	X	O	O		
Richmond	X	O	O		
Bruinsburg	X		O		

O = Domes studied
X = Domes identified for further study

* 263 domes were studied, all of which are not shown
** 26 domes were studied, all of which are not shown

TABLE 3-1. (Cont'd)

MISSISSIPPI BASIN (Cont'd)

	USGS* 1973	NSAI 1975	Mellen 1976
Byrd	X	O	O
Leedo	X	O	O
Raleigh	O		O
McBride	O		O
County Line	X	O	O
Moselle	O		O
Sardis Church	X	O	O
Dont	O		O
Dry Creek	O		O
Centerville	O		O
D'Lo	O		O
Eminence	O		O
Midway	O		O
New Home	O		O
Oakley	O		O
Oakvale	O		O
Ruth	O		O
Walnut Bayou	O		
Monticello	O		O
Allen	O		O
Prentiss	O		O
Carmichael	O		O
Bothwell	O		O
South Tallulah	O		
Edwards	O		O
Caseyville	O		O
Kola	O		O
Carson	O		O
Utica	O		O
Coleman	O		
Hervey	O		O
Wesson	O		O
Kings	O		O
Halifax	O		O
Glass	O		O
Ashwood (Somerset)	O		
Newellton	O		
Singer	O		
Vicksburg	O		O
Eagle Bend	O		O
Galloway	O		O
Learned	O		O
North Tallulah	O		
Brownsville	O		O
Oakridge	O		
Newman	O		
Duck Port	O		
Sunrise	O		
Snake Bayou	O		
Foules	O		
Glazier	O		
Heidleberg	O		
Gwinville	O		
South Carolton	O		
Burns	O		
Yellow Creek	O		
Eucutta	O		
Laurel	O		
Valley Park	O		
Rufus	O		
Ovette	O		
Hiwanee	O		
Baxterville	O		
Ellisville	O		
Grange	O		O
Cypress Creek (New Augusta)	X		
Hubbard	O		O
Zion Hill Church	O		O

O = Domes studied
X = Domes identified for further study

* 263 domes were studied, all of which are not shown
** 26 domes were studied, all of which are not shown

4.0 REGIONAL SUMMARY

4.1 PHYSICAL ENVIRONMENT

In this section, the geosphere, hydrosphere, atmosphere and background radiation are summarized from the regional reports (Law Engineering Testing Co., 1978; BNI, 1979).

4.1.1 Geosphere

4.1.1.1 Physiography

The Gulf Coastal Plain is the emergent portion of the Gulf Basin. This physiographic province is 320 to 960 km (200 to 600 miles) wide along the northern periphery of the Gulf of Mexico. It extends from the Gulf inland to the inner margin of the preserved Mesozoic and Cenozoic sediments, including its farthest inland position, the Mississippi embayment region. From Georgia to northeastern Texas these sediments lap on older Paleozoic rocks of the Appalachian provinces, the interior low plateaus, and the Ouachita Province. Where lower Cretaceous strata extend westward beyond the coastal plain, as in central Texas, the Balcones fault trend is designated as its inner boundary.

Elevations average several hundred feet above sea level, and drainage generally extends gulfward within the province. The Mississippi River is the largest trunk stream with an alluvial valley 40 to 200 km (25 to 125 miles) wide. It extends southward to the Gulf down the axis of the Mississippi embayment. This lowland effectively separates the higher topography east and west of the valley into the eastern and western hills. Tributary streams of the Mississippi form broad shallow valleys. Trunk streams flow southward directly to the Gulf both east and west of the Mississippi drainage basin.

Present physiography is primarily a product of Quaternary incisement (erosion) associated with continental emergence. The Citronelle-Willis terraces probably represent an extensive alluvial plain formed in pre-Pleistocene time. The existing stream patterns were established by the incisement caused by sea level fall associated with the Nebraskan glacial cycle. Successive sea level fluctuations have caused deepening and widening of these valleys and the removal of the Citronelle-Willis terrace in inland areas. The younger coastal terraces occur gulfward from the Citronelle-Willis belt and extend inland as fluviatile terraces adjacent to the present stream valleys. Recent deposits are found in floodplains and modern deltas.

4.1.1.2 Major Geologic Events

The Gulf Basin was initiated in the Late Triassic by block faulting and rifting of the continental crust accompanied by basic igneous activity. The faults that formed the northern boundary of the basin developed along the south and east flanks

of the Late Paleozoic Ouachita orogenic belt. Along the basin boundaries, subregional crustal blocks similarly developed. This tectonic episode is attributed by various authors to initial rifting of the continental crust which, elsewhere, produced the Atlantic Ocean by sea-floor spreading. An alternative view ascribes the activity to development of an underlying thermal anomaly (Kehle, 1978).

In the northern Gulf Coastal Plain, as well as throughout the Gulf Basin, the establishment of subregional crustal blocks of varying thickness provided a structural pattern which influenced subsequent geologic history. Areas of thicker and thinner crust generated relatively different rates of subsidence and/or uplift. During the Late Triassic episode uplifts were eroded, supplying thick red-bed sediments to the adjacent basins. When regional subsidence ensued, this contrasting behavior was reflected in the creation of varying sedimentary deposit thicknesses. Differential subsidence was pronounced during Early Jurassic sedimentation when the Louann Salt formation was deposited, resulting in isolated basins of thick salt beneath the northern Gulf Coastal Plain. These include the three interior salt basins of interest as well as the coastal salt basin of coastal Louisiana and southeastern Texas and the south Texas salt basin. Intervening elevated areas such as the prominent Sabine uplift,, the Monroe-Sharkey uplift and the Hancock Ridge contain no salt domes because salt deposition on the uplift was either thin or did not occur.

Regional sedimentation occurred continuously between the Late Jurassic and the Middle Cretaceous. This pattern was interrupted in the Middle Cretaceous by general emergence during which the Sabine uplift was differentially eroded. Contemporaneous igneous activity occurred into the Late Cretaceous, forming the Jackson Dome and producing numerous igneous occurrences in the Monroe-Sharkey area and along the Balcones escarpment. Resumption of marine sedimentation in the Late Cretaceous extended beyond the original Gulf Basin, including the entire Mississippi embayment. The Laramide Mountain building episode in western North America affected only the southwestern margin of the Gulf Basin. Continental emergence recurred in the Cenozoic Period and extended progressively gulfward in association with geosynclinal sedimentation.

4.1.1.3 Stratigraphy

Depositional cycles in the northern Gulf Coastal Plain during periods of inundation are characterized by limestone, clastics, or occasional evaporites alternating with gulfward extension of deltas associated with periods of erosion in the lands to the north. These cyclic patterns have sufficient geographic extent for the resultant stratigraphic units to be correlated throughout the area, as depicted on the stratigraphic chart (Table 4-1).

EXPLANATION

UNCONFORMITY

TABLE 4-1

NORTHERN GULF COAST STRATIGRAPHIC COLUMN

SYSTEM	SERIES	GROUP	SUB GROUP	EAST TEXAS BASIN FORMATION	NORTH LOUISIANA BASIN FORMATION	MISSISSIPPI BASIN FORMATION	AGE IN MILLION YEARS BEFORE PRESENT
QUATERNARY	RECENT			RECENT	RECENT	RECENT	11,000
	PLEISTOCENE			BEAUMONT	COASTWISE PRAIRIE/ PORT HICKEY	PAMLICO/ COASTWISE PRAIRIE	SANGAMON 60-100,000
				LISSIE WILLIS	TERRACE SURFACES EXIST BUT BASINWIDE CORRELATION IS NOT OBVIOUS		
	PLIO-PLEISTOCENE			GOLIAD	CITRONELLE (PRE-GLACIAL)	CITRONELLE (PRE-GLACIAL)	1.8
	PLIO-MIOCENE					PASCAGOULA	
	MIOCENE	GRAND GULF		FLEMING CATAHOULA	MISSING IN SECTION	HATTIESBURG CATAHOULA	5.5
				MISSING IN SECTION	MISSING IN SECTION	PAYNES HAMMOCK CHICKASAWHAY BUCATUNNA BYRAM GLENDON MARIANNA MINT SPRING	22.5
	OLIGOCENE	VICKSBURG				FOREST HILL/ RED BLUFF	36
TERTIARY	EOCENE	JACKSON		WHITSETT MANNING WELLBORN CADDELL MOODYS BRANCH	DANVILLE YAZOO MOODYS BRANCH	YAZOO MOODYS BRANCH	42
		CLAIBORNE		YEGUA COOK MTN. STONE CITY SPARTA	COCKFIELD COOK MTN. SPARTA	COCKFIELD COOK MTN. KOSCIUSKO (SPARTA)	44.5 48
				THERRILL WECHES	CANE RIVER (POSSIBLY WITH	ZILPHA WINONA	
				QUEEN CITY REKLAW	QUEEN CITY, REKLAW, AND	TALLAHATTA	
				CARRIZO	CARRIZO EQUIV. AT ITS BASE)	MERIDIAN	50
				SABINETOWN CALVERT BLUFF SIMSBORO	SABINETOWN PENDLETON	WILCOX UNDIFFERENTIATED	
		WILCOX		HOOPER SEGUIN	MARTHAVILLE HALL SUMMIT LOGANSPORT NABORTON	NAHEOLA	53.5
	PALEOCENE			WILLS POINT KINCAID	PORTERS CREEK CLAYTON	PORTERS CREEK CLAYTON	58
		MIDWAY		KEMP NACATOCH NEYLANDVILLE MARLBROOK PECAN GAP WOLFE CITY OZAN	ARKADELPHIA NACATOCH SARATOGA MARLBROOK ANNONA OZAN	PRAIRIE BLUFF	65
CRETACEOUS	GULFIAN	NAVARRO (Selma in Mississippi)				RIPLEY DEMOPOLIS CHALK	66 71 76
		TAYLOR (Selma in Mississippi)				COFFEE	79
		AUSTIN (Selma in Mississippi)		GOBER BROWNSTOWN BLOSSOM BONHAM	BROWNSTOWN TOKIO– (INCLUDES BLOSSOM)	ARCOLA MOOREVILLE CHALK	81
				ECTOR	RAPIDES–ECTOR		
		EAGLE FORD (Eutaw in Mississippi)		EAGLE FORD UNDIFFERENTIATED	EAGLE FORD UNDIFFERENTIATED	EUTAW	92
		WOODBINE (Tuscaloosa in Mississippi)		WOODBINE UNDIFFERENTIATED	TUSCALOOSA (LEWISVILLE)	UPPER T. MIDDLE T. LOWER T.	100
		WASHITA		SOUTH TYLER MANESS BUDA GRAYSON MAIN STREET	WASHITA-FREDERICKS-BURG UNDIFFERENTIATED	DANTZLER WASHITA-FREDERICKS-BURG UNDIFFERENTIATED	
	COMANCHEAN		GEORGE-TOWN	WENO-PAWPAW DENTON FORT WORTH DUCK CREEK	(LOCALLY ABSENT)		
		FREDERICKS-BURG		KIAMICHI GOODLAND-COMANCHE PEAK WALNUT			104
		TRINITY	GLEN ROSE	PALUXY RUSK	PALUXY RUSK-MOORINGS PORT	PALUXY MOORINGS PORT	105 106
				FERRY LAKE RODESSA JAMES PINE ISLAND SLIGO (PETTET) HOSSTON	FERRY LAKE RODESSA JAMES PINE ISLAND SLIGO HOSSTON	FERRY LAKE RODESSA PINE ISLAND SLIGO HOSSTON	107 109 113
	COAHUILAN	NUEVO LEON (AND DURANGO)					135
JURASSIC	UPPER	COTTON VALLEY		SCHULER BOSSIER HAYNESVILLE	SCHULER BOSSIER HAYNESVILLE-BUCKNER	DORCHEAT SHONGALOO HAYNESVILLE-BUCKNER	139 143
	MIDDLE-LOWER	LOUARK		SMACKOVER	SMACKOVER	SMACKOVER	
				NORPHLET	NORPHLET	NORPHLET	
		LOUANN		LOUANN SALT WERNER EAGLE MILLS	LOUANN SALT WERNER EAGLE MILLS	LOUANN SALT WERNER EAGLE MILLS	
	LOWER OR PRE-JURASSIC						

Table 4—1

NORTHERN GULF COAST STRATIGRAPHIC COLUMN

4.1.1.4 Structure

The structural geology of the GIR is shown in Figure 4-1. The regional dip of the sediments averages one degree to the south; however, uplifts, faults, and salt domes interrupt this pattern. Southwestern dips occur on the eastern side of the Mississippi embayment and southeastern dips occur on the western side, so that surface outcrops extend far inland within the embayment.

The most pronounced structural movement within the basins occurred in the Louann Salt. This movement is due to the weight of the overlying sediments and the differential density between the salt and adjacent geological units. Movement of the salt began as early as the deposition of the Late Jurassic-Smackover Sediments. The salt first formed ridges and eventually developed diapiric domes as additional sedimentation occurred where the salt was sufficiently thick. Salt movement and diapirism in the interior salt basins reached its peak during the Mesozoic, occurring at an ever decreasing rate in the Tertiary. In the coastal salt basin, this peak was reached in the Late Tertiary and is considered to be continuing today. The timing was controlled by the gradual gulfward migration of the areas of maximum deposition.

4.1.1.5 Seismology

The GIR is a region of low seismicity (Figure 4-2). The seismic implications to siting a repository for long-term waste isolation in the Gulf Interior Region may be summarized as follows:

- The low level of historical earthquake activity, when considered alone, indicates either a low level of current tectonic activity, or tectonism associated principally with aseismic release of strain.

- There is no clear correlation between the geologic structures and the regional earthquake activity. The GPM is delineating seismotectonic provinces to facilitate the estimation of the seismic risk.

- Future vibratory ground motion levels from local and distant earthquakes are expected to be low.

4.1.1.6 Interior Salt Basins

The Northeast Texas, North Louisiana, and Mississippi basins represent subprovinces of the north Gulf Coastal Plain described above. Of these, the Northeast Texas and North Louisiana basins are smaller and, due to the Sabine uplift separating them, have more exact boundaries than the Mississippi Basin. The La Salle arch, a southern projection of the Monroe-Sharkey uplift, narrowly separates the North Louisiana Basin from the Mississippi Basin, which has more domes, and is located farther gulfward than the other two basins. The youngest Tertiary sediments in the Texas and Louisiana basins are Eocene and the Pleistocene Willis-

Citronelle formation which has been removed by erosion. In Mississippi, Tertiary sediments through the Plio-Miocene are present, and the Citronelle is widely preserved. The youngest Tertiary sediments in the Texas and Louisiana basins are of Eocene age. The only younger formations are the Pleistocene stream terraces and recent floodplain deposits. In Mississippi, Tertiary sediments through the Plio-Miocene are present, and the Citronelle is widely preserved. In addition, Pleistocene Terrace and recent floodplains also occur. Consequently, the major upward Tertiary unconformity of the Texas and Louisiana basins is represented by sedimentary formations in the Mississippi basin.

The east Texas embayment is a crustal depression which occupies about 39,000 square km (15,000 square miles) of northeast Texas. It is defined by the Mexia-Talco fault zone on the west and north, the Sabine uplift on the east, and the Mount Enterprise fault zone on the south.

The Northeast Texas Basin occupies the central portion of the east Texas embayment where the greatest thickening of Mesozoic and Cenozoic sediments occur. It is about 240 km (150 miles) long and 145 km (90 miles) wide. Within the Northeast Texas Basin, salt movement has produced at least 20 salt domes. An additional salt basin containing six salt domes occurs in south Texas.

The North Louisiana Basin is roughly rectangular, approximately 160 km (100 miles) long and 48 to 80 km (30 to 50 miles) wide. The basin covers an area of approximately 10,400 square km (4,000 square miles). It is bordered on the southwest side by the Sabine uplift, on the northeast by the Monroe arch, and on the north by the Rodessa fault zone. On the south, it opens into the southward-dipping Angelina-Caldwell Flexure. There are 20 known salt domes in the North Louisiana Basin.

The Mississippi Basin is approximately 400 km (250 miles) long by 100 km (60 miles) wide. It extends from northeastern Louisiana, east-southeasterly across southern Mississippi, into southwestern Alabama. The Mississippi Basin is bounded on the south by the Hancock ridge, on the north and east by the Pickens-Quitman-Gilbertown-Pollard fault zone, and on the west by the Monroe uplift. There are 80 salt domes in this basin.

4.1.2 Hydrosphere

4.1.2.1 Surface Waters

The land area of the 48 contiguous states of the United States has been divided into 18 water resource regions (U.S. Water Resource Council, 1958). Four of these water resource regions intersect the Gulf Interior Region, namely: Texas Gulf Region, Arkansas-White-Red Region, Lower Mississippi Region, and South Atlantic-Gulf Region.

The surface water resources of the GIR can be best summarized by briefly reviewing the surface water characteristics of the applicable portions of each of the four water resource regions (Figure 4-3). The various surface water parameters, including precipitation, runoff, and discharge, are tabulated in Table 4-2. These parameters, as well as flood history, surface water quality, and availability and demand may vary significantly among and within water resource regions.

The Texas Gulf Region consists of ten separate river basins. Three of these (Trinity, Neches, and Sabine rivers) flow through the northeast Texas portion of the GIR. The headwaters of the Trinity River Basin are in Montague, Cook, Grayson, and Fannin counties, Texas. The headwaters of the Neches River Basin rise in Van Zandt and Smith counties, Texas; however, the exit from the GIR is upstream of the confluence of the Neches and the Angelina rivers. The headwaters of the Sabine River basin rise in Fannin County, Texas.

Total dissolved solids concentrations in the Texas Gulf Region vary from less than 100 mg/l to over 2500 mg/l. Approximately one-half of the Texas Gulf Region's water needs are met from surface water sources, and surface water use is expected to triple by 2020. Although the regional supply of surface water is expected to meet that demand, unequal geographic distribution of surface water supply and demand may pose problems.

The Red River is the principal river of the Arkansas-White-Red Region that flows through the GIR. The headwaters of the Red River rise in eastern New Mexico and thus its drainage area at its exit from the GIR consists of portions of Texas, Oklahoma, Arkansas, and Louisiana. Most of this drainage area is outside of the GIR with only a minute portion of the Northeast Texas Basin and about half of the Northern Louisiana Basin being part of the Red River watershed.

Eastern lowlands of the Arkansas-White-Red Region are subject to severe rainstorms and recurrent flash flooding. Flood control problems have been reduced by construction of numerous reservoirs along the Red River. Surface water quality in several major waterways of the Arkansas-White-Red Region is poor due to widespread natural and man-induced pollution, including natural mineralization, mine discharges, erosion, and municipal and industrial effluents. The availability and use of many Arkansas-White-Red Region surface waters for agriculture, municipal, industrial, and recreational uses are severely limited by the low quantities and qualities of surface waters in some parts of the Arkansas-White-Red Region. In general, most water supplies are derived from surface storage in the eastern portions of the Red River Basin.

The Mississippi River obviously is the principal river of the Lower Mississippi Region. The drainage basin of the Mississippi River at New Orleans, Louisiana, consists of 41 percent of the land area of the 48 contiguous states. The mean annual

TABLE 4-2

Surface Water Parameters for Selected Rivers Within the GIR

River	Drainage Area[1] (mi^2)	Precip. Mean Ann. (in.)	Runoff Mean Ann. (in.)	Discharge[2] Max.[3]	Discharge[2] Min. (cfs)	Discharge[2] Mean Ann.
Texas Gulf Region						
Trinity	14,000	40	6.0	78,000	275	6,200
Neches	2,000	44	7.1	50,000	0.1	1,300/1,000*
Angelina	1,000	47	8.4	30,600	2.0	790
Sabine	3,000	43	9.8	138,000	5.6	2,000/1,800*
Arkansas White-Red Region						
Red	65,000	12 to 60	6.4			
Tributaries attached within GIR		50 to 60	14 to 20			
South Atlantic-Gulf Region						
Pearl	6,000	53	15.0	99,000	1,020	9,000
Leaf[4]	4,000	57	20.3	128,000	478	5,200
Chickasawhay[4]	3,000	58	18.7	73,600	160	3,700
Lower Mississippi Region						
Mississippi (at Vicksburg)	1,122,160		14-20	844,000	272	553,000

1. At the exit from the GIR.
2. These values are derived from the *Water Resources Data* publications and were obtained at the nearest USGS station for the given rivers exiting the GIR; therefore, the drainage areas are not exactly the same as listed in Column 2.
3. Observed/estimated from high-water marks.
4. Tributaries to Pascagoula River

* Regulated by upstream dams

precipitation of the Lower Mississippi Region within the GIR is about 55 inches and the mean annual runoff for this same area is about 16 inches.

The South Atlantic-Gulf Region consists of 24 separate river systems of which three flow through the Mississippi Basin of the GIR, namely: Pearl, Pascagoula, and Mobile rivers. However, none of the salt domes currently (January, 1979) being considered as a possible repository site are in the Mobile River Basin. The headwaters of the Pearl River rise in Winston, Neshoba, and Kemper counties, Mississippi. The Pascagoula River starts at the confluence of the Leaf River and the Chickasawhay River. This also is its exit point from the GIR. The Leaf River system consists of a number of fair-sized tributaries that rise in Pearl River, Lamar, Jefferson Davis, Smith Scott, Newton, and Jasper counties, Mississippi. The headwaters of the Chickasawhay River rise in Neshoba and Kemper counties, Mississippi.

Widespread, disastrous flooding is uncommon in the South Atlantic-Gulf Region, although an estimated (in 1968) additional 3.3 million acres of land will require flood protection by 1980. Seasonal flood potential is highest from December to April and from August to October. Areas most prone to flooding include the floodplains of major rivers and coastal areas. Numerous watershed/flood control projects have been constructed throughout the South-Atlantic Gulf Region.

Natural surface water quality is generally excellent in the South Atlantic-Gulf Region, with dissolved solids concentrations averaging less than 100 mg/l. In some coastal plain streams, high turbidity and high sediment loads are not uncommon. In some localized areas, municipal, industrial and agricultural sources of pollution have caused restricted use of surface waters and an increased reliance on upstream reservoir storage and ground water for municipal water supplies. Because of abundant surface and ground water supplies within the South Atlantic-Gulf Region, no current or projected water shortages are expected.

4.1.2.2 Ground Water

Potable quality ground water is present throughout the Gulf Interior Region, and it is used extensively for domestic, municipal, and industrial purposes. Several aquifers (hydrologic units) are recognized in the post-Cretaceous coastal plain sediments. They comprise a thick sequence of interbedded sands, which form confined aquifers between less permeable clay and marl beds. Important aquifers in the region include the Wilcox-Carrizo units, the Sparta (Kosciuko) Formation, the Queen City sand, the Cockfield (Yegua) Formation, Miocene sands, and Pleistocene to Recent alluvial valley deposits.

In the Northeast Texas Basin, the most important aquifer for current water supply is the Queen City sand. Fresh water can also be found in two lower aquifers, the Carrizo and Wilcox formations. The base of the Wilcox (top of the Midway) is the

approximate base of fresh water in the northern portion of the basin (Wood County). However, some saline waters have been found at the lower portions of the Wilcox, particularly in the southern portion of the basin.

In the North Louisiana Basin, the most important aquifer for current water supply is Sparta sands. However, fresh water can also be found within the Wilcox Group.

In the Mississippi Basin, the most important aquifer for current water supply is the Miocene sand. Fresh water can also be found in Forest Hill, Cockfield, and upper portions of the Sparta formations. Saline waters have been found in some Sparta sands.

In general, the base of fresh water is between -500 to -2000 ft (MSL) throughout the GIR. All aquifers below the Midway aquiclude are saline throughout the GIR.

The water-bearing formations receive recharge in their outcrop areas from precipitation and in some cases from stream flow. In general, the recharge moves down the dips of the formations. Under natural conditions (prior to pumping), some water in lower aquifers will seep upward through confining beds, eventually to be discharged at the sand surface as base flow and/or evapotranspiration. However, numerous exceptions exist, i.e., data are available that show the upper aquifers having a higher potentiometric surface than a lower aquifer. The Midway is considered to be a true aquiclude due to its thickness (500 to 1500 ft) and very low permeability. Other formations that have low permeabilities include Cook Mountain throughout the entire GIR*, the Reklaw in northeast Texas, Cane River in north Louisiana, and Yazoo, Zilpha, and Tallahatta in Mississippi. Whether the clays in these formations are definitely acquicludes has not yet been determined. There are indications that some leakage exists through these formations; therefore, until further data are obtained, these formations will be classified as aquitards. Rates of water movement in the formations, where affected by pumping wells, range from infinitesimally slow to as much as several hundred feet per year.

Due to the abundance of available ground water, practically all water wells in the region tap only the uppermost aquifer at a given location. In general, the ground water throughout the region is suitable for most purposes with little or no treatment required. Exceptions exist on a very local basis where too much iron, or undesirable amounts of hydrogen sulfides may be present. Throughout most of the region, sufficient ground water is available for present needs and foreseeable future development. However, there are a number of cases, generally in populated areas, in which a sizeable cone of depression exists. In a very few cases there are indications that the water levels are presently declining.

* A few local Cook Mountain sands have been pumped in Texas.

4.1.3 Atmosphere

The Gulf Interior Region lies within a humid temperate zone with moderately high temperatures and moderate amounts of rainfall throughout the year. These conditions indicate a relatively low potential for wind erosion. Although this area has experienced significant temperature decreases (5-16°C or 9-28.8°F) within the recent geologic past, indications of glaciation within that period are absent. In fact, the previous glacial boundary appears to be more than 700 km (435 mi) north of this region.

Severe weather occurrences within the GIR generally include high winds and the precipitation associated with hurricanes which intrude inland from the Gulf of Mexico. The 100-year recurrence intervals for these two meteorological phenomena are 28 cm (11 in.) of precipitation within a 24-hour period and winds of 40 m/s (90 mph). Another severe weather phenomenon experienced within this region is the occasional tornado (ranging from six in a twelve-year period on the Louisiana-Mississippi border to 43 or more in portions of northeast Texas during the same period).

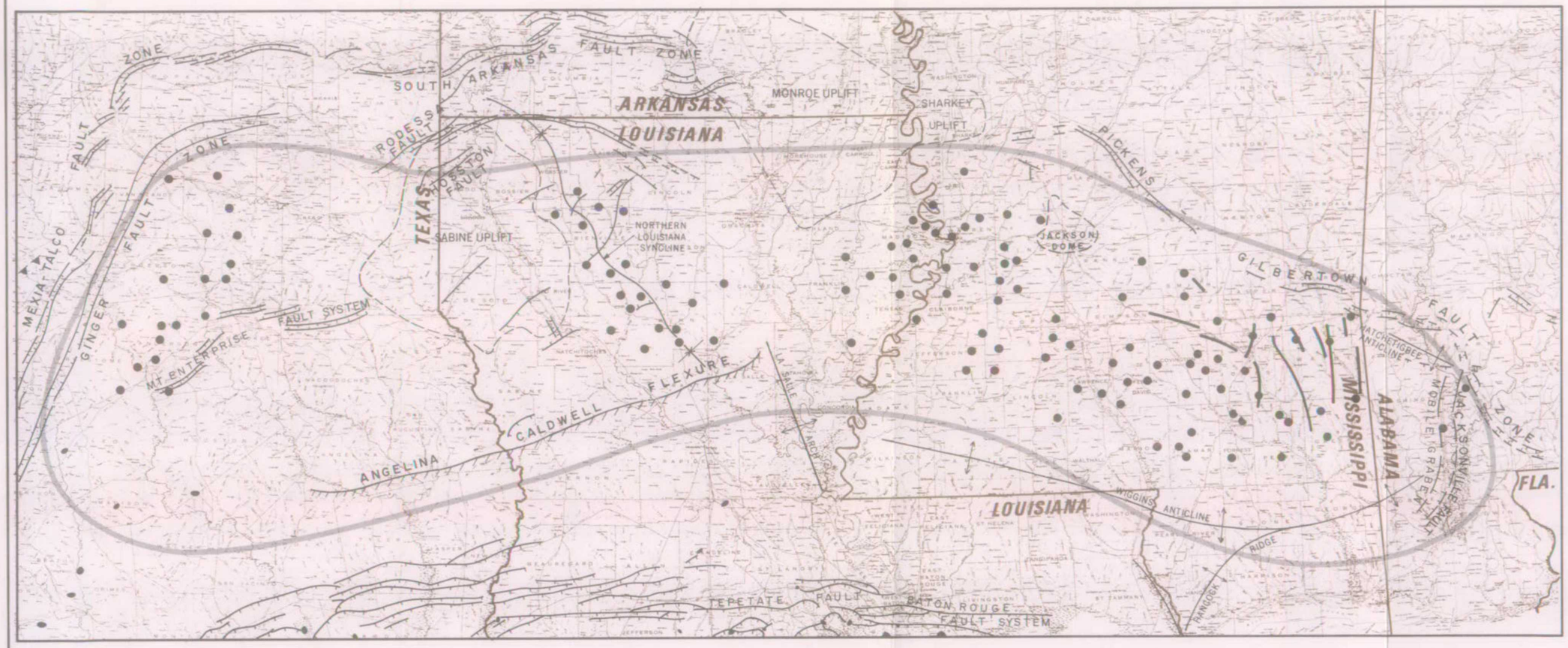
Generally, moderate mixing levels together with moderate wind speeds and rolling topography make the GIR unlikely to experience poor dispersion conditions that would cause air quality problems. Stations within and near this region have reported 13 to 28 episodes (long duration periods of poor dispersion conditions) corresponding to 32 to 71 episode-days within a five-year period.

This region, like most of the country, experiences periods during which National Ambient Air Quality Standards (NAAQS) for particulates are exceeded. There are also a number of areas within this region that have been designated by the EPA as areas of concern for the control of photochemical oxidants. In most cases these areas, consisting of large metropolitan sites and their immediate surroundings, are presently exceeding NAAQS for this pollutant.

Relative to Prevention of Significant Deterioration, the region lies within a Class II area, which allows for moderate industrial development. The nearest presently defined Class I areas are more than 100 miles away.

4.1.4 Background Radiation

Data for approximately 38 locations in the Gulf Interior Region and surrounding territory indicate that the region is about average in natural terrestrial and cosmic background radiation. The highest reported background radiation values are in Texas, but regional variations appear to be insignificant.



EXPLANATION

GULF INTERIOR REGION

Normal fault; hachures show direction of dip of fault plane

Flexure; dips are steeper on hachure side

Uplift boundary (Locations approximate)

Anticline

Syncline

Salt diapir-Approximate size of salt mass.

Salt diapir-Size of salt plug unknown

Salt anticline-Faulted anticline with deep seated salt core.

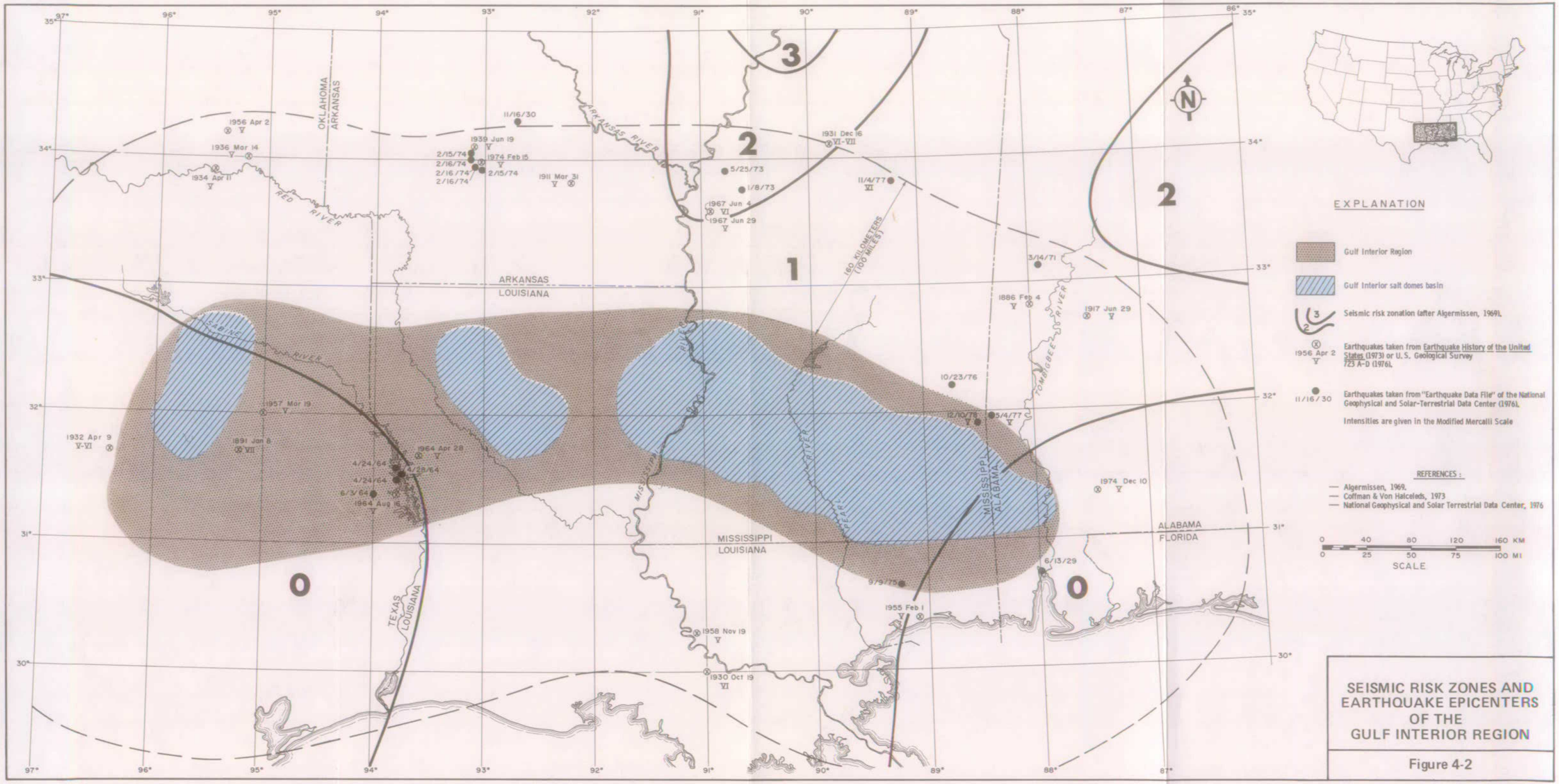
REFERENCE:

Tectonic Map of Gulf Coast Region, AAPG, 1972

Tectonic Map of the United States, USGS, 1962

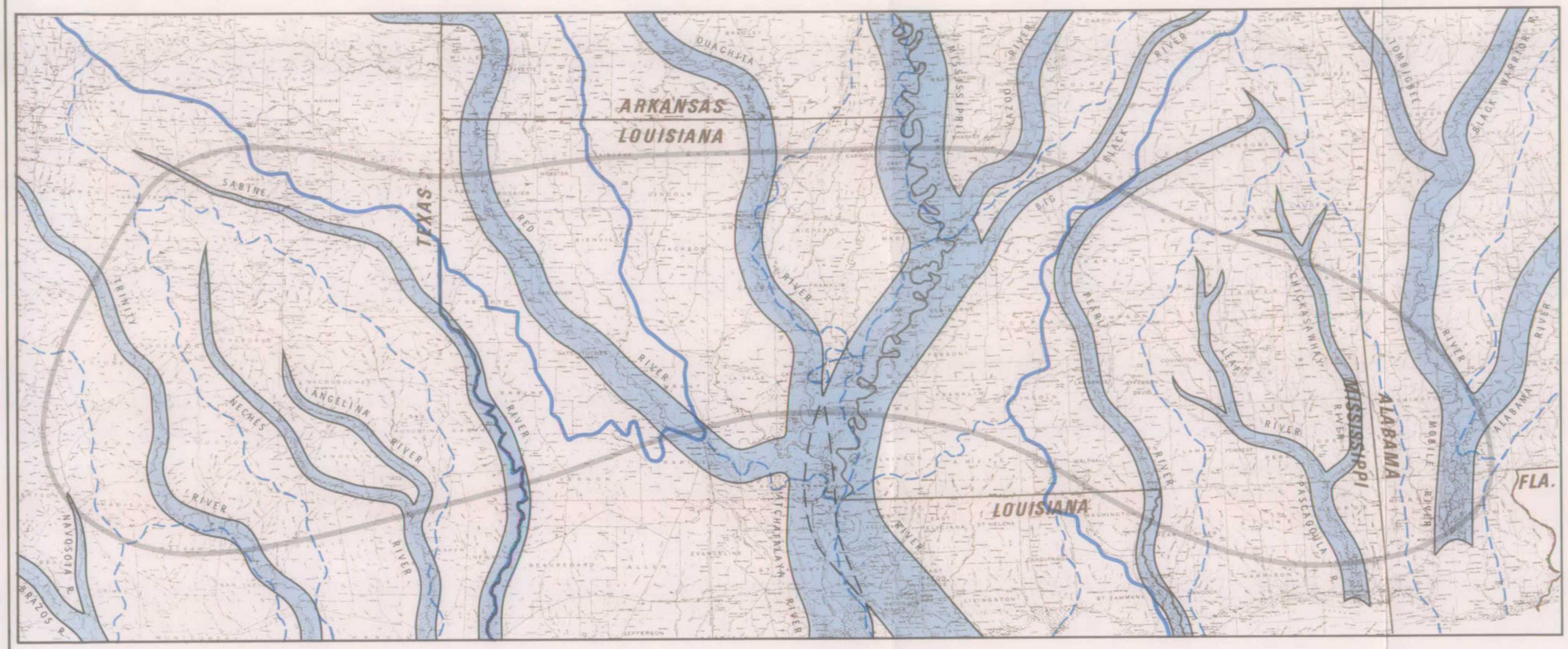
STRUCTURAL GEOLOGY OF THE GULF INTERIOR REGION

Figure 4-1



SEISMIC RISK ZONES AND EARTHQUAKE EPICENTERS OF THE GULF INTERIOR REGION

Figure 4-2



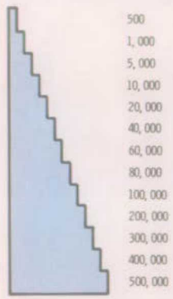
EXPLANATION

GULF INTERIOR REGION

WATER RESOURCE REGION BOUNDARY

WATER RES. SUBREGION BOUNDARY

WIDTH OF RIVER INDICATES AVERAGE DISCHARGE, IN CUBIC FEET PER SECOND



REFERENCE: U.S. Geological Survey, 1968 a, 1968 b, 1969, 1972.

0 20 40 60 80 KM
0 10 20 30 40 50 MI
SCALE

MEAN DISCHARGE FOR THE MAJOR RIVERS IN THE GULF INTERIOR REGION

Figure 4-3

4.2 DEMOGRAPHY, SOCIOECONOMICS, AND LAND USE

In this section, descriptions of the current demography, socioeconomics, and land use are summarized from the Regional Environmental Characterization Report for the Gulf Interior Region and Surrounding Territory (BNI, 1978).

4.2.1 Demography

4.2.1.1 Texas

The East Texas Gulf Interior Region includes 32 counties and is a rural area with many small towns. The major cities within the area are Tyler and Longview, but large urban areas such as Dallas, Fort Worth, Waco, and Austin are adjacent to the region. Approximately 75 percent of the population is white; the remaining is primarily black (0.7 percent are Indian, Chinese, Japanese, or other nationality). The total population of the area was 766,154 in 1970 and most of the counties showed a population growth rate of more than 7 percent between 1970 and 1975.

4.2.1.2 Louisiana

The Gulf Interior Region in Louisiana encompasses 29 parishes in the northern part of the state and includes the cities of Shreveport, Monroe, and Alexandria. The total population of the region was 1,062,685 in 1970. About 67.5 percent of the 1970 population was white; 32.6 percent of the population was black and 0.07 percent was American Indian. Population growth was slower in Louisiana than in Texas and many parishes had a net decline of up to 10 percent between 1970 and 1975.

4.2.1.3 Mississippi

There are 35 counties within the Gulf Interior Region in Mississippi. The largest cities in the region are Jackson (166,512), Meridian (46,256), Hattiesburg (38,097), and Vicksburg (29,726). The total population for the region was 778,158 in 1970 and increased to 1,064,217 (estimated) in 1975. Six counties experienced a decline in population between 1970 and 1975, and counties other than those having the major cities listed above had a slower growth rate than the rest of the nation and the slowest for all states in the GIR. Nearly 66 percent of the 1970 population was white, 34 percent was black, and less than 1 percent was of other national origin.

4.2.2 Socioeconomics

4.2.2.1 Texas

The economy of the East Texas Region is largely natural resource oriented. Extractive industries such as mining, petroleum and natural gas extraction, manufacturing based upon regional

resources, and agriculture comprise the core of the export economic base for the region. In rural counties in east Texas, tourism is an important element in the local economy. Mining and manufacturing activities account for 44 percent of the total employment of the region. East Texas is a producer of agricultural crops and livestock; some counties produce considerable amounts of livestock and poultry for export to other states. The average per capita income in 1974 for the 32-county Texas portion of the GIR was $3,120.00. The comparable average for the state was $4,188.00 (U.S.D.C., 1977).

4.2.2.2 Louisiana

Much of the region in Louisiana is rural, and is either forested, farmed, or grazed. More than 64 percent of the total employment of the region is located in the Shreveport, Monroe, or Alexandria urban areas. The state is one of the largest producers of natural gas and petroleum; in fact, only two parishes do not produce gas or petroleum. Manufacturing is located near the larger urban areas, and industries based on lumber and wood products, food products and appliances, textiles and apparel, and chemicals all have notable employment. In 1970 agricultural production of crops was centered in the lowland region along the Mississippi River; livestock production was concentrated in upland areas. Total agricultural income in 1974 was $445 million, up 114 percent from 1969. Approximately 70 percent of this market value of agricultural products was attributed to crops and hay. The average per capita income in 1974 for the 29-parish Louisiana portion of the GIR was $2,788.00. The comparable average for the state was $3,545.00 (U.S.D.C., 1977).

4.2.2.3 Mississippi

Manufacturing accounts for 31 percent of the total Mississippi Gulf Interior Region employment, and represents the largest single employment sector. Extractive industries such as natural gas and petroleum production, sand and gravel, and other minerals employ less than 40 percent of the labor force. Agriculture is also a significant contributor to the local economy. Lowland counties of the Mississippi River basin are intensively cultivated for field and row crops; upland counties are extensively utilized for livestock grazing. The average per capita income in 1974 for the 34-county Mississippi portion of the GIR was $2,826.00. The comparable average for the state was $3,098.00 (U.S.D.C., 1977).

4.2.3 Land Use

4.2.3.1 Texas

The majority of the population in the east Texas portion of the GIR is located in the Tyler and Longview urban areas. As much as 10 percent of the region is urban but the average density throughout the region is 0.02 people/acre. Vast expanses of woodlands and agricultural lands characterize the region. East

Texas has three national forests: Angelina, Davey Crockett, and Sabine, totaling 507,012 acres. Recreational use of lakes, reservoirs, and parks in the region is rapidly growing, and second home development around some lakes, such as Cedar Creek Reservoir, has occurred recently. The Federal government maintains and is acquiring jurisdiction over sizeable land areas to meet growing demands for various recreational uses. Airports of various sizes are found throughout the region, as are restricted airspaces. Highways and railroads are extensive throughout the region. One Indian reservation exists in Polk County, Texas.

4.2.3.2 Louisiana

The majority of residential, commercial, and industrial lands are around the cities of Shreveport, Monroe, and Alexandria. Outside these urban areas small towns are numerous, but rural areas are, for the most part, devoted to agriculture or forests. Upland parishes in northwestern Louisiana have less field and row crops and more livestock grazing lands than lowland parishes along the Mississippi River. Kisatchie National Forest is distributed in several parcels throughout Louisiana, and the total of all parcels is 500,302 acres or 6.1 percent of the land in the region. State fish and wildlife management areas and state forests provide abundant recreational facilities. Airports and restricted airspace of varying size are found throughout the region. Rail and highway transit facilities are well developed in all of Louisiana. One Indian reservation is located in the Gulf Interior Region in Allen and Jefferson parishes.

4.2.3.3 Mississippi

Like Louisiana, the region is largely rural and agricultural lands predominate. Five national forests are located in the region and comprise 1.7 million acres or 15 percent of the region. Many types of uses are provided, including recreation and timber harvesting. The Natchez Trace Parkway covers about 47,000 acres in the GIR. Airports of various sizes are found throughout the region as are restricted airspaces. Rail and highway systems are well developed.

4.3 BIOLOGICAL ENVIRONMENT

In this section terrestrial and aquatic ecosystems are summarized from the Regional Environmental Characterization Report for the Gulf Interior Region and Surrounding Territory (ONWI-67).

4.3.1 Terrestrial Ecosystems

4.3.1.1 Texas

The Gulf Interior Region and surrounding territory in Texas supports nine potential vegetation types, ranging from mixed hardwood-softwood forests to open prairies and savannas. No ecological reserves have been established in the basin but a number of locally administered natural areas and four national forests do assure preservation of habitats in a nearly undisturbed condition. Important animal species include approximately nine fur bearers, several game animals, and 20 protected, threatened, or endangered species. There are also 153 species of plants designated as rare by the Texas Parks and Wildlife Department (1974) which are reported to occur in the vegetation types characteristic of the Texas portion of the GIR. Seven of these plant species are proposed to be included as endangered species by the Federal Government (U.S. Fish and Wildlife Services, 1976).

Major range types in the Texas portion of the GIR include grasslands, shrublands, chaparral, and juniper-oak savanna. The rangeland has relatively high productivity compared to a typical western range, and livestock and livestock products accounted for the highest portion of all agricultural products sold in the Texas portion of the GIR in 1974 (47 percent). This lead was followed by poultry and poultry products (36 percent), crops and hay (12 percent), nursery and greenhouse products (3 percent), and forest products on farms (1 percent). Harvested hay, sorghum, and cotton were the crops covering the greatest land area in 1974. Commercial forests in counties within the east Texas Piney Woods region cover about 63 percent of the region. Forest types with the most coverage are loblolly-shortleaf pine, oak-pine, and oak-hickory.

4.3.1.2 Louisiana

Four potential vegetation types occur within the Gulf Interior Region of Louisiana - prairie, and three types of mixed hardwood and softwood forests. However, the variation within these vegetation types, due to man's activities as well as the natural soil and climatic variation, contributes to diverse wildlife habitats. Bayou Boeuf Natural Area, an ecological reserve, the Kisatchie National Forest, and several state, private, and federal wildlife areas occur in the region. Important animal species include approximately 13 fur bearers, 11 game mammals, and six threatened or endangered species. Four plant species in Louisiana have been proposed for endangered status by the U.S.

Fish and Wildlife Service (1976). It is not known whether any of these plant species occur in the GIR of Louisiana.

Livestock grazing occurs on cultivated pasture as well as in forested lands. Livestock and livestock products represented only 18 percent of the value of agricultural products sold in 1974. Principal livestock types produced in the area in 1974 were beef and dairy cattle. Livestock productivity varies throughout the region, as do agricultural crop and timber resource productivity. The most productive livestock parishes are De Soto, Caddo, Richland, Natchitoches, and Rapides. Agricultural crop production was largest in Morehouse, East Carrol, Marison, and Avoyelles parishes. Crops and hay represented 70 percent of all agricultural products sold in the Louisiana portion of the GIR in 1974. Cotton was the crop with the largest harvested area, followed by soybean, rice, corn, sorghum, wheat, and sugarcane. There are three major forest types in Louisiana: southern pine, upland hardwood (oak-hickory), and bottomland hardwood. Commercial southern pine forests are mostly longleaf and slash pines in the southern half of the state, and shortleaf and loblolly pines in the north. Bottomland hardwoods include species such as oak, gum, cypress, elm, ash, and cottonwood. Production of timber resources was highest in Ouachita, Caldwell, Winn, Natchitoches, Sabine, and Caddo parishes.

4.3.1.3 Mississippi

Five potential natural vegetation types occur in the GIR portion of Mississippi and western Alabama. These are: (1) the blackbelt, (2) the oak hickory forest, (3) the oak hickory pine forest, (4) the southern mixed forest, and (5) the southern flood-plain forest. The blackbelt, a special section of the oak-hickory ecosystem, is found only on the rich black soils of Mississippi and Alabama. Six ecological natural areas and five national forests have been established in the Gulf Interior Region of Mississippi for the preservation of vegetation types and wildlife habitat. Important animal species include approximately 11 fur bearers, 11 game animals, and 13 federally listed threatened and endangered species. One plant species is proposed by the U.S. Fish and Wildlife Service (1976) as endangered in Mississippi. It is not known if it occurs in the GIR of Mississippi. In the Mississippi GIR, poultry and poultry products accounted for the highest portion of all agricultural products sold in 1974 (45 percent); this was followed by crops and hay (30 percent), and livestock and livestock products (22 percent). Rangeland and wooded pasture is extensively distributed throughout the region. In 1974, soybeans, hay, and cotton were the crops with the largest harvested area. Commercial forests are extensive and occupy about 52 percent of the land area in Mississippi. Commercial forests are largely composed of oak-hickory, loblolly-shortleaf pine, oak-pine, and oak-gum-cypress.

4.3.2 Aquatic Ecosystems

The Gulf Interior Region is noted for its extensive and valuable recreational and commercial warmwater stream and lake fisheries. Stream and lake habitats within the region can be divided into bottomland and upland habitat types. Bottomland habitats are generally in the larger, deeper, slow moving, and turbid streams and rivers which meander through the interior region. Upland habitats are generally in the smaller, faster moving creeks and streams that are the tributaries to the major waterways within the region. Six endangered fish species have been identified as possibly occurring in the Mississippi portion of the Gulf Interior Region (U.S. Fish and Wildlife Service, 1977; Mississippi State Game and Fish Commission, 1977).

5.0 RECOMMENDATION OF STUDY AREAS BASED ON THE REGIONAL CHARACTERISTICS

5.1 METHODOLOGY

The recommendation of study areas within the GIR requires a siting approach which is distinctly different from the screening procedure used for an area having a continuous bedded salt formation. In bedded salt formations, nongeologic screening specifications are used to identify areas of high-siting potential. In this manner areas which may have conflicting uses are eliminated and geologic studies can be focused on those remaining high potential areas. In the GIR, potential repository sites are limited to salt dome locations. Consequently, it is necessary to ascertain which domes have suitable geologic properties and then define study areas to include these geologically attractive domes. The final consideration is to identify and recommend those geologically attractive domes having minimal conflicts with nongeologic factors.

It is emphasized that the domes recommended for continuing studies are those domes that appear to have the highest potential to be suitable sites. However, other domes within the GIR may also be suitable but are being deferred from further consideration at this time.

In the GIR, criteria for selecting salt domes were provided by NUS (1978), Brunton and McClain (1977), Brunton et al.(1978), and ONWI-33(2). The results of the GPM/RPM screening are discussed below and summarized in Table 5-1.

5.1.1 Application of Geologic Screening Specifications

The GPM has used established geologic screening specifications (Brunton et al., 1978) to identify domes that appear to have high potential as NWTS repositories. Seventeen criteria and associated specifications were provided. However, three criteria dominated the screening:

- Domes should be at depths less than 915 meters (3,000 feet)
- Domes should have cross-sectional areas greater than 1,000 acres in lateral extent, plus a surrounding 500-foot salt barrier zone.
- Domes should not have been used by industry for hydrocarbon production, storage, or other mineral-related use.

The GPM identified 11 domes that exhibited the highest geologic potential. These domes were Palestine, Brooks, Keechi, Mt. Sylvan, Oakwood and Boggy Creek in Texas; Cypress Creek, Lampton and Richton in Mississippi; and Rayburn's and Vacherie in Louisiana.

5.1.2 Application of Nongeologic Screening Criteria

On the basis of technical (geologic) factors, the above 11 domes were attractive as repository sites. The RPM evaluated these domes, considering the likelihood of land use conflicts and potential problems in licensing based on nongeologic criteria (NUS, 1978) and the RPM's nuclear licensing experience. Further, in order to optimize the economics and management of acquiring the information necessary to identify suitable repository sites, an objective of the region-to-area screen was to select two or three domes in each basin for additional study. These considerations resulted in the removal of three of the 11 domes from further consideration at this time: Brooks because it is located under Lake Palestine; Mt. Sylvan because it is near the Tyler urban area and airport; and Boggy Creek because it is located under the Neches River. The remaining eight domes are more favorably situated and are recommended for the next phase of studies - Area Characterization.

5.1.3 Recommendation of Study Areas

The combined RPM/GPM evaluation has resulted in the recommendation of the following salt domes for additional studies during the Area Characterization phase of the NWTS program.

- Rayburn's Dome, LA
- Vacherie Dome, LA
- Cypress Creek Dome, MS
- Lampton Dome, MS
- Richton Dome, MS
- Keechi Dome, TX
- Oakwood Dome, TX
- Palestine Dome, TX

In accordance with the environmental survey plans (NUS, 1978b) a study area, which encompasses these recommended domes, was identified in each basin (Figures 2-1, 2-2, 2-3).

5.2 SPECIAL FACTORS TO BE CONSIDERED IN AREA STUDIES

5.2.1 Potential Land Use Conflicts

Three of the eight domes recommended for further study have potential land use conflicts that will require special evaluation during the Area Study program.

- Lampton Dome (MS). About half of the southern portion of this dome is under the Marian County Wildlife Management Area.

- Cypress Creek Dome (MS). This dome is located under the Camp Shelby Military Reservation which is also part of the De Soto National Forest.

- Richton Dome (MS). The town of Richton, Mississippi, with a 1975 population of 1,205 is located within one mile of the southeast edge of the dome.

The significance of these potential land use conflicts is not presently known. These considerations will receive special attention during the Area Study phase of the NWTS Program.

5.2.2 Ground Water Resources

Both geologic and nongeologic criteria require avoidance of areas of deep, extensively used ground water resources (Brunton and McClain, 1977; Brunton et al., 1978; NUS, 1978; ONWI-33(2)). Fresh ground water is present throughout the GIR and is used extensively for domestic, municipal and industrial purposes. Because of the complexity of the relationship between salt domes in the GIR and ground water aquifers, and the need for detailed site-specific information, no areas were deleted from the regional studies program under this criterion. This subject will be considered in greater detail in the site screening process in the Area and Location studies.

TABLE 5-1 (Sheet 1 of 5)

Salt Domes Investigated in the Gulf Interior Region and Recommended for Further Study During Area Characterizations

NORTHEAST AND SOUTH TEXAS BASINS

No.	Dome	Recommended	Reason for Not Being Considered Further at this Time
1	Bullard	no	Less than 1000 acres + 500′ barrier
2	**PALESTINE**	**yes**	—
3	Brooks	no	Under a lake
4	Grand Saline	no	Brine production
5	Steen	no	Less than 1000 acres + 500′ barrier
6	Butler	no	LPG storage, too small
7	Whitehouse	no	Less than 1000 acres + 500′ barrier
8	**KEECHI**	**yes**	—
9	Palangana	no	Brine and sulfur production.
10	Mt. Sylvan	no	Near an urban area and airport
11*	Gyp Hill	no	Less than 1000 acres + 500′ barrier
12	East Tyler	no	LPG storage
13	**OAKWOOD**	**yes**	—
14	Hainesville	no	LPG storage
15*	Piedras Pintas	no	Petroleum production
16	Bethel	no	Less than 1000 acres + 500′ barrier
17	Boggy Creek	no	Under a major river
18	Day	no	More than 915 m deep
19	Brushy Creek	no	More than 915 m deep
20	Kittrell	no	More than 915 m deep
21	La Rue	no	More than 915 m deep
22	Concord	no	Less than 1000 acres + 500′ barrier & more than 915 m deep
23*	Moca	no	More than 915 m deep
24*	Dilworth Ranch	no	More than 915 m deep
25	Elkhart	no	More than 915 m deep
26*	Pescadito	no	More than 915 m deep

* South Texas Basin Domes

TABLE 5-1 (Sheet 2 of 5)

Salt Domes Investigated in the Gulf Interior Region and Recommended for Further Study During Area Characterizations

NORTH LOUISIANA BASIN

No.	Dome	Recommended	Reason for Not Being Considered Further at this Time
27	**RAYBURNS**	**yes**	—
28	Kings	no	Less than 1000 acres + 500′ barrier
29	Winnfield	no	Less than 1000 acres + 500′ barrier
30	Cedar Creek	no	Less than 1000 acres + 500′ barrier
31	**VACHERIE**	**yes**	—
32	Drakes	no	Less than 1000 acres + 500′ barrier
33	Gibsland	no	LPG storage
34	Protho	no	Petroleum production and too small
35	Prices	no	Less than 1000 acres + 500′ barrier
36	Arcadia	no	LPG storage
37	Minden	no	Petroleum production
38	Bistineau	no	Less than 1000 acres + 500′ barrier
39	Coochie Brake	no	Economic—held in reserve
40	Chestnut	no	Less than 1000 acres + 500′ barrier
41	Milam	no	More than 915 m deep and less than 1000 acres + 500′ barrier
42	Chester	no	More than 915 m deep and less than 1000 acres + 500 barrier
43	Sikes	no	More than 915 m deep and less than 1000 acres + 500′ barrier
44	Packton	no	More than 915 m deep and less than 1000 acres + 500′ barrier
45	Castor Creek	no	Less than 1000 acres + 500′ barrier

TABLE 5-1 (Sheet 3 of 5)

Salt Domes Investigated in the Gulf Interior Region and Recommended for Further Study During Area Characterizations

MISSISSIPPI BASIN

No.	Dome	Recommended	Reason for Not Being Considered Further at this Time
46	McIntosh	no	Brine production
47	**RICHTON**	**yes**	—
48	Crowville	no	Less than 1000 acres + 500′ barrier
49	Tatum	no	Nuclear test site & less than 1000 acres + 500′ barrier
50	**LAMPTON**	**yes**	—
51	Petal	no	LPG storage
52	Gilbert	no	Less than 1000 acres + 500′ barrier
53	Hazelhurst	no	Less than 1000 acres + 500′ barrier
54	Arm	no	Less than 1000 acres + 500′ barrier
55	McLaurin	no	Less than 1000 acres + 500′ barrier
56	Richmond	no	Less than 1000 acres + 500′ barrier
57	Bruinsburg	no	Less than 1000 acres + 500′ barrier
58	Byrd	no	Less than 1000 acres + 500′ barrier
59	Leedo	no	Less than 1000 acres + 500′ barrier
60	Raleigh	no	Less than 1000 acres + 500′ barrier
61	McBride	no	Less than 1000 acres + 500′ barrier
62	County Line	no	Less than 1000 acres + 500′ barrier
63	Moselle	no	Less than 1000 acres + 500′ barrier
64	Sardis Church	no	Less than 1000 acres + 500′ barrier
65	Dont	no	Less than 1000 acres + 500′ barrier
66	Dry Creek	no	Less than 1000 acres + 500′ barrier
67	Centerville	no	Less than 1000 acres + 500′ barrier
68	D'Lo	no	Less than 1000 acres + 500′ barrier
69	Eminence	no	Less than 1000 acres + 500′ barrier
70	Midway	no	Less than 1000 acres + 500′ barrier
71	New Home	no	Less than 1000 acres + 500′ barrier
72	Oakley	no	Less than 1000 acres + 500′ barrier
73	Oakvale	no	Less than 1000 acres + 500′ barrier
74	Ruth	no	Less than 1000 acres + 500′ barrier
75	Walnut Bayou	no	Less than 1000 acres + 500′ barrier
76	Monticello	no	Less than 1000 acres + 500′ barrier
77	Allen	no	Less than 1000 acres + 500′ barrier
78	Prentiss	no	Less than 1000 acres + 500′ barrier
79	Carmichael	no	More than 915 m deep and less than 1000 acres + 500′ barrier

TABLE 5-1 (Sheet 4 of 5)

Salt Domes Investigated in the Gulf Interior Region and Recommended for Further Study During Area Characterizations

MISSISSIPPI BASIN (Cont'd)

No.	Dome	Recommended	Reason for Not Being Considered Further at this Time
80	Bothwell	no	More than 915 m deep and less than 1000 acres + 500' barrier
81	South Tallulah	no	More than 915 m deep
82	Edwards	no	More than 915 m deep
83	Caseyville	no	More than 915 m deep
84	Kola	no	More than 915 m deep
85	Carson	no	More than 915 m deep
86	Utica	no	More than 915 m deep
87	Coleman	no	More than 915 m deep
88	Hervey	no	More than 915 m deep
89	Wesson	no	More than 915 m deep
90	Kings	no	More than 915 m deep
91	Halifax	no	More than 915 m deep
92	Glass	no	More than 915 m deep
93	Ashwood (Somerset)	no	More than 915 m deep
94	Newellton	no	More than 915 m deep
95	Singer	no	More than 915 m deep
96	Vicksburg	no	More than 915 m deep
97	Eagle Bend	no	More than 915 m deep
98	Galloway	no	More than 915 m deep
99	Learned	no	More than 915 m deep
100	North Tallulah	no	More than 915 m deep
101	Brownsville	no	More than 915 m deep
102	Oakridge	no	More than 915 m deep
103	Newman	no	More than 915 m deep
104	Duck Port	no	More than 915 m deep
105	Sunrise	no	More than 915 m deep
106	Snake Bayou	no	More than 915 m deep
107	Foules	no	More than 915 m deep
108	Glazier	no	More than 915 m deep
109	Heidleberg	no	More than 915 m deep
110	Gwinville	no	More than 915 m deep
111	South Carolton	no	More than 915 m deep
112	Burns	no	More than 915 m deep
113	Yellow Creek	no	More than 915 m deep
114	Eucutta	no	More than 915 m deep
115	Laurel	no	More than 915 m deep

TABLE 5-1 (Sheet 5 of 5)

Salt Domes Investigated in the Gulf Interior Region and Recommended for Further Study During Area Characterizations

MISSISSIPPI BASIN (Cont'd)

No.	Dome	Recommended	Reason for Not Being Considered Further at this Time
116	Valley Park	no	More than 915 m deep
117	Rufus	no	More than 915 m deep
118	Ovette	no	More than 915 m deep
119	Hiwanee	no	More than 915 m deep
120	Baxterville	no	More than 915 m deep
121	Ellisville	no	More than 915 m deep
122	Grange	no	More than 915 m deep
123	**CYPRESS CREEK (New Augusta)**	**yes**	—
124	Hubbard	no	More than 915 m deep and less than 1000 acres + 500′ barrier
125	Zion Hill Church	no	Less than 1000 acres + 500′ barrier

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APPENDIX

This Appendix lists the individuals who received review copies of the Summary Characterization and Recommendation of Study Areas for the Gulf Interior Region. Following the list of recipients, copies of each of the comment letters received from the reviewers are presented, along with the response to these comments.

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Battelle Office of Nuclear Waste Isolation
505 King Avenue
Columbus, Ohio 43201

Re: Comments on the final draft "Summary Characterization and Recommendation of Study Areas for the Gulf Interior Region" - OWNI-18

Dear Mr. Glora:

After reviewing the referenced final draft, I would like to offer the following comments for consideration in the preparation of the final report.

Section 3.0, pg. 13

Rock salt was recommended as a geologic medium for the storage of nuclear wastes by a number of scientific sources. The endorsement of salt was due to certain listed characteristics and properties. Some of these pose questions.

#2 - "Salt is structurally strong. The compressive strength of rock salt approaches that of concrete." - According to Waterway's Experiment Station data, the strength of the salt cores tested from Tatum Dome in Lamar County, Mississippi, averaged approximately 3300 psi. Granted, this is even slightly stronger than the concrete in most house slabs in this area (2500 psi), but it is not as strong as Interstate highway concrete. The Mississippi State Highway Department reports the results of 203 tests made on pavement concrete in 1977 averaged about 5000 psi. Strength, therefore, is relative. How strong is the rock in a repository required to be? How strong is salt after it is subjected to temperatures that supposedly will be produced in a nuclear waste repository?

#5 - "Many existing, inactive, or abandoned salt mines are present in the United States." - This implies that abandoned salt mines are being considered as waste repositories. If this is true, where are they and what studies have been completed, currently underway and/or planned for the investigation of their suitability? If this implication is not true, how is the statement relative to the problem?

#7 - "Salt has a high inherent plasticity. This characteristic results in a tendency for fractures to heal by flowage and recrystallization; thus impervious deposits tend to remain intact over long periods of time." - The very fact that salt is plastic and will flow under the influence of heat and pressure is a primary reason why salt domes exist in the first place. Since heat and pressures do exist in these domes, it appears salt may not reflect the presence of stability over a long period of time. What will insure the stability of a repository cavity mined in salt when the waste itself is reported to be capable of giving off heat? Cavities mined in some salt domes in South Louisiana, obviously, are gradually closing in, and they are at shallower depths in the salt stock than the repository is programmed to be.

#8 - "Salt has low permeability to water. Most salt deposits lack any appreciable ground-water flow." - The very wording of this statement indicates the acknowledgment that some salt deposits (presumably, includes domes) do <u>not</u> lack appreciable ground-water flow. In order to make an accurate statement that most salt deposits do or do not anything, all salt deposits would have to be studied for the parameter in question and, obviously, this has not been done and is not going to be done. Salt itself may have a low permeability to a fluid but salt deposits (including domes) are not 100% salt and they are not without fracture zones through which saturated brines may move. Communication from C. A. Armstrong (U.S.G.S.) to Frank Stead (U.S.G.S.) concerning a field trip to Avery Island, Louisiana, salt mine in October, 1961, states, "The first stop was in an area of a few bands at a newly opened drift that was leaking water from the face at about 40 gallons per minute." From Engineering News-Record, October 11, 1979, page 29, the following statement is made by a project manager with regard to shaft construction at Weeks Island, Louisiana salt mine. (The contractor)... "went to the double-wall system to protect the shafts against water seepage and to provide structural stability in the sometimes shifting salt-dome formation." I have personally observed and sampled brine seepage from around the inner casings of three or four wells drilled in the 1960's into the salt at Tatum Dome, Mississippi. U.S.G.S. reported one of these wells was flowing brines at the surface before any nuclear testing was done at the site. During the summer of 1979, wells were constructed in each of the aquifers over Tatum Salt Dome. All of these aquifers yielded fresh water and the closest any of the static heads were to the surface was approximately 80 feet. Obviously, pressures within the dome itself are great enough to cause a brine to flow at the surface. It appears far-fetched to assume fresh water would leak downward <u>against</u> such an artesian pressure, enter a supposedly plugged casing, and then flow <u>with</u> that pressure to the surface. This is just some evidence that the salt deposits in this area may not be as dry as we are told. Since,

on page 14 of ONWI-18, it is indicated assurance of a dry repository is required, why aren't studies being conducted to investigate this situation?

#9 - "The relatively old (100 million years) age of these deposits is evidence that significant ground-water flows have not occurred in these areas for that period of time." - On page 14 of ONWI-18, it is stated the report is concerned with only the salt deposits (presumably domes) in the Gulf Coastal Plain of Texas, Louisiana, and Mississippi. Since many of the domes have penetrated and/or arched sediments of Miocene age in Mississippi, the 100-million-year figure may need to be revised downward to become less misleading. The domes in this state reportedly under consideration to receive nuclear waste are enveloped with salt and/or fresh ground water. I fail to understand what evidence is presented, regardless of the age of the deposits, that significant ground-water flows have not occurred in these areas of study in Mississippi.

Section 4.1.1.4, pg. 23

In the second paragraph it is stated, "Salt movement and diapirism climaxed during the Mesozoic in the interior salt basin ..." The Mississippi domes, of course, are in the interior salt basin, but there is some question, perhaps, when the activity actually climaxed. Since Miocene sediments are affected by the domal movements, the activity certainly extended to a much later date than the Mesozoic.

Section 4.1.1.5, pg. 23

While the Mississippi portion of the GIR may not be as seismically active as certain other areas of the country, I feel there is additional information which needs to be added to the final report.

There is some indication that earthquakes occurring in eastern United States are felt over wider areas than earthquakes of equal magnitude occurring in Western United States. The reason(s) for this is apparently unknown. What effects do earthquakes have on cavities in salt?

There are four earthquake episodes that have occurred in Mississippi, three of which are in the GIR, that are not shown on Figure 4-2, page 39.

(1) Location: Latitude 34.6°N., Longitude 89.7°W.
Near Wyatte, Mississippi.
Date: March 27, 1923
Intensity: IV on the Modified Mercalli Scale.
References: Branner and Hansell, 1932
Docekal, 1970
Moneymaker, 1957
Stearns and Wilson, 1972

(2) Location: Latitude 32.3° N., Longitude 90.2° W.
Near Jackson, Mississippi.
Date: November 13, 1927
Intensity: IV on the Modified Mercalli Scale
References: Branner and Hansell, 1932
Docekal, 1970

(3) Location: Latitude 32.3° N., Longitude 90.8° W.
Near Vicksburg, Mississippi.
Date: June 28, 1941
Intensity: III - IV on the Modified Mercalli Scale
References: Docekal, 1970
Moneymaker, 1958
Neuman, 1943

(4) Location: Latitude 31.9° N., Longitude 88.5° W.
Near Quitman, Mississippi.
Date: December 10, 1978
Intensity: V on the Modified Mercalli Scale
References: Earthquake Information Bulletin, 1979
Preliminary Determination of Epicenters, 1978.

Section 4.1.1.6, pg. 24

The first complete sentence at the top of the page stating that the western portion of the Citronelle Formation extends beneath the Mississippi alluvial valley needs a reference or scientific explanation. I believe the geologic community in Mississippi is of the opinion that the so-called Citronelle was eroded by the Mississippi River, the Big Black River and the Pearl River, and other streams and, therefore, cut off by the valleys.

Section 4.1.2.2, pg. 28

Third paragraph from the top states the base of fresh water is between -500 to -1000 feet (msl) throughout the Gulf Interior Region. That statement, as it relates to Mississippi, is somewhat conservative. Fresh water extends -2000 feet (msl) in portions of Jasper, Covington, Smith, Simpson, Jefferson Davis, Lawrence, Copiah, Hinds, Claiborne, and Warren Counties.

Section 5.2.1, pages 44 and 45

It is stated <u>two</u> of the eight domes recommended for further study have potential land-use conflicts. Yet <u>three</u> domes are listed. They are Lampton, Cypress Creek, and Richton - all in Mississippi. Camp Shelby Oil Field is located on the flank of Cypress Creek Dome. Richton is recommended for further study in spite of the fact that it has been penetrated by approximately 30 bore holes. I understand a site at Lyons, Kansas was <u>not</u> recommended for any additional study for this same reason.

I appreciate the opportunity of commenting on this final draft and am looking forward to the final report.

Sincerely yours,

BUREAU OF GEOLOGY AND ENERGY RESOURCES

John W. Green ARB

John W. Green
Environmental Geologist
Division of Geology

JWG:js

cc: Peter J. Walley
Director
Division of Fuel and Energy

Response to October 23, 1979 letter from John W. Green, Mississippi Department of Natural Resources, Bureau of Geology and Energy Resources

The purpose of comparing salt with concrete is to provide the layman with a general idea of the strength of salt. This is generally considered a valid order of magnitude comparison.

Concrete, made and tested under standard conditions, ordinarily has a compressive strength varying from 1500 to 4000 psi. Normal mass concrete is usually made with a design strength of 3500 psi. The compressive strength of rock salt ranges from 2500 to 4000 psi. This range is well within the limits of acceptable repository design. The elastic modulus of concrete varies from 2×10^6 to 5×10^6 psi. Tests at the Waste Isolation Pilot Project in New Mexico measured an elastic modulus of 3×10^6 psi for rock salt. The strength of rock having an elastic modulus of 1×10^6 is considered very high.

The sentence regarding abandoned salt mines has been revised to read: "There are many existing, inactive, and abandoned salt mines present in the United States which are being used to study the conditions that will likely occur at candidate salt dome repositories. Existing salt mines are not being considered as nuclear waste repositories."

Louisiana State University, Institute of Environmental Studies (LSU/IES) has been studying the internal structure of salt domes (in existing salt mines) for several years. These studies are being used to infer conditions which might occur in an eventual salt dome repository.

Domes which have been identified for possible repository sites have been stable for a very long period of time, as witnessed by the existence of overylying Eocene and Miocene deposits. The small amount of warping of these sediments indicates that little growth has occurred in the last 12 to 35 million years.

Heat and presure do exist in the domes but only in the form of the geothermal gradient and lithostatic pressure which are all in equilibrium. Hence, the long periods of stability. Changing the heat and stress states will undeniably increase the rate of creep locally, but this is expected to occur in the vicinity of the repository only. This subject has been addressed by Battelle in the following partial list:

> Lomenick, T. F., "Laboratory Pillar Model Experiments," in "Project Salt Vault: A Demonstration of the Disposal of High-Activity Solidified Wastes in Underground Salt Mines," Report, ORNL-4555, Oak Ridge Nat. Lab., 1971

Dreyer, W., The Science of Rock Mechanics, Trans. Tech. Publ., 1972

Wawersik, W. R. and Hannum, D. W., "Interim Summary of Sandia Creep Experiments on Rock Salt from the WIPP Study Area, Southeastern New Mexico," SAND79-0115, Sandia Laboratories, 1979

Cavities mined in salt do exhibit some degree of creep closure. This is an inherent property of salt and one of the reasons it was chosen as a possible repository medium. Gradual closure due to lithostatic pressure does not in itself indicate dome growth or instability. Salt has the unusual property of undergoing large creep strains without losing its load-bearing capabilities. The openings for respositories are being designed so that gradual closure will not affect operations and so that structural stability will be maintained. By way of example, some Canadian and German mines have been open for over 50 years.

The statement concerning low permeability to water has been changed to read: "Salt is considered to be very impermeable to water." According to a Dames and Moore study (Dames and Moore, 1977), the horizontal permeability of salt is 4.6×10^{-18} ft/min. The occurrence of water in Gulf Coast salt domes is currently being studied by LSU/IES and LETCo. This is a portion of the internal structure studies being conducted in existing salt mines.

The presence of significant amounts of water in a dome will cause disqualification of that dome, per Criteria # III of ONWI-33(2). Some of the near-shore and offshore coastal domes, including Avery Island, are known to have significant amounts of water locally. None of the coastal area domes are being considered for a repository location at this time due to the higher probability of water being present.

The ongoing area characterization studies are designed to obtain hydrologic data necessary to define those cases where the hydrologic gradient would increase the risk to the public. For any domes determined to be potential repository sites, more detailed hydrologic studies will be conducted, and these data will be used in modeling runs to determine the mobility of radionuclides from the repository to the biosphere. Preliminary calculations show travel times to be over 100,000 years to the accessible biosphere from the potential repository horizon. These calculations make simplifying but conservative assumptions, and they do not consider factors such as sorption.

Flowing brine wells are not uncommon in the Gulf Interior Region. However, the present evidence indicates that the origin of the brine is not from within the dome, but rather from deep formations well below likely repository levels.

The statement concerning age of deposits has been revised to read: "The relatively old (100 million years) age of the salt

domes is evidence that ground water flow has not significantly affected salt domes for that period of time."

The fact that the salt domes have not greatly altered in shape or size over this period indicates that there has not been significant salt dome dissolution by ground water. Many geologists think that caprock was formed over the tops of Gulf Interior salt domes partly as a result of ground water flow and partly because of surface water flow. A presently popular dome-growth theory suggests that Gulf Interior dome growth is contemporaneous with sediment deposition. This implies that the salt dome did not pierce the overlying sediments, as previously thought, but rather the sediments were deposited around the growing dome. Applying this theory to caprock formation then, surface water was able to attack the domes' surface throughout most of their growth history.

The evidence strongly suggests that concerns about dissolution rates of salt domes are overemphasized but studies pertaining to caprock formation and halite dissolution are nevertheless ongoing under various ONWI-funded programs. Dissolution rates, if present at all, must be demonstrated to be compatible with the repository isolation requirement to meet Criteria #III in ONWI 33-2. Salt dome studies to date have stressed the questions of tectonic and hydrologic stability. Efforts to assess hydrologic stability can best be described as a determination of the resistance of salt masses to external dissolution. Because of the nature of the domes' genesis, they may have become, through geologic time, encapsulated in a sheath composed of impermeable materials. These "sheaths" are postulated to have prevented the domes from dissolving since their final stage of growth 20 million years ago. Direct evidence to support this hypothesis has been found in some oil company core samples, and in geologic and geophysical logs. Plans have been made to drill directional holes to explore the peripheral sheath at a time when one or two domes have been selected for more detailed studies. Because salt has a high solubility, one would expect domes to have dissolved completely long before the present if such sheaths did not exist. Nevertheless, the presence, patterns, and origins of a few saline anomalies in fresh water aquifers near domes are being investigated by examination of geophysical logs from existing wells, and by the drilling of new test wells.

See also the answer to the previous question.

The statement concerning salt movement has been revised to read: "Salt movement and diapirism in the interior salt basins reached its peak during the Mesozoic, occurring at an ever decreasing rate in the Tertiary. In the coastal salt basin, this peak was reached in the Late Tertiary and is considered to be continuing today. The timing was controlled by the gradual gulfward migration of the areas of maximum deposition."

Regarding earthquakes, none of Intensity IV or smaller have been listed. The reason for this is that earthquakes of Intensity IV or less are not considered a threat to the planned surface and subsurface facilities. Also, seismologists feel the effort expended in compiling Intensity IV or less earthquakes is not commensurate with the small amount of helpful information obtained from these data. The December 10, 1978 earthquake occurred after the report was drafted and has been added to Figure 4.2. We appreciate your pointing out this earthquake to us.

The statement regarding the Citronelle Formation has been revised to read: "The youngest Tertiary sediments in the Texas and Louisiana basins are of Eocene age. The only younger formations are the Pleistocene stream terraces and recent floodplain deposits. In Mississippi, Tertiary sediments through the Plio-Miocene are present, and the Citronelle is widely preserved. In addition, Pleistocene Terrace and recent floodplains also occur. Consequently, the major upward Tertiary unconformity of the Texas and Louisiana basins is represented by sedimentary formations in the Mississippi basin."

On page 28, third paragraph from the top, change "-500 to -1000" to "-500 to -2000".

On page 44, "Two" is changed to "Three."

The situations at Lyons, Kansas and that at Richton, Mississippi are quite different. The existence of boreholes at the Lyons, Kansas experimental site of Project Salt Vault was complicated by the fact that there were a large number of holes, the locations of which were not well documented. The holes intercepted the testing chambers and were not plugged adequately, if at all. Please refer to references in Section 1.2 of the Regional Environmental Characterization Report for the Gulf Interior Region and Surrounding Teritory (ONWI-67) for documented reports on the Lyons, Kansas work. There are 7 Interior Gulf Salt domes in Mississippi, Louisiana, and Texas presently being examined for suitability as a waste repository site. Three of these, Richton, Lampton and Cypress Creek are in Mississippi. Site Selection Criterion #IX of ONWI 33-2 requires that present and future conflicting land use be evaluated in the site characterization process. The Gulf Salt Dome Regional Report (ONWI-67) covers this subject from a regional point of view, and subsequent reports deal with the specific dome areas. The existence of multiple boreholes into salt to depths where a repository could be located will be considered relative to possible mitigation through borehole plugging. Potential paths of radionuclides to the biosphere will also be considered during the site evaluation process. The Richton holes are chiefly in the caprock.

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Capital-Area Groundwater Conservation Commission

P. O. Box 64526
Baton Rouge, Louisiana 70896
Telephone (504) 924-7420

October 16, 1979

Mr. B. Jim Porter
Department of Natural Resources
P.O. Box 44396
Baton Rouge, Louisiana 70804

REF: ONW1-18-Final Draft, May, 1979

Dear Mr. Porter:

I have reviewed the referenced document brought to my office by Mr. John Cadwalder.

Although the document is brief and not oriented to hydrogeology, I believe that the following assumption on page 13 be revised or deleted. Scientifically it is in error.

> "The relatively old (100 million years) age of these deposits is evidence that significant groundwater flows have not occurred in these areas for that period of time".

The age of 100 million years is considered to be of the Cretaceous period. Water in beds of Tertiary age which overlies the Cretaceous beds has been and is in motion as evidenced by cap rock (anhydrite) that is the result of water movement or flow during the Tertiary and Quaternary periods.

Very truly yours,

A. N. Turcan, Jr.
Director

ANT:jo
cc: Battele Project Management Division

Response to October 16, 1979 letter from A. N. Turcan, Jr., Capital-Area Groundwater Conservation Commissicn, Baton Rouge, Louisiana

This statement is revised to read:
"The relatively old (100 million years) age of the salt domes is evidence that groundwater flow has not significantly affected salt domes for that period of time."

The fact that the salt domes have not greatly altered in shape or size over this long period of time indicates that there has not been significant dissolution.

THE UNIVERSITY OF TEXAS AT AUSTIN
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October 26, 1979

Mr. M. A. Glora
Office of Nuclear Waste
Isolation, Battelle
505 King Avenue
Columbus, OH 43201

Dear Mr. Glora:

The Bureau of Economic Geology has reviewed the final draft of the document ONWI-18. I raise only three questions.

On page 5, Section 2.1, next to last sentence, March 1981 does not appear a realistic date. Section 2.2, first sentence, reference should be Bechtel. Table 4-1, Texas geologists date the Willis as Pleistocene along with Lissie; our Pliocene formation is named Goliad. No other comments.

Sincerely yours,

E. G. Wermund
Associate Director

EGW:dl

Response to October 26, 1979 letter from E. G. Wermund, the University of Texas at Austin Bureau of Economic Geology, Austin, Texas

Site identification is now scheduled for late 1982 or early 1983.

NUS is the correct reference for the plans for the NWTS program. Table 4-1 has been so corrected to reflect these comments.

This report was initially prepared in early 1979. Subsequent revisions have been made based on public comments.

ONWI

Office of Nuclear Waste Isolation

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