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GEOTECHNICAL REVIEW OF THE STATUTORY ENVIRONMENTAL ASSESSMENT (EA) FOR VACHERIE SALT DOME SITE WEBSTER AND BIENVILLE PARISHES, LOUISIANA

DRAFT FINAL REPORT

PREPARED FOR

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1.0 INTRODUCTION

1.1 Nuclear Waste Program

The U.S. needed to adopt a nuclear waste program in order to handle increasing amounts of waste generated by nuclear power plants throughout the country and other high-level radioactive wastes. Options for disposal waste include expanded on-site storage at reactors, monitored retrieval be stored at various locations, or construction of geologic repositories. To assure more suitable site selection, licensing, construction, operation, and sute closure, several regulations have been adopted by various federal agencies to assure the protection of society and the environment from radionuclide release. This process was established by the Nuclear Waste Policy Act of 1982.

1.2 Vacherie Dome Site Descriptions

The Vacherie Dome site lies in a small valley located on the Webster/Bienville parish line in Louisiana. The site is 34 miles east of Shreveport and 10 miles south of Minden. Several smaller communities are within a ten mile radius. This rural area is heavily vegetated, with rolling hills and an extensive surface water system. The dome is elliptical in shape, trending northwest. It is a typical salt dome in that caprock covers the dome top and drapes over part of the flanks. Strata overlying and flanking the dome are poorly to moderately consolidated, saturated sands, silts, clays, and marls. The top of the salt stock approaches to within 545 ft of the surface. Domal growth has resulted in local folding and faulting of strata.

1.3 Purpose of the EA

Development of Environmental Assessment (EA) by DOE is required by the Nuclear Waste Policy Act of 1982. These EA's serve as a basis for site nomination. In general, the purpose of the EA's are to describe a decision process for nominating a site, and they must describe the site and its surroundings. Impacts of a repository on the public and on the environment must also be assessed along with an evaluation as to whether a site is suitable. Finally, a comparison and evaluation must be made among sites. Draft EAs have been submitted for review and comment for nine potential sites. These documents represent, or are intended to represent, the culmination of NWPA requirements and information requirements in the Mission Plan prepared by the Department of Energy.

1.4 Site Screening

After salt was considered as a possible storage medium for nuclear waste, Gulf Coast salt domes were one of four regions in the U.S. considered as potential repository sites. A selection screening process over about 14 years reduced the number of potential salt dome sites from 500 to 3. Screening criteria included on-shore location, depth to caprock, depth to salt, present use of the site, resource potential, lateral extent, and other factors. The USGS initiated the screening process, with the Department of Energy making the final selection of candidate sites.

The Vacherie Dome site is one of the three potential salt dome sites. It was discovered by Standard Oil Company in 1921 during field investigations. From 1922 to 1924 four wells were drilled ranging from 788 ft to 2,558 ft in depth. Two of the holes encountered salt at 799 ft and 777 ft. (Spooner, 1926)

The National Academy of Sciences and the National Research Council first recognized salt as a medium for storing nuclear waste in 1955 (NAS-NRC, 1957). There are several inherent advantages to salt, namely, it occurs in large deposits, remains dry and undisturbed, dissipates heat effectively, behaves plasticaly to heal fractures, undergoes only local changes upon radiation exposure, and has excellent radiation shielding properties.

The U.S. Geological Survey took the next step and identified four regions in the U.S. having salt deposits large enough to house a repository. The Gulf Coast is one such selected region (Johnson and Gonzales, 1978, Pierce and Rick, 1962). In all, 500 salt domes were identified in Texas, Louisiana, and Mississippi, including offshore domes. Of the 500, 237 offshore domes were eliminated from further consideration, leaving 263 potential sites. Application of further selection criteria including depth to dome top and present use of a site narrowed the group to 36 potential sites with 89 worth further study (Anderson et al, 1973).

Selection criteria, expanded by the Department of Energy to include depth to the salt, lateral extent of the dome, and resource potential, reduced potential sites to eleven by 1980 (NUS 1978, ONWI 1979a, ONWI 1980). Of these, three were eliminated for environmental factors, and solution mining damage eliminated another.

As of 1982 the following domes were under consideration:

Rayburn's,

Cypress Creek,

Lampton,

Richton,

Keechi,

Oakwood,

Vacherie,

(ONWI 1980 (LET/Co 1982 a through d, ONWI 1982) Applying a more limited lateral extent criteria caused Rayburn's, Lampton, and Keechie Domes to drop out. (ONWI 1982, ONWI 1982). Further evaluation considering extent of exploratory drilling for oil and gas eliminated Oakwood Dome.

1.5 Applicable Documents

1.5.1 10CFR60

These regulations provide administrative and procedural guidelines as well as technical performance criteria for the isolation of nuclear waste in geologic repositories and are promulgated by the Nuclear Regulatory Commission. The rule contains requirements for design and site characterization such as preventing development of preferential pathways for water migration, maintaining stability of the underground openings, maintaining the option of waste retrieval, and providing adequate engineered waste packages and barriers, among others. The purpose of these regulations is to provide reasonable assurance that the objectives and criteria will be met based upon the record available to the Nuclear Regulatory Commission as the repository concept advances towards siting and licensing. This approach recognizes the inherent uncertainty in geologic disposal of waste. It will be very important, therefore, to independently assess the level, importance, and relevance of the uncertainty in plans and findings.

1.5.2 10CFR960

These regulations are general guidelines for the recommendation of sites for nuclear waste repositories promulgated by the Department of Energy. The siting process consists of screening, site nomination, site recommendation for characterization, site selection and recommendation for development as a repository. The first phase, screening, resulted in EA's for nine individual sites selected after a reduction survey from provinces, to regions, to areas, to locations, to sites. Site recommendation requires data examination with emphasis on hydrogeologic setting. Evaluation will be based on siting guidelines requiring no site characterization for their application, and then on those guidelines requiring site characterization, that is, suitable for further study. Site characterization will occur only at those sites recommended, after which site selection will begin for determining whether a site is suitable for the development of a repository.

States must assess available data that DOE is using for its evaluation to assure it is accurate and complete enough for conclusive evaluations. Any uncertainties must be assessed or inherent inaccuracies must be examined to assure justification for site selection based on objective and dependable data.

1.5.3 40CFR191

The standards for radionuclide release rates to the accessible environment proposed by the Environmental Protection Agency in 40CFR191, as interpreted by NRC, provide a rate of radionuclide release from the engineered barrier system following the containment period that shall not exceed one part in 100,000 per year of the inventory of that radionuclide calculated to be present at 1,000 years following permanent closure. The Commission may allow other release values. To assess compliance with such criteria, the groundwater characteristics, radionuclide inventory, radionuclide solubilities, radionuclide absorption, groundwater travel times, and other properties and their inherent uncertainties must be understood.

1.5.4 Nuclear Waste Policy Act of 1982

The NWPA provides a framework and policy for resolution of the nation's nuclear waste problem. The states, affected Indian tribes, and others, have a role mandated by the Act to assess the desirability and suitability of any proposed HLW repository within its borders. The DOE is to follow the Act in the undertaking of the EA, while also following the siting guidelines, Mission Plan, and supporting documentation.

The Act provides for DOE identification and recommendation of various sites for HLW disposal, and states must be assured that the DOE procedure is fully and specifically within the Act without arbitrariness and unnecessary subjectivity. Recommended sites must be ranked, with geological, performance, environmental, socio-economic, transportation, intrastructure, cost, and other factors considered. States must assess the uncertainty and inherent inaccuracy in ranking criteria to ensure that objective and defensible ranking and selection have been made. A state's veto of such a proposal may be overridden by Congress, leading to political and constitutional uncertainties.

1.5.5 Mission Plan

The Department of Energy Draft Mission Plan for Civilian Radioactive Waste issued in April 1984, provides an overview and preliminary plan for the HLW Management Program. It contains DOE's interpretations of the Act's requirements and the methodology and schedule for achieving them. The document puts forth DOE's intentions in sensitive areas such as consultation and cooperation with states, affected Indian Tribes, and others; approach to socio-economic impacts; approach to development of seals and barriers; transportation system requirements for acceptance of waste at reactors and delivery to repositories; site characterization; site selection; and repository design. States must assure themselves that the long lead time required to develop engineered systems for waste handling and retrieval, seals and barriers, and design solutions are provided for. They must assure themselves that DOE's final Mission Plan is in their best interest, not only as a potential site for a HLW repository but also as a state relying in part on nuclear power for its consumers and industries.

2.0 GEOTECHNICAL REVIEW OF VACHERIE DOME SITE EA

2.01 General

The following comments have been developed from a careful review of the EA from a geotechnical as well as from general geological and engineering aspects. Comments are identified by page, section, and paragraph, as appropriate, to aid the reader by having a "roadmap" to the EA. Every attempt has been made to have each comment specific, brief, and self-contained, though unless the reader is especially familiar with the EA, having an EA present for ready reference will make the comments more useable.

Where helpful and appropriate, comments are related to the Program framework of 10CFR60, 10CFR960, 40CFR191, and the NWPA.

2.0.2 EA Executive Summary

p. 1, E.S., Sect. 1, para. 1. The Act provides a program to establish a schedule and defines Federal policy. The Act does not "specify" a siting process (as stated in the EA), however, DOE siting guidelines attempt this.

p. 1, E.S. Sect. 1. The Act assigns DOE responsibility under the program, however, the following points must be noted:

1. The President must select the site.
2. The NRC must license the facility.
3. States and affected Indian tribes may disapprove and veto a site.

4. The U.S. Congress has ultimate responsibility by power to override a state or Indian tribe veto, and will place the burden of proof of site sufficiency on DOE at that time.

p. 1, E.S. Sect. 1, para. 2. The EA states that the repository "can be viewed as a large underground mine with a complex of tunnels occupying roughly 2,000 acres at a depth of from 1,000 to 4,000 feet." The implication is that the repository will be on a single level. The Vacherie Dome Site is proposed as a multiple-level repository due to domal space limitations, and is proposed to cover a total of 3,734 acres (EA Table 5-25).

p. 1, E.S., Sect.1, para 3. Vacherie Dome is incorrectly listed as being in Texas; it is located in Louisiana.

p. 1, E.S., sect. 1, para. 3. The reference repository location at the Hanford Site contains not one but several suitable sites. (Long and WCC, 1984; WCC, 1980; WCC 1981) Because the Paradox and Permian Basins were divided into multiple sites, the Hanford region basalt flows should also be divided into multiple sites.

p. 2, E.S., Sect. 1, para. 1. The draft EA's were published in December 1984, nearly concurrent with the 10CFR960 Final Siting Guidelines. It is extremely doubtful that the final guidelines and the received comments could have been used in the EA's.

p. 3, E.S., Sect. 1, para. 2. The Act does not use language of "not fewer" or "at least" with respect to site nomination and recommendation.

p. 4, E.S., Sect. 2.1, para. 3. The EA implies that the President will approve the DOE nominated sites. However, it must be pointed out the President may approve or disapprove the DOE nominations.

p. 5, E.S., Sect. 2.2, para 2. The EA states that domes are "anomalous structures." Domes are ubiquitous in the Gulf Coast Region and, as such, cannot be considered to be anomalous.

p. 6, E.S., Sect. 2.2.3, para.1. The EA has designated Richton Dome as the preferred site in the Gulf Interior Region; however, the NWPA does not provide for selection of preferred sites in a particular region; instead, sites must be selected on their own merits to protect public health and safety.

p. 8, E.S., Sect.3, para.1. The EA states that the Vacherie Dome Site is located only 10 miles from Minden, with a population of about 15,000. Mount Sylvan Dome in Texas was eliminated from consideration because it is 8 miles from Tyler, with a 1980 population of 70,000. In order for DOE to be consistent and fair in site selections, either Mount Sylvan Dome should have been retained or Vacherie Dome eliminated at that time.

p. 8, E.S., Sect. 3., para. 3. The EA states that the cross-sectional area of Vacherie Dome is 2,120 acres at "the planned repository level." (Note that "level" is singular). The three-digit accuracy is unwarranted. All that is warranted is one-digit accuracy to say domal area is one to two thousand acres at the repository depth.

p. 10, E.S., Fig. 3. The degree of certainty in the geological cross-section of Vacherie Dome is over-indicated. Some indication of the high degree of uncertainty in the figure is warranted.

p. 11, E.S., Sect. 3, para. 6. The EA states that lignite seams "are considered uneconomical to extract." However, seams in excess of 20 ft. thickness have been found in the Wilcox Formation in at least one core over the dome. (Hole LSU-V5, Martinez et al; 1977, p. 466). Seams of this size can be economically extractable.

p. 12, E.S., Sect. 4, para. 6. The EA states that there would be minimal effects from the salt stockpile. Industry experience does not include the effect of tornadoes, hurricanes, and high rainfall on salt stockpiles. These large quantities of salt cannot be disposed in a licensed landfill in the region, owing to the high rate of precipitation and infiltration in the Gulf Coast area that may cause brine seepage and aquifer contamination. Disposal in a hazardous waste facility would be very expensive, perhaps $30 per cubic yard at present, but $100 per cubic yard in a few years. (Telephone conversation between M. F. Dunn and R. Martin, Chemical Waste Management, Inc. Lake Charles, LA, on 04 April 1985).

p. 14, E.S., Sect. 5, para. 2. The EA states that salt contamination will be minimal. Same comments as p.12.E.S., Sect.4, para.6.

p. 17, E.S., Sect. 6.2, para. 1. The 100,000-year travel time to the dome flank has been derived from analyses on rock salt cores and not domal salt containing anomalous zones or shear zones, which have much higher hydraulic conductivities than rock salt cores.

p. 17, E.S., sect. 6.2, para. 1. Although salt creep is favorable for isolation of waste by sealing fractures, it is unfavorable for preclosure operations and underground safety and stability.

p. 18, E.S., Sect. 6.3.3., para.3. The EA states that underground excavations will require only minimal support with rock bolts and will require constant maintenance due to creeping salt. Rock bolts in creeping salt can only be maintained with re-installation. This amounts to constant renewal, not maintenance.

p. 19, E.S., Sect. 7, para.1. The structure of the guidelines results in regions being rated and not sites. The EA's presentation should list Yucca Mountain, Hanford, Paradox Basin, Permian Basin, and Gulf Coast Region, so as to indicate the true rank of Vacherie Dome as 4b.

2.1 Chapter 1.0 - Process for Selecting Sites for Geologic Repositories

p. 1-1, Sect.1.1, para.1. The E.A. incorrectly implies that DOE has all responsibility for siting, constructing, operating, closing, and decommissioning of the repository. See comments for p.1, E.S., Sect.1, para.1.

p. 1-13, Sect.1.1.2, para.3. Site nomination and recommendation. Same comments as p.3, E.S., Sect.1, para.2.

p. 1-3, Sect.1.1.3, para.1. The EA states "DOE will consider public comments on these drafts before making any final decisions about nomination and recommendation." As early as 1979 and definitely by 1981, DOE was already investigating Yucca Mountain, Hanford, and "a salt site" as possible repository locations. There has been little change in 4 years of comments.

p. 1-19, Sect.1.3.2.2, para.3. The EA states that bedded salt has a higher water content and lower strength than domal salt; however, water content alone does not dictate salt strength. Crystal size and strain history also affect strength. Davis Canyon salt has the highest strength of any known natural salt, including domal rocksalt (Handin et al., 1984, ONWI-550, p.107). The EA also states that bedded salt has a faster rate of creep than domal salt, however, Vacherie Dome salt has the highest rate of volumetric closure of all salt sites, including bedded salt (IT Corporation, 1984, ONWI-546, p. 51).

2.2 Chapter 2.0 - Site Selection - Gulf Coast Salt Dome Basin

p. 2-1, Sect. 2-1, para. 2. The rationale for consideration of the Northern Louisiana and Mississippi Salt Basins as the same is not convincing. While both basins lie in the Gulf Coastal Province, this province encompasses the area from New England to Texas along the coast. This physiographic province may have gross similarity over its extent, but large differences do exist, especially in the subsurface. Significant differences occurs in structure of the area, local stratigraphy, and hydrogeologic properties, including local flow paths and travel times. The internal conditions and material properties of salt domes in the two salt basin differ significantly in terms of temperature, composition, and growth history. If the Mississippi and Northern Louisiana Salt Basins are considered the same, based upon the logic presented by Neff (1984), then either similar logic should be applied to the Paradox and Permian Basins, or the EA should revise its logic for Vacherie Dome.

p. 2-2, Fig. 2-1. Some domes are eliminated from the final seven by criteria used to eliminate 493 other sites. Several of the remaining seven should have been eliminated in earlier stages of evaluation because of their sameness with eliminated sites. It appears that criteria of lateral extent and future resource recovery potential would have either included eliminated sites, or eliminated included sites if consistently applied so as to re-examine previously examined sites.

p. 2-6, Sect, 2.2.1, para. 2. No account is taken of the degree of uncertainty of dome size. Some domes with extensive but non-penetrating drilling were relatively well-defined with certainty as to size, other domes with less drilling were relatively poorly defined, with uncertainty as to size, but were indicated as sufficient in size.

p. 2-6, Sect. 2.2.1, para. 3. Mt. Sylvan Dome was eliminated on the basis of its proximity to Tyler, Texas; however, no numerical criteria were in use as to either population size or population proximity at that time. Mt. Sylvan Dome is 8 miles from Tyler with a 1980 population of 70,000 while Vacherie Dome is 10 miles from Minden with a 1980 population of 15,000.

p. 2-11, Sect. 2.2.2, para. 2. No justification can be found for the selection of the 800 ft (244-m) buffer zone given in Stearns-Roger Services, Inc. (1981, ONWI-283). Owing to the improved subsurface knowledge of the location of the dome edge in present mines, the 244-m buffer zone is not an industry standard and appears arbitrary. Kupfer (1980, p. 134) suggests a 100-m buffer zone.

p. 2-17, Table 2-4, Geohydrology. The EA estimate of a ground water travel time through undisturbed salt stock of greatly over 1,000 years does not represent actual travel times in the dome. No account is taken for ground water travel through zones with higher hydraulic conductivities such as those associated with anomalous zones and shear zones. Mining for the repository will disturb the salt stock prior to waste replacement. This was not considered in the EA estimate.

p. 2-18, Table 2-4, Rock Characteristics. The EA states the subsurface excavation instability hazards can be mitigated, however, creep and resultant opening instability, and the required functioning of repository openings for periods of decades is not demonstrated at these mining depths and temperature conditions.

2.3 Chapter 3.0 - The Site

p. 3-1, Sect. 3.0, para. 6. The cross-sectional dome area at -2,500 ft. MSL is stated as 2,400 acres; this differs from the 2,120-acre dome area stated in the 5th draft, and the value of 2,080 acres determined by Ertec (1983, p. 47). The Executive Summary uses 2,120 acres on p. 8. The upper value is used consistantly through the EA and may be in considerable error as discussed in this report.

p. 3-8, Sect. 3.2.1, para. 3. The uplift of the Northern Louisiana Basin has not occurred linearly since middle Tertiary time as indicated by precise relevelling data (Holdahl and Morrison, 1974, p. 381) which determined that at least short term subsidence is occurring in northern Louisiana. Furthermore, Walcott (1972, p. 1,847) never specifically mentioned which areas would be uplifted; his is a general model. Extrapolations of his model should be used with care taking regional stress fields and hydro-isostacy into consideration.

p. 3-11, Fig. 3-6. The topographic map of Vacherie dome indicates that there are several areas of gentle slopes surrounding the proposed repository site location. While the present hazard potential of these slopes may be low, potential future slope stability problems have not been discussed in the EA with respect to stream relocation to the south side of the valley, excavation and fill activities, devegetation, and changes in potentiometric levels. Even slopes of low grade may be subject to movement under these conditions, particularly in this region of high precipitation.

p. 3-13, Sect. 3.2.2.2, para. 1. Regional estimates of denudation cited in the EA (Ritter, 1978; Bloom, 1978) are of too little value to be of worth for local erosion rates. The use of any erosion rate should be used with caution, inasmuch as erosion is nonlinear over any time frame, and may be highly site specific depending on the local weather and climate history, local variations in physiography, local variations in vegetation and materials, and local variations in vertical crustal movements. In effect, the erosional history of the Vacherie Dome site is unknown.

p. 3-13, Sect. 3.2.2., para 2. Estimates of stream entrenchment (Kolb et al., 1983, ONWI-467,p.85) are based on very poor time control. Regional uplift undoubtedly was not continual over the period of terrace formation, changes in sediment load and stream discharge are not considered as possible reasons for terrace formation, and do not consider the effects of local (as opposed to regional) base level changes. The Ertec (1983) study is based on an area which has a much higher rate of vertical crustal movement (Holdahl and Morrison, 1979, p. 381) and a different physiography and climatic history. The data from Richton Dome for the Citronelle Formation can not be validly applied to Vacherie Dome. The erosion rate of 5 inches/1,000 yrs was calculated by averaging, assuming that the process was linear. Two further assumptions made in the calculation (the use of an average thickness of the Citronelle Formation, and the assumption that it was deposited at sea level) should be questioned, as this is the primary basis for erosion rate.

p. 3-13, Sect. 3.2.2.3, para.1. Details of climatic history are not particularly well defined over the last 125,000 years. Knowledge of this period is almost entirely qualitative.

p. 3-13, Sect. 3.2.2.3, para. 3. Effective precipitation and streamflow were undoubtedly much higher than at present as witnessed by terrace deposits, both local and regional. The EA here is attempting to soften the adverse facts. Saucier and Fleetwood (1970) state that precipitation was 60 inches/year in this area and that stream discharges were considerably greater. Effective precipitation must have been much greater, even assuming that temperatures were the same. For the Ouachita Basin, determined that stream discharges were 5 times greater than present and suggest that mean annual precipitation was 100 inches.

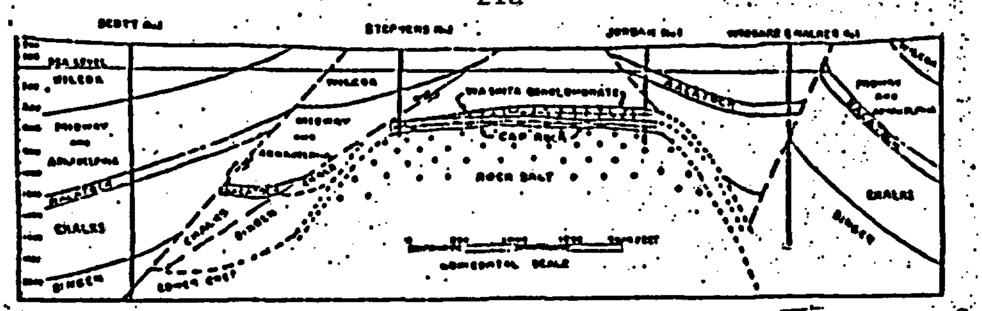
p. 3-17. Fig. 3-8. This stratigraphic column presented in the EA encompasses too large a region to be of any real use for the Vacherie Dome area. This chart is actually based on a study which included Louisiana, the Northern Coastal Region, and the Gulf Basin Province (Anderson, 1979).

p. 3-19, Sect. 3.2.3.2.1, The presented surficial geology is vastly over-simplified and shows errors in interpretation of contacts in Figure 3-9 and Brandwein and White (1983, ONW-299, Fig.1). From these two figures it becomes clearly evident that the dome is heavily faulted and fractured, probably much more than indicated, and that the Tertiary sediments in several places must have very steep (up to 70-degree) dips. Furthermore, distinct contacts between formations are not explicitly shown on the geologic map in order to emphasize the sporatic and imprecise nature of the field data.

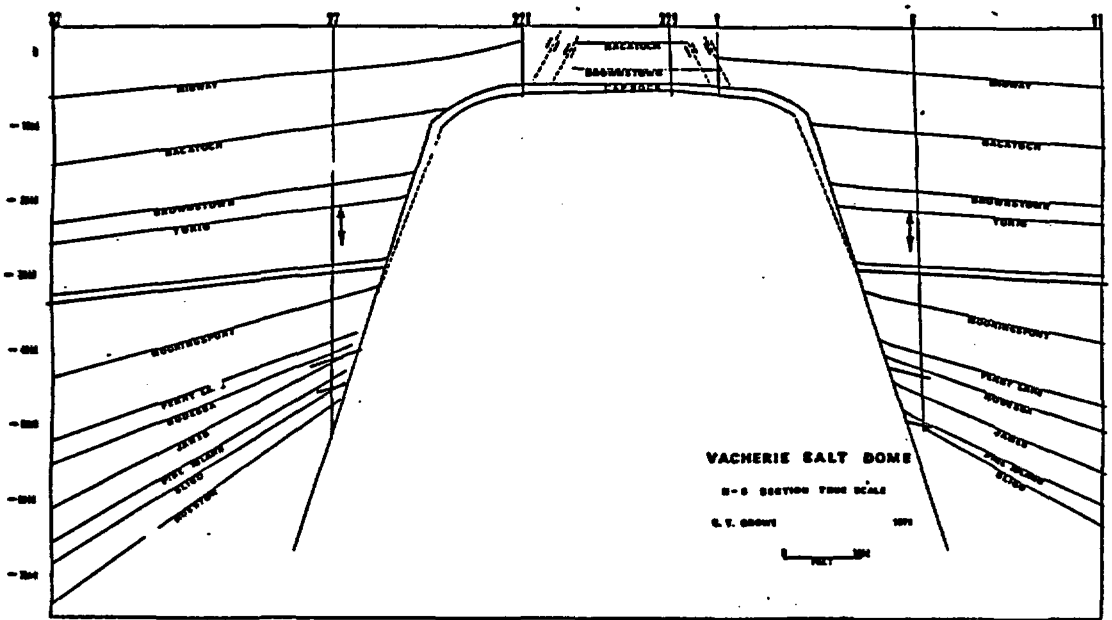
p. 3.19, Sect. 3.2.3.2.2 There is surprisingly little of the highly complex stratigraphy of the dome area and adjacent sediments presented in the EA. Surely, this merits more than half a page in the EA and references to a general regional study (LETCO, 1982 ONWI-119) and a surficial sediment study (Kolb et al) 1983, IBWU-467). The profile of Vacherie Dome (Fig.3-10) is grossly oversimplified. There are considerable differences between the profile in the EA (Fig.3-10, LETCO, 1982, ONWI-119, p.11-77) and the various attached profiles. These differences include the occurrence, thickness, and lithologies of the various dome flanking formations; the age, extent and number of faults, and errors in interpretation of dips.

p. 3-19, Sect. 3.2.2.2, para.2. If the topographic depression in the center of the domal area is caused by collapse of sediments, then there is quotential for such processes to occur in the future, whether due to dissolution or to tensional forces.

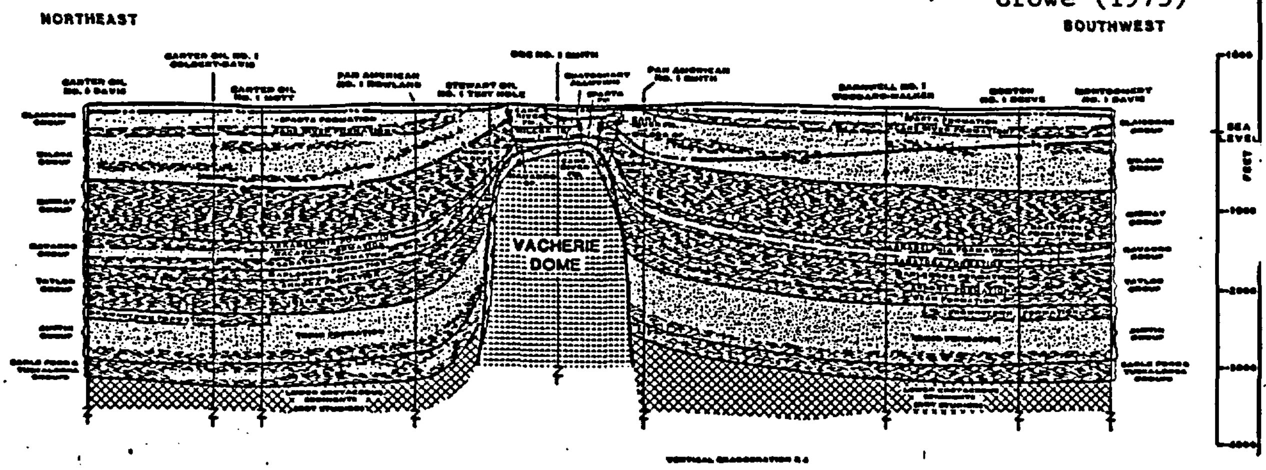
p. 3-23, Fig. 3-10. Errors of interpretation are probably great on this profile due to a lack of well control and poor lithologic understanding. Stratigraphic boundaries for some formations may have been greatly misinterpreted especially from older well logs. Crowe (1975, p. 28) states "The top of the Arkadelphia is difficult to correlate on the electric logs because there is no definite break between the marl and the overlying shale of the Midway Group on either the resistivity curve or the spontaneous potential curve of the electric logs. The boundary between the Midway Group and the overlying Wilcox Group is based on a lithologic change between the Midway shale and the Wilcox sand. The contact is gradational and a very inconsistent time maker." The understanding of local lithology, stratigraphy, and structure is of crucial importance to the geophydrologic modeling of these strata, their mechanical properties, and to radio nuclide containment. The EA



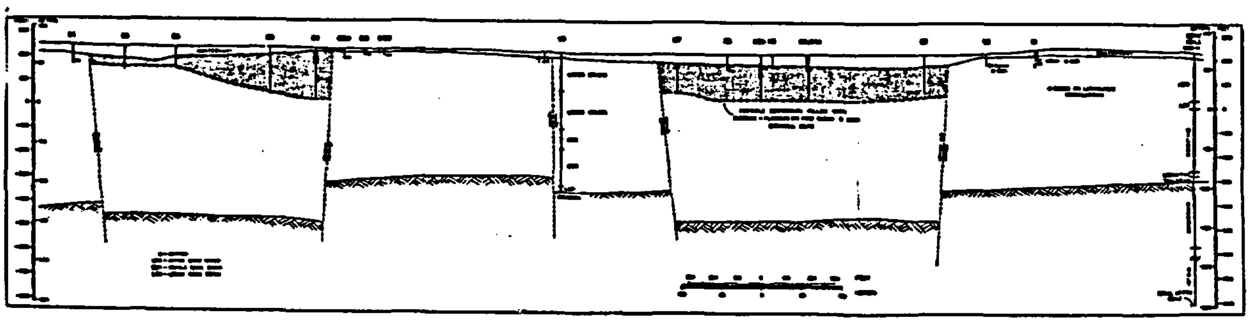
Spooner (1926)



Crowe (1975)



LETCo (1982, ONWI-119)



Kolb et al. (1983, ONWI-467)

has omitted important information by presenting only this idealized profile across the dome, based on outdated data. The major down-to-the-southeast normal fault shown on the Midway and Nacatoch structural maps, and the Midway isopach (LETCo, 1982, ONWI-119) and the structural features intrepreted from high-resolution seismic profiles (Ertec, 1984, ONWI-520) should be presented in several updated cross-sections.

p. 3-23 to 3-24, sect. 3.2.2.3, para. 5. The discussion of anomalous zones in the text is minimal and their characteristics are downplayed. Although they as yet have not been identified by the minimal exploration, the presence of anomalous zones is nearly certain, and not just possible.

The presence of anomalous zones and elevated temperatures can cause a large group of associated problems. Differential stress due to the different coefficients of thermal expansion in different materials could lead to spalling and other types of failure which greatly exceed those found in other non-thermally stressed mines. In particular, the high coefficients of expansion which characterize gases present should be expected to lead to "blow-outs" even under conditions which normally do not lead to such events.

The presence of a borehole or shaft has an equivalent effect on the possibility of failure. While the elevated temperatures expected would lower the failure rates and extent, they would enhance flowage of the salt as a response to unloading. The differential motion could lead to enhanced permeability in what is the most likely area of leakage. While the salt may flow in response to stress, the material in the anomalous zones would have a much greater tendency to fracture. To properly isolate the waste from any anomalous zones may reduce the areal extent of the repository to a level below that required by the guidelines. These zones cannot be distinguished by either gravity or seismic methods and so must be, in effect, "tripped over" during mining to determine their presence.

DOE core hole DOE-V (vertical) did not encounter any features definitively diagnostic of an anomalous zone, but anomalous zones tend to be vertical or steep, and a single vertical hole has a minimal chance of such an encounter. Anomalous zones have often been encountered while mining salt domes in the Gulf Coast Region. These zones can range from 3m to 100m wide and run hundreds of meters long at the edge or interior of a dome. Their vertical extent is difficult to determine. Anomalous zones usually contain bands of "low-grade" dark salt, inclusions and gas pockets throughout shear zones (Kupfer, 1979). Gas pockets can contain pressurized CO_2, CH_4, CO, N_2, or H_2S that "blowout" when intercepted by the mining front. Case histories indicate that some domes are more prone to blowouts than others, although the reasons are not clear (Thoms and Martinez, 1979). This may be due, in part, to mining practices.

Repository design will need to allow for the presence of anomalous zones and define barrier pillar widths to avoid peripheral anomalous zones which are almost certain to exist. This designed width will no doubt change during mining as experience and knowledge about the dome is acquired. Thus, repository designs do not appear to be flexible or allow for changes during mining. This is critical for Vacherie Dome in that storage space is very limited and the interception of anomalous zones will certainly reduce the estimated storage area.

Methane and hydrogen sulfide gases associated with anomalous zones will also affect repository design. Gassy mine regulations require crosscuts at intervals of less than 100 ft, making the proposed storage room design inadequate, and more frequent crosscuts will increase the extraction ratio. Emergency capability is also relevent implying the need for refuge stations for personnel; such stations are not shown in repository plans. Specially designed equipment, classsified as permissable by the U.S. Bureau of Mines, is necessary for operation in environments containing less than 1.0% methane and must be shut down if concentrations exceed 1.0% . This equipment is required by gassy mine regulations, thereby complicating a ventilation network and maintenance procedures. Although the repository will be deeper than mining horizons in salt domes currently being mined, there is no evidence of gas occurrence increasing or decreasing with depth (Schatzel and Hyman, 1984).

Avoiding anomalous zones is of primary concern. Blasting into a gas pocket could release large amounts of gas, although personnel could be far enough removed to be unaffected. Most gas pockets blowout during a mine blast. However, continuous mechanical mining into a gas pocket would present a high risk to the mining equipment operator.

Research to predict gas outbursts in advance of mining is ongoing (Mahtab, 1982). These techniques are based on drill and blast methods, as drill holes form the basis for future gas outburst prediction. Continuous mining methods do not offer advance examination of rock conditions beyond the face, and, therefore, may not aid gas outburst prediction without special drill holes used for probing.

Anticipation of or occurrence of anomalous zones adversely affect mining schedules for a number of reasons. Advance drilling is slow and will impede drill development from approaching average rates obtained in industry. In addition, mine development may stop due to geologic studies to decide how to best avoid an anomalous zone. Weak roof near these zones will require extra roof cleaning and roof support.

It is not clear how anomalous zones will react to heating by the stored canisters. However, even improved mining techniques or gas production methods will not regain lost storage space resulting from avoiding anomalous zones. In the Vacherie Dome, this storage space can only be recovered by developing additional levels.

[NWPA Title I, Section 8(b)(3)(B); 10CFR60.131(g); 10CFR960.5-2-9(d)]

p. 3-24, Sect. 3.2.3.2.3, para. 2. The nature of the caprock/saltstock interface is highly unusual because of the very sharp contact between these two layers based on a single core described by Nance et al., (1979). This sharp contact would seem to indicate that dissolution is not presently occurring, based on Kreitler and Dutton's (1983, p. 41) analysis of Oakwood Dome. However, Dix and Jackson (1982, p. 39) indicate that this may represent renewed movement of the salt diapir after the most recent episode of dissolution. It is very difficult to deduce the nature of the caprock or the caprock/salt interface on the basis of a single borehole; features such as shear, tension, and echelon faults and fractures have been recognized in the caprock of many other domes (for instance, in Sulphur Dome, Louisiana, by Goldman, 1952) and are suggested by the core log of DOE Smith et al., No. 1 (Nance et. al, 1979), and by profiles presented in Kolb et al., (1983, ONW1-467, v. 1, p. 117). Site characterization may discover vertical extension fractures in the caprock, as at Oakwood Dome, which can create "further avenues for ground water to enter and wastes to escape" (Dix and Jackson, 1982, p. 39) voids in the caprock or interface filled with high pressure brine, or other detrimental features that are impossible to detect with geophysical methods.

[NWPA Title I, Subtitle A, Section 112(b)(1)(E)(i)]

p. 3-26, Sect. 3.2.5.1, para. 3. The EA incorrectly implies that all faults in the geologic setting are due to diapirism. When discussing shallow Tertiary-age faulting, dissolution should be addressed as a primary cause.

p. 3-29, Sect. 3.2.5.2, para.2. The ground motion of 0.14G for Vacherie Dome is a surface motion. No consideration is given to subsurface effects, especially on shaft linings, that may markedly differ owing to different responses of different lithologies.

[NWPA Title I, Subtitle A, Section 112(b)(1)(E)(t); 10CFR60.113(b)(4), 10CFR960.5-2-11]

p. 3-29, Sect. 3.2.5.4, para. 3. Holdahl and Morrison's (1974, p. 381) analysis indicates that Northern Louisiana is subsiding at the rate of 1 mm/year (1 meter/1,000 years). If this trend is correct, terrace formation may be due to changes in discharge, sediment load, and base level, and not to uplift. The terraces over Vacherie Dome have been analyzed by Kolb et. al, (1983, ONWI-467, v. I, pp. 11-27) who measured terrace preservation and dissection. He concluded that there is some "support for solution/landscape lowering of the dome through the Quaternary" (p. 25). The contention that this area is isostatically stable may be correct, however, precise relevelling begun in 1977 (Thoms and Gehle, 1983, ONWI-412, p. 87) indicates variable uplift and subsidence which, as yet, cannot be systematically interpreted over this short amount of time. Dissolution may be occurring, or diapirism may occur in intervals.

Statements concerning regional Pleistocene uplift need to be qualified because the reader may get the false impression that Vacherie Dome is being locally uplifted whereas, in effect, the data indicates that local downwarping occurred over the dome during the Quaternary.

[NWPA Title I, Subtitle A, Section 112(b)(1)(E)(i); 10CFR 60.122(C)(10); 10CFR 60.122 (c)(11); 10CFR 960.4-2-7(c)]

p. 3-31, Sect. 3.2.5.5, para. 5. The Sibley-Ada structure exhibits its greatest structural complexity in the Lower Cretaceaus units, not the Upper Cretaceous units (Crowe, 1975; Letco, 1982, ONWI-119).

p. 3.32, Sect. 3.2.5.6, para. 2. The description of rim synclinal development during the diapiric stage is incomplete. The pillow stage occurred in late Jurassic time; whereas, the diapiric stage began in the early Cretaceaus (Crowe, 1975).

p. 3-32, Sect. 3.2.5.6. para. 3. The stability or equilibrium of Vacherie Dome is not clearly defined. The EA states that "the processes which cause vertical flow of salt (sedimentation and subsidence) have ceased in the North Louisiana salt basin, Vacherie Dome is inferred to be in a post-diapiric stage of dome evolution." The completion of dome growth does not necessarily require the cessation of forces causing vertical flow. Equilibrium of these forces with the piercement resistance of the sediments surrounding the salt stock can cause a total or temporary halt to dome growth. The cessation of dome growth has been stated in the EA, however, Karably et al., (1983 LETCo, ONWI-355, p. 39) state that "in terms of present rock temperatures, the earlier in geologic time the salt flowed from the mother salt bed, the lower the residual temperature would be." In other words "geologically younger salt diapirs may have higher internal temperatures than older diapirs". Because Vacherie has one of the highest thermal gradients of all salt domes in the Northern Louisiana salt basin, it may be inferred that diapirism has only recently ceased or is still occurring. A study result (Seni and Jackson, 1983) reveals a very low, 10 to 60 mm/1,000 years post-diapiric dome growth rate for the East Texas salt basin. A similar study for the North Louisiana salt basin would confirm or disprove the cessation of dome growth at Vacherie. Such a study need to be performed before extrapolating the results of Seni and Jackson (1983).

[NWPA Title I, Subtitle A, Section 112(b)(1)(E)(i); 10CFR60.122(c)(11); 10CFR 960-4-2-7(c)(1)]

p. 3-32, Sect. 3.2.5.6, para. 5. Analysis of seismic sections reproduced in Ertec (1983) was conducted by our project personnel. We conclude that the dome size and shape interpretations of LETCo (1982, ONWI-119, Appendix E-3) and Ertec are greatly in error and may be overestimating dome size by over 100%. A summary of our analysis is presented in Section 4.0 of this report, and a summary of important points follows:

1. Absence of processing to include migration for dipping layers was not done, resulting in an overestimation of dome size.
2. Shallow structures (faults, discontinuities) have a profound effect on sections directly below them.
3. The presence of a sheath was not included in dome areal estimates.

4. Velocities were not correctly determined for certain sections during processing.
5. Caprock velocity signatures were missing in several inferred locations.

The minimum dome area from our interpretations of seismic sections is 1,585 acres at the -3,000-ft level and possibly less due to a lack of information on the northern portions of the dome. Because of the inclusion of an 800-ft buffer zone, a domal area of less than 1000 acres is available for the repository. On this basis alone, the site should be disqualified.

[NWPA Title I, Subtitle A, Section 112(b)(1)(E)(i); 10CFR60.113(c)(a); 10CFR960.5.2.9(6)(1)]

p. 3-35, Sect. 3.2.5.7, paras. 1 and 2, Table 303. The Martinez et al.; (1979) data strongly indicate that present dissolution is occurring. Their radial contour map of salinity in the Wilcox Group has the highest salinity values centered at Vacherie Dome. Because isotopic ratios indicate a meteoric orgin for water samples, this precludes intrusion of deeper waters into the Wilcox Formation and it can be concluded that the dome is presently undergoing dissolution. It seems that continuing tests to determine dissolution rates planned in Martines et al,; (1979) were either not carried or are not reported in the EA, resulting in a huge data gap.

p. 3-35, Sect. 3.2.5.7, para. 4. As indicated above, dissolution is occurring at Vacherie Dome. This dissolution may be occurring along the sides or even the top of the dome and can take place without concomittant collapse. The large downward collapse of overdome sediments (152 meters) indicates that such processes may be active in the future, and have implications for surface facility safety. The EA states that this collapse may have occurred sporadically during Quaternary time. Further evidence for this may be indicated from Engstrom (in Kolb et al; 1983, ONWI-467, v. II, p. 13-27) who stated that terraces may have been deformed as a result of subsidence due to dissolution.

p. 3-35, Sect. 3.2.5.7, para. 6. The estimate of present dissolution rate is based upon imprecise knowledge and assumptions regarding Quaternary sedimentation. However, it is realized that the "anomalous" sand has to be taken into account. However, the question of whether thicker sections of "anomalous" sands exist over the dome has not been answered in background studies. Additionally, nowhere in the EA is the effect of increased temperatures upon dissolution rates mentioned. The enhancement of dissolution could include rather straight-forward kinetic effects, as well as an increased contact area due to differential expansion and fracturing at the dome edges.

[NWPA Title I, Subtitle A, Section 112(b)(1)(E)(c); 10CFR 60.122(c)(10); 10CFR 960.4-2-6(c)]

p.3-38, Sect. 3.2.6.11, para. 2, p. 3-39, Table 3-4. The data presented for geomechanical properties of overburden in the EA are of very limited value. It would have been better had the EA stated that no data were available rather than produce a table of misleading values. Comments on Table 3-39 follow on a point by point basis.

<u>Plasticity</u> - Martinez et al.; (1976) only present logs of borings with visual plasticity descriptions. Plasticity is thus apparently equated with "silt" or "clay" with no allowances for natural differences these two terms encompass. Atterberg limits were presented (Martinez et al; (1977), however, results of Atterburg limit determinations indicate soils vary from ML (low plasticity

silt) to CH (highly plastic clay). Thus the range of engineering behavior is quite wide.

Undrained Shear Strength - The presented values are apparently based on empirical correlations between standard penetration test results and undrained strength presented by Terzaghi and Peck (1967). This type of correlation is extremely unreliable.

Compressibility - Values of compressibility were apparently calculated from the relation Cc = 0.009 (LL-10), where LL is the liquid limit. The standard error for this relation is ± 30% and is unreported in the EA. In this case, values of LL range from 21 to 70 (Martinez et al.; 1976, - Appendix A). This range puts all values of compressibility in the low to high range. The above relationship is intended for normally consolidated clays. Soils at the site are overconsolidated, in some cases, extremely so. For clay to be normally consolidated, it must be geologically young, must always have been saturated, and must never have been subjected to overburden pressures higher than those which exist at present. None of the soils at the site fit these requirements.

Swelling Potential - Swelling potentials are estimated in terms of consistency limits and percentage of clay-sized particles from data available in Martinez et al; (1976, Appendix A). The characterization of the entire Sparta Formation as having high swelling potential is in error; it is described as "weathered sand with silty sand with occasional clay stringers." Other units have a similar wide range in lithology, minerology, and swelling potential.

Angle of Internal Friction - This is based on correlations with standard penetration tests. An intermediate correlation was made between blow count and relative density. The relative density is then related to friction angle, introducing a great deal of uncertainty in the analysis. Standard penetration test values are known to become abnormally high when gravel is encountered and can be considered unconservatively unreliable.

The maximum "low" strain shear modules (G) is a dynamic modulus. As such, it is used in computations of vibrational effects on foundations or soil-structure interaction analysis of earthquake loadings. Use of this value in any static analysis, such as settlements of structures or fills will result in an underestimation of settlement (that is, G-dynamic is greater than G-static). The correlations cited (Imai and Tonouchi, 1982) relate standard penetration test values to G_D on a log-log scale. Their recommended relationship is $G_D = (d/g)\ (0.97^2 N^{0.314})^2$ where g = acceleration due to gravity and d = density, and where shear wave velocity, $VS_1\ 0.97\ N^{0.314}$ (a straight line on a log-long plot). This masks scatter in the data. For example, for N = 10, the shear wave velocity (V_S) varies from 100 to 50,000 KN/m^2. For N = 30, V_S varies from 200 to 50,000 KN/m^2. Possible V_S values can be the same for a loose sand (N = 10) and a dense sand (N = 30) implying that the correlation is of extremely limited value.

[NWPA Title I, Subtitle A, Section 112(b)(1)(E)(i)]

p. 3-38, Sect. 3.2.6.2, para. 1. Sample testing from one borehole is of limited value and cannot represent the entire dome. The number of samples tested was minimal. The information presented in the EA on stress fields are based on data from the entire eastern coast of the U.S. and other broad regional areas. They have little to do with actual stresses at Vacherie Dome because of wide ranges of values in the original reports and values measured from many different lithologies. Hardy and Mangolds (1980, p. 62) indicated that considerable residual stress may be present in salt deposits. If present at Vacherie Dome, they will present engineering difficulties.

[NWPA Title I, Subtitle A, Section 112(b)(1)(E)(i); 10CFR60.133(e); 10CFR960.4-2-3(c); 10CFR960.5-2-9(c)]

p. 3-38, Sect. 3.2.6.2, para. 2. The ambient temperature of 126°F at the lower repository level is extremely high and will require extensive cooling for workers, even in exploratory phases. Thermal decrepitation may be a real and serious problem because of wide temperature changes. The EA states that decrepitation occurs at 842°F, however, Roedder (1984) states that decrepitation may occur at temperatures as low as 140°F, just a few degrees above "normal" pre-emplacement temperatures.

p. 3-42, Table 3-6. Rather broad ranges for the six tests of samples are given for elastic parameters. Tests were limited to above 2,000 ft. Serious doubts are raised concerning the use of these data for site characterization. Several creep law parameters are incorrectly stated. Q/R should be 7,569, not 7,569 x 10^3; beta should be 188, not 188 x 10^2. Ess was not an experimentally derived parameter, but is an assumed parameter based on Avery Island domed salt and New Mexico bedded salt data (ONWI-450, p. 42). No evaluation of the presence of anomalous zone material was presented in this table; anomalous zones will affect mechanical properties of salt.

Limited data are presented in the rock characteristics section (3.2.6). These data are, in general, from two previous studies, ONWI-295 and ONWI-450. The strength data presented for the Mises-Schleicher strength criteria are only curve-fitting parameters or coefficients. They do not have any physical meaning by themselves. Alternate methods of presenting the strength should have been considered. The shear strength curve presented on page 3-45 is a schematic curve. By not coming tangent to the two low stress circles, use of the curve is likely to over-estimate shear strength at low normal stresses.

In underground salt openings stress levels around an opening are low and over-estimation will lead to an unconservative design of the openings. The Mohr's circles presented in EA Figure 3-16 are not those at "failure" of the specimen in a classic rock mechanics sense. The circles are based on maximum allowable limit strains. The basis for the limit strain is not presented in the EA nor are the implications of this method of strength determination for the design of the underground openings. In summary, the shear strength data has a limited geomechanical use in the form submitted.

p. 3-43, Fig. 3-16. A Mises-Schleicher strength envelope and seven Mohr's circles are presented in this drawing. Only five tests can be traced back to data presented in ONWI-450 - triaxial compression tests at 24°C with sigma-3 = 5, 10, and 15MPa, and two triaxial compression tests at elevated temperatures.

Apparently, the two circles for which raw data could be found, represent tests of an unconfined compression test (sigma-3 = 0) and some type of tension test. No reference to these tests was found. Selection of the Mises-Schleicher strength criteria will lead to an overprediction of available salt strength at low normal stresses. Low normal stress is typical of rock conditions near the face of an opening. Tests used to establish failure criteria were conducted at room temperature (24°C). The in situ temperature at the repository level is 57°C. As seen in Figure 3-16, strength decreased for increased temperatures (T=100°, 200° C). Therefore, strength parameters, K, alpha, and beta in Table 3-6 are not valid for the expected thermal regime prior to waste emplacement.

p. 3-45, 3-46, Sect. 3.2.7.2, para. 4. Not only does the halite include water in inclusions, but also hydrocarbons and other gases. The implications of these inclusions are that blowouts may occur.

p. 3.54, Sect. 3.2.8.2, para. 3. The presence of a 23-ft thick lignite seam at Vacheire Dome represents a high potential for development of this resource. Lignite had been planned to be mined in nearby Red River, Bienville and DeSoto Parishes. The chance encounter of the thick seam at Vacherie Dome by a borehole indicates that thicker seams may exist. The lignite also has good potential for gasification.

p. 3-54, Sect. 3.2.8.2, para. 4. The EA neglects to mention that a large "silica" mining operation, Dresser Mineral Industries, mines Sparta sand for glass production, approximately two miles north of the Vacherie Dome. The Sparta outcrops at the Vacherie Dome represent a potential valuable resources because of their quality.

[10CFR960.4.2.8]

p. 3-58, Sect. 3.3.1.1. No data are presented for discharge of Bashaway Creek or its tributaries. This stream is of prime importance because of its planned diversion to the south of the surface facilities. The nearest streamflow gaging station is about 20 km away, and is one of two in the entire drainage basin. This one station (07352500) supposedly is representative of at least 2/3 of the basin and does not produce specific information for the Vacherie Dome site.

p. 3-61, Sect. 3.3.1.2, para. 3. The surface water quality data, as presented in the EA, is very incomplete. It is unwarranted to base conclusions on such sparse but easily obtainable data.

p. 3-61, Sect. 3.3.1.3, para. 2. A large portion of the surface repository area would be flooded by large storms, yet no information is presented for flood flow to be used in design purposes. A calculation of peak discharge for Bashaway Creek can be made by using the Soil Conservation Service method, as outlined by Viessman et al. (1972). Using a basin area of 7 square miles and a probable maximum 6-hour precipitation of 9 inches, the peak discharge that can be expected at the mouth of the stream is 3,182 cfs, about 7 hours after the start of the storm. This represents a considerable flow of water that may lead to flooding of surface facilities or damage to the diverted channel. Flooding of hot cell areas could lead to serious contamination of surface water runoff flow.

p. 3-64, Sect. 3.3.2.1.1, paras. 1 and 2. Hydrogeologic data, as presented in this section, are of limited value due to overgeneralization of conditions present in the Vacherie Dome vicinity. The EA has oversimplified hydrogeologic units by combining water-bearing and non-water-bearing units. The EA recognizes four aquifers: the "upper aquifer unit," the Sparta aquifer unit, the Wilcox-Carrizo aquifer unit, and the Austin aquifer unit; and four aquitards: the Cook Mountain confining unit, the Cane river confining unit, the Midway-Navarro-Taylor confining unit, and the Eagle Ford-Woodbine confining unit. Of these, the Cook Mountain is not present at the Vacherie Dome; the Sparta sands being overlain directly by terrace and recent alluvial deposits. The Nacatoch Formation is a sand layer at Vacherie Dome and should not be combined with the Midway and Taylor groups. The Cane River Formation has a silty-sand layer near its top. The Woodbine Formation is composed partly of massive sandstone (as indicated in EA Table 3-18). The Wilcox has several clay and lignite layers which as as aquitards. A more realistic grouping should have been constructed, not based on regional data, but on local characteristics.

Table 3-18 (EA p. 3-67) is of little use because of the broad range of values for hydraulic conductivity, transmissivity, and thickness. These values were obtained from a broad regional data base, masking actual hydrologic properties of material surrounding the dome. Aquifer anisotropy is undoubtedly of major concern in determination of directions and rates of radionuclide movement, yet little discussion is given to this in the EA.

It is generally recognized that many of the Eocene formations represent ancestral Mississippi River deposits (INTERA, 1984, p. 21), therefore coarse paleo-channel deposits would be preferentially oriented in a north-south direction, along with layers of lignite, shale, and other fine-grained deposits which represent the channel fill and floodplain. The wide variation in regional aquifer properties presented in the EA is therefore expected for a regional determination. However, due to the complexity of these deposits, regional models, at best, are a poor characterization of aquifer properties along the paths of possible radionuclide travel. The various shallow marine formations (Austin, Taylor, Navarro, and Midway Groups) are also undoubtedly anisotropic both vertically and horizontally in the dome vicinity. Several facies may be present in these deposits which may represent a combination of terrigenous tidal-dominated and weather-dominated facies. In the vicinity of the dome, these facies are likely to be even more complex due to domal uplift. Well control for these lower formations is too sparse to even make an estimation of this point. The complexity of their actual hydrologic properties in the dome vicinity makes the groundwater flow models inapplicable to the understanding of groundwater flow paths.

p. 3-69, Fig. 3-23. The long arrow NNE of Vacherie Dome pointing towards the dome and presumed to show the general direction of flow, actually runs on top of a hill rather than valleys on either side.

p. 3-70, Sect. 3.3.2.1.1, para. 4. The upper aquifer unit is not clearly defined. The EA states that this aquifer is the uppermost waterbearing unit and may contain saline water locally, referring to Hosman (1978, p.10). Hosman's description is for the Cockfield Formation, a member which is missing over the dome due to erosion. The real upper aquifer is the Quaternary terrace deposits and alluvium, which is in hydraulic connection with the Sparta sands over the dome and in the surrounding area.

p. 3-70, Sect. 3.3.2.1.1, para.1. The porosity values for the Sparta Formation are not present on page 32 of Slaughter et al. (1983, ONWI-356). Values begin with the Wilcox Formation. A single porosity value for well LVH-6B is given on page 33. It is unclear how the range in the EA was derived.

p. 3-70, Sect. 3.3.2.1.1, para. 2. Because estimates of field hydraulic conductivity are stated to be not available, flow through this unit is unknown at Vacherie Dome. Porosity ranges for this formation are not derived from the pages referenced in Slaughter et al., (1983, ONW-356, p. 32, 38-39). Their origin is unknown.

p. 3-70, Sect. 3.3.2.1.1, para. 3. Storativity values have too wide a range to be of any use for Vacherie Dome. Porosity values as high as 0.38 do not occur in LVH-6A. The orgin of this higher value is unknown.

p. 3-70, Sect. 3.3.2.1.1, para. 4. The Nacatoch sand is a water-bearing unit at Vacherie Dome and should not be included with the Midway and Taylor Groups. Storativity values given here are of limited utility.

p. 3-70, Sect. 3.3.2.1.1, para. 6. The EA states that the Eagle Ford-Woodbine is "relatively impervious based on its lithologic composition." Massive sandstone contained in the Woodbine is indicated to contain salt water in Table 3-18 (EA p. 3-67), and is not impermeable.

[NWPA Title I, Subtitle A, Section 112(b)(1)(E)(i); 10CFR60.113(a)(2); 10CFR960.4-2-1(b); 40CFR191-15]

p. 3-70, 3-73, Sect. 3.3.2.1.2. The use of broad regional data for ground water flow is of limited value for determining paths of groundwater flow in the vicinity of Vacherie Dome. Flow in the dome vicinity is largely controlled by steeply dipping strata associated with diapirism, and numerous fault and fracture systems which were poorly investigated. Major pathways for vertical and horizontal flow include the numerous near-vertical faults and fracture zones associated with diapirism and dissolution, and the disturbed zone immediately adjacent to the salt stock. The inferred lineaments from aerial imagery indicate that near-vertical fracture concentrations exist in surrounding strata. Unfortunately, any fracture trend analyses were not reported in the EA.

Fractured areas are known to be zones of much higher hydraulic conductivity than intact strata. Fetter (1980, p. 224) estimates that these types of features have hydraulic conductivities 10 to 1,000 times greater than that of adjacent material.

Fractures and faults create avenues for vertical flow through strata with low hydraulic conductivity. Evidence for aquifer interconnectedness is presented by Martinez et al., (1978, p. 106) who note that water well LVH-6, drilled over the dome has an anomalous pressure head. This well was screened ind the zone of the salt/caprock interface in an area where the dome is directly overlain by the Wilcox Formation. They stated that the caprock "cavity" may be " . . . in hydraulic connection with the deeper, high-pressured aquifers." This is also suggested by temperatures 11 to 12°F higher than other wells at equivalent depth.

Saline springs over the dome and saline ground water anomalies in the Wilcox aquifers are further evidence of aquifer interconnectedness. One large saline spring was noted by Spooner (1926, p. 239) who stated: "Fresh water springs are numerous around the base of the hills, and a spring of saline water is present in the SW 1/4 of section 15 T17N R8W. This spring, according to people living in the vicinity, has increased several times in volume during the past fifteen years."

[NWPA Title I, Subtitle A, Section 112(b)(1)(E)(i); 10CFR60.113(a)(2); 10CFR960.4-2-1(b); 40CFR191.15]

p. 3-73, 3-75, Sect. 3.3.2.2. The INTERA (1984) hydrogeologic model is of limited use for Vacherie Dome. Data was restricted to only published information (INTERA, 1984, p. 3) and covers a broad region. The lack of aquifer data for lower formations casts doubt on successful modeling. Well control is poor for the Austin and Nacatoch aquifers and virtually non-existent for the Woodbine aquifer. Evaluations of hydraulic interconnection did not include numerous fracture concentrations in the formation. Hydraulic gradients for lower formations are based on three or four test wells.

Estimates of travel time to the accessible environment in INTERA (1984) may be in error by several orders of magnitude. Average hydraulic conductivity values were used to model aquifers. A conservative modeling technique would be to use the highest values available, because they represent the fastest travel times. Hydraulic gradients used by INTERA (1984) are also averages of broad regional data that are of little significance to actual hydraulic gradients of steeply dipping strata on the flanks of Vacherie Dome. Porosity values used by INTERA (1984) are actual porosity and not effective porosity as should be used in velocity determinations. The INTERA (1984) study arbitrarily assigned porosities of 0.25 to all aquifers used in the modeling. Effective porosities are probably much lower along paths of fastest travel.

An analysis of travel time was conducted by our project personnel using the following initial values:

AQUIFER	EFFECTIVE POROSITY (dimension/ess)		HYDRAULIC CONDUCTIVITY (m/day)	HYDRAULIC GRADIENT (dimension/ess)
Sparta	0.25	0.20	30.2	5.2×10^{-3}
Wilcox	0.25	0.20	4.6	4.4×10^{-3}
Nacatoch	0.25	0.20	0.3	2.0×10^{-3}
Austin	0.25	0.20	0.4	1.4×10^{-3}

Effective porosities of 0.25 are derived from INTERA (1984), values of 0.20 are provided for comparison because they may more closely represent actual values for the Wilcox, Nacatoch, and Austin aquifers. Hydraulic conductivities for the Sparta and Wilcox Formations represent highest values obtained from Hosman (1978). The hydraulic conductivity for the Nacatoch Formation was obtained from LETCo (1982, ONWI-119) and that for the Austin from INTERA (1984). Because of a lack of hydraulic gradient data for the vicinity of the Vacherie Dome, hydraulic gradients for the Sparta, Wilcox, and Austin aquifers were obtained from INTERA (1984). The hydraulic gradient for the Nacatoch Formation is an average of Wilcox and Austin values. Actual hydraulic gradients may be much higher for some formations because of hydrocarbon extraction within two to five miles of the dome, heavy pumpage from the Sparta aquifer two to five miles north of the dome by Dresser Mineral Industries which extracts 1.5 million gallons per day, and highly dipping strata.

Velocities were calculated using the standard seepage velocity equation:

$$V = \frac{Ki}{N}$$

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Where V is the velocity, i is the hydraulic gradient, and N is the effective porosity. The results are presented in the following table:

AQUIFER	VELOCITY (meters/yr)		TRAVEL TIME 10 km (yrs)		TRAVEL TIME 2 km (yrs)	
	N=0.25	N=0.20	N=0.25	N=0.20	N=0.25	N=0.20
Sparta	229.6	287.0	43.6	35.0	8.7	7.0
Wilcox	29.4	36.8	340.1	272.0	68.0	54.0
Nacatoch	1.3	1.6	7,692.3	6,250.0	1,538.5	1,250.0
Austin	0.9	1.1	11,111.1	9,242.0	2,222.2	1,848.0

Travel times calculated above are two orders of magnitude higher than those calculated for the Wilcox Formation in INTERA (1984, p. 125) and twice as high as those calculated for the Austin. These values may be too conservative for reasons stated above. Additionally, waste migration along fractures may be enhanced by the convective nature of the waste-heated effluent. Shaft construction techniques may enhance vertical travel because of the creation of disturbed rock zones surrounding the shafts. Freeze-blasting techniques will result in enhanced fracture propogation through frozen materials over regular mining techniques. Permeability will be enhanced by expansion of water in voids due to freezing. Pre-existing fractures and faults will also enlarge due to freezing water. The net result will be the creation of a disturbed, permeable zone around shafts through which radionuclides may escape to the accessible environment.

[10CFR 960.4-2-1(b), 40CFR 191.15, NWPA Title I, Subtitle A, Section 112(b)(1)(E)(i), 10CFR 60-113(a)(2)]

p. 3-75, Sect. 3.3.2.3, para. 1. The conclusions in the EA based on "median boron concentrations" are doubtful. No boron analyses are reported in LETCo (1982, ONWI-119) or any other available supporting documentation.

p. 3-77, Table 3-19. Table 3-19 incompletely summarizes available data on groundwater quality. Data from LH-17 should have been included as it is closer to Vacherie Dome than LH-2. Data from well LH-17 indicates that the lower Wilcox Formation has a lower TDS than the upper Wilcox at LRH-13 near Rayburns Dome (ONWI-119, v.5, Appendix C-3). The exclusion of this and other important data indicates that water quality modeling is questionable.

2.4 Chapter 4.0 - Expected Effects of Site Characterization Activities

p. 4-2, Sect. 4.1.1, para. 2. The EA states that locations of field activities are tentative. Moving locations will affect environmental impacts greatly primarily due to the extent of stream diversion and fill.

p. 4-15, Sect. 4.1.1.1.1, para. 4. References to Figure 3-18 shows it to be a general soil classification diagram for Louisiana and Mississippi. There is great unclarity concerning the extent of Bashaway Creek characterization.

p. 4-15, Sect. 4.1.1.1.3. The definition of upper aquifer is unclear. In Chapter 3 of the EA it included alluvium, terrace deposits, and the Cockfield Formation; in Figure 4-4, the upper aquifer is the Sparta Formation.

p.4-16, Fig. 4-3. The location of the surface facilities on the dome should have been very carefully evaluated with considerations of topography and locations of Bashaway Creek and its tributaries. The location shown on Figure 4.3 is different than the other locations shown in the attached photocopies. The planned overdome stratigraphic boreholes only are designed to penetrate the edge of the dome, as shown in this figure. If our calculations of dome size are correct, these boreholes will not encounter the salt stock. It is recommended that additional boreholes be located on the dome. The singular engineering design borehole, even in conjunction with exploratory shafts, will be insufficient to characterize the dome. The location of multiple aquifer test well sites are too far away from the repository to determine the effect of steeply dipping, fractured strata on hydrogeology. Additional wells should be located on dome flanks.

p.4-24, Sect 4.1.1.1.12. It is doubtful that a single borehole will deduce the nature of the "anomalous sand" layer. The anomalous sand layer has been shown to be highly discontinuous by Kolb et al. (1983, ONWI-467).

p-4-24, Sect. 4.1.1.1.24. The large area used for 3-D seismic reflection surveys (26 Km^2) will cause major disruptions of the surface environment. The main effect will be the creation of a grid of 30-meter by 30-meter cells, whose boundaries will be devegetated. Grading and leveling over this area is of serious concern.

p. 4-24, Sect. 4.1.1.2.1. The use of shallow aquifer ground water from the dome for the EDBH will influence hydrogeologic monitoring.

p. 4-24, Sect. 4.1.1.2.2. The 350 foundation boreholes will cause a major disruption of the surface facility area due to clearing of vegetation. If this area is not recommended for a repository, it will have to be restored.

p. 4-29, Sect. 4.1.2, para. 6. The ESF is not designed to meet any of the criteria outlined in this paragraph. The ESF facility will be located on a flood plain near a junction with a major tributary resulting in the need for filling and excavation activities. These activities will promote erosion and sedimentation around the site. Clearing and disturbance will be major in this area. The grading and filling requirements will encompass an area larger than that of the ESF site.

p. 4-33, Fig. 4-10. The layout of the exploratory shaft facility is based upon an outmoded design. Because a 2-level facility is planned for Vacherie Dome, this figure should reflect 2-level testing. No rationale or background information is given for orientation selection of the underground facility, or if the facility is adequate for all proposed testing.

p. 4-34, Fig. 4-11. The location of the 10-ft shaft plots close to the edge of the dome as determined by Ertec (1984, ONWI-520), and outside the dome as determined by us. The two shafts stradle Bashaway Creek, indicating that stream diversion must occur before shaft construction. It is recommended that the shaft locations be moved North.

p. 4-51, Sect. 4.1.2.2.2, para. 4. When the steel liner is floated into place, it is filled with water to resist buoyancy forces. After the outside annulus is filled with grout and sets, the internal water is pumped out. Before this water is pumped out, the steel liner is in equlibrium with the outside grout hydraulic pressure and the internal water hydraulic pressure. As the internal water is pumped out, the liner will tend to relax inwards as it destresses itself. This relaxation will lead to separation of the liner from the grout, cracking of the grout, and separation of the grout from the rock. Groutlines could be damaged during casing emplacement. The EA makes no mention of checks to assure adequate grout-rock bond. All of this will provide pathways for vertical water leakage.

[NWPA Title I, Subtitled, Sec. 112 (b)(1)(E)(iii), 112 (b)(1)(i)(ii); 10CFR 60.133(d); 10CFR 60.134(a)]

p. 4-39 to 4-40, Table 4-4. This table is outdated because of the 2-level concept. All quantities are now different. The plan view of the workings (p. 4-65) shows a total of 3,960 linear ft which disagrees with the 4,250 ft estimate given in this table. The quantity of material excavated is 267,000 cubic yards while storage volume is 282,000 cubic yards. It is unclear whether this represents bank yards or if swell factors were considered. These volumes are much higher than our calculations from given excavation dimensions.

p. 4-40, table 4-6. The estimated number of dozers, graders, and trucks is undoubtedly underestimated considering the amount of surface preparation required. Activities will include excavation of diversion channels, filling of the Bashaway Creek floodplain, compaction of fill, excavation on the north side of the site, and other modifications. It is difficult to maintain an 8½-month site preparation schedule with this equipment.

p. 4-53, Sect. 4.1.2.2, para. 6. The assumption that the shaft is watertight is invalid. There is some questions regarding the disturbed zone around the shaft caused by blasting, and the effectiveness of grout sealing in the presence of "freezing" is uncertain.

p. 4-55, Sect. 4.1.2.2.2, para. 7. Gas detectors and monitors must be inspected daily to assure proper operation. There is no discussion of system maintenance programs, or whether monitors can withstand repository conditions.

p. 4-56, Sect. 4.1.2.2.3, para. 2. The 10-ft diameter shaft will make transport of excavation equipment to the repository level very difficult, therefore, increasing mobilization time. The smaller the shaft, the more a piece of equipment must be broken down for transport.

p. 4-52, Fig. 4-17. It is unclear what measures will be used to minimize disturbed rock zones during shaft construction.

p. 4-62, sect. 4.1.2.2.5. This section was written with regard to a single-level repository; if a multi-level repository design is used, then testing should be done on several levels to monitor interaction possibilities.

p. 4-71, Sect. 4.1.2.4.7. No mention is made of the fate of Bashaway Creek. It is assumed that the creek will be diverted to south of the site, and a large fill will exist in its former location. The channelized creek can only be restored to its former position at great expense.

p. 4-72, Sect. 4.1.2.6. The draft EA identifies existing municipal and commercial disposal facilities which (1) can lawfully accept the wastes; (2) have sufficient capacity; and (3) would consider accepting the waste.

The availability of existing sites may not be relevant compared to availability of sites five or ten years in the future. State and Federal criteria for siting landfills and regulations pertaining to landfills are in a state of flux. Additionally site life is an important. Many landfills currently in operation may not be in operation in two, five or ten years. As existing sites are closed, the site life of remaining sites may be substantially decreased. It is becoming increasingly difficult to site new landfills, particularly those which accept speical or hazardous wastes, due to increasing public opposition to such sites. The general waste management trend is the avoidance of landfilling of hazardous wastes where possible.

Salt disposal may require special criteria for landfilling. There is evidence (Crooks and Quigley, 1984) that salts within leachate migrate significantly ahead of the main leachate front beneath the landfill by molecular diffusion. Consequently, special siting and construction criteria may be involved for the disposal of large amounts of salt. Such migration, if disposal at a hazardous waste site is considered, should be studied with respect to its affects on other mobile contaminants.

p. 4-82, Sect. 4.1.3.1.5. The EA states that the soil survey will include "depth to a limiting layer, such as caliche." It would be unusual to find caliche horizons in Louisiana; probably this was written for western sites where caliche occurs. This indicates that planned soil surveys are generic and not site specific.

p. 4-87, Sect. 4.2.1, para. 4. The EA is comparing the quantity of airborne salt from Louisiana wastepiles to that in New Mexico. The analogy is poor because of great differences in climate. A better estimate would have been to usee airborne quantities from Gulf Coast salt mines if any have salt piles.

p. 4-80, Sect. 4.2.1.1.1. This section describes major disruptions over an area of 5,190 acres (8 miles^2). The EA attempts to minimize the actual impacts by not providing a calculation of the total impact on the site, but instead provides piecemeal estimates for individual impacts of various activities. The EA neglects to list borrow pits, access roads, and stream diversions as land disturbances. Actual disturbance and deforestation may entail several square miles.

p. 4-90, Sect. 4.2.1.2.1, para. 1. The EA calculates clearing will entail 478 acres of land. This estimate does not include cleared areas for borrow pits and stream diversion.

p. 4-92, Sect. 4.2.1.2.2, paras. 3 and 4. The diversion of Bashaway Creek and its tributaries has clearly not been investigated enough in the EA. Locations for Bashaway Creek to the south of the site would have to be excavated to depths of 30 ft or more in some areas. It would be very difficult to create a "natural" channel under those conditions. Expected results will be very much higher peak floods due to elimination of the floodplain, high sedimentation and turbidity in Bashaway Creek and Black Lake Bayou for extended periods of time, and rapid changes in flow hydrograph is. Impacts on aquatic vegetation and biota will be severe for the Bashaway Creek Basin and the Black Lake Bayou basin. This will result in the loss of original ecosystem diversity for both basins.

p. 4-103, Sect. 4.2.1.4.1, para. 9. The EA states that rainwater is expected to dissolve very little salt after crust formation, however, the crusted-over salt pile may be expected to lose 5% per year from runoff according to Ver Planck (1958). Stockpiled salt in the salt industry is de-icing salt, which is coarse salt about 0.25 inches or more in diameter. The continuous miner salt from the ESF (which will be on top of the pile) is fine salt because it is scraped and gouged from the face. This will contribute to winds blown desposition more so than indicated.

[NWPA Title 1, Subtitle A, Sec. 112(b)(1)(E)(iii), 10 CFR960.3-4, 10CFR 960.5-2-5(c)(3), 10CFR960.5-2-5(d)(1)].

p. 4-106, Sect. 4.2.2.5, para. 3. The EA states that the worst-case soil loss would be 30 tons/acre/year. For a disturbed area of 478 acres, this translates to 14,340 tons/year. This will be most severe during construction and diversion activities, before catchment basins and culverts can be developed. This material will adversely affect Bashaway Creek and Black Lake Bayou. Worst case erosion may be more severe if a probable maximum storm, hurricane, or severe thunderstorm occurs during site preparation.

p. 4-106, Sect. 4.2.1.5.2, para. 4. The EA states that "The generally poor consolidation of the deposits, however, will limit the lateral propagation of cracks and the fracturing is not expected to cause surface subsidence or contribute to overdome fault reactivation."

Considerting the potential for dissolution, and the previous history of overdome collapse, this statement cannot be made with certainty. If dissolution has been occuring throughout the Quanternary and another collapse is imminent, shaft activities could trigger such a collapse.

p. 4-125, Sect.4.3.2, para. 5, The Department of Labor's Mine Safety and Health Administration (MSHA) regulation 30CFR57.21-46 states that crosscuts shall be made at intervals not to exceed 100 ft for mines operated under gassy conditions. This is not followed in the exploratory shaft facility plan. If the ESF or repository is "gassy," neither has been designed as such.

[NWPA Title 1, Subtitle A, sec. 112(b)(1)(i)(ii); 10CFR60.131(b)(9)(a)].

p. 4-117 to 4-124, Sect. 4.2.2. The socioeconomic impact section in the EA is of limited value. For example, the estimated peak "in-migrating" school-age children in Heflin will be 8, which appears unrealistic. Any predictions of population and worker trends should be presented with probable errors. In the EA analysis, the probable errors could be great enough that any trends are unpredictable.

p. 4-127, Sect. 4.3.4.2, Onsite Landfill. If onsite landfilling is considered for salt disposal, the site will be regulated as a special waste landfill. This will require possibly at least two years for all of the appropriate studies to be done and permits to be aquired. Studies of salt diffusion through the liner should be conducted, as well as environmental impact analyses.

p. 4-130, Table 4-29, Point 5. It is clearly recognized that not enough is known about local ground water conditions. Consequently, the activities planned for Vacherie Dome may affect both ground water quality and the hydrogeologic conditions. This ranks as a potentially adverse condition.

[10CFR960.4-2-1)

2.5 Chapter 5.0 - Regional and Local Effects of Locating a Repository at the Site

p. 5-2, Sect. 5.1.1.1, para. 2. The estimate of 400 acres given in the EA for surface facilities is outmoded. The two-level repository would require 530 acres of land. It may be assumed that this entire chapter is based upon outmoded designs that could result in less severe impacts than current designs.

p. 528, Fig. 5-13. The ESF is about 4,000 ft or more away from the closest waste panel. This distance severely questions the use of ESF data in design considerations. Confirmatory boreholes may resolve inconsistencies or may create inconsistencies. [NWPA Title 1, Subtitle A, Sec. 114(a)].

p. 5-11, Sect. 5.1.1.3, para. 3. The shaft pillar location will be in the area of ESF experimentation, while waste panels will be located about 4,000 ft away. The reason for offsetting the shaft pillar to one side of waste panels is not clearly stated in the EA. This paragraph implies that space is valuable due to limited storage area within the dome, if heater tests suggest pitch should be increased from the planned 60 ft or if anomalous zones are intercepted, available space will become critical.

p. 5-12, Fig. 5-5. The relation of the exploratory shaft facility to the repository underground layout is not stated in the EA. There is no indication of this relation in drawings of the underground facility.

p. 5-15, Sect. 5.1.1.4, para. 2. The EA states that the cross-section of the passageways will be rectangular with total drift lengths of 118,500 ft. The rectangular design of passageways is much less stable than circular or horseshoe cross-sections due to stress concentrations, increases in creeps rate, and spalling. According to IT Corporation (1984, BMI/ONWI-546, p. 52), Vacherie Dome salt has the highest rate of volumetric closure due to creep of all of the potential salt repository sites. A closure of 45% may occur in as little as 30 years for circular openings at Vacherie Dome based on laboratory creep tests. For rectangular openings, the creep rate will be much higher. ONWI-482 (Fig. 2p6) also shows that creep closure rates are the highest for Vacherie Dome salt, with a 10% closure limit reached in only two years. The underground facilities must be kept open for at least 26 years and possibly 50 years for waste emplacement and retrieval. This high rate of creep closure requires a great deal of maintenance and remining of passageways, more so than any other site, even without the added effect of waste cannister heat.

p. 5-16, Sect. 5.1.2.1, para. 4. The initial development for one year's waste emplacement leaves the majority of the repository unexplored by any means. Waste will be emplaced while elsewhere unknown geologic conditions are being developed. This is not prudent. After completion of ESF testing, the new area is still not characterized, but waste will be emplaced, and retrievability will not be demonstrated for five years or more.

[NWPA Title 1, Subtitle A, Sec. 112(b)(1)(i)(ii), Sec. 114(a); 10CFR 60.133(c); 10CFR60.41; 10CFR60.140(a)(1)(d)(2)].

p. 5-24, Sect. 5.1.2.3, para. 3. The site preparation estimates of fill and excavation indicate a major discrepancy in the amount of fill which must be trucked in. Subtracting the amount of excavation from the amount of fill leaves a deficit of 3 million cubic yards of material that must be brought in from elsewhere. However, because the quantities were calculated for the outdated 400-acre surface facility concept, additional fill must be brought in for an additional 130 acres. An estimate of the additional amount of fill can be made by assuming that surface facilities will be at an elevation of 233 ft MSL (ONWI-283). In lowlying areas, such as the former position of Bashaway

Creek, fill will have to be piled 43 ft high. Using a conservative average elevation of 215 ft MSL for the additional area to be filled, approximately an additional 3,775,200 cubic yards are needed, for a total of 6,775,200 cubic yards that must be trucked in. A total of 225,000 truck trips of 30-cubic-yard-capacity would be required, requiring an immense fleet of trucks, loaders, graders, compacters, and other equipment. Because site preparation schedules allow for 18 months, 480 truck visits per day are needed using 6-day work weeks without considering delays due to weather problems. This is one truckload every 3 minutes, 24 hours a day.

The schedule calls for shaft development to start within 9 months from the start of construction (EA, p. 5-17, Fig. 5-7). In the shaft area an approximate maximum fill of 30 to 40 ft will be emplaced to bring the surface level to 233 ft MSL. This fill will settle due to deformations in the material itself and in the underlying foundation soils. This settlement will be time-dependent; no reasonable estimate of the magnitude or rate of settlement is possible from data presented in Table 3-4 (EA, p. 3-39). Aside from the inadequate characterization of soil properties, the compositon of the fill soils and the stratigraphy of the shaft sites have not been defined. If settling occurs after shaft construction, the settling soil will exert down-drag force around the periphery of the shafts. This must be considered in the design of the temporary liners to prevent water intrusion through cracks.

The water content of the fill is another consideration which may delay completion of site preparation. The water content of a fill as it is being compacted has a large impact on its engineering properties. Some control of this moisture will be necessary, that is, drying if moisture content is too high, and wetting if the moisture content is too low. The careful control of moisture content in the fill will add time to the construction schedule.

[10CFR960.5-1(a)(3)]

p. 5-24, Sect. 5.1.2.3, para. 6. Discussions is provided regarding several types of retention ponds for waste salt, storm water retention, and non-radioactive liquid wastes. No provisions are amde here or elsewhere in the draft EA for retention, storage, or disposal of radioactive liquid wastes. There is a tacit assumption throughout the EA that liquids will not be radioactively contaminated. Yet, as discussed in several parts of this report, the potential for inflow to the repository during operation is high. The experience at other Gulf Coast salt dome mines has indicated inflows from several sources such as anomalous zones, brine pockets, fracture zones, etc. Consequently, the subject of radioactively contaminated fluids needs to be addressed.

p. 5-25, Sect. 5.1.2.4, para. 1. A ground water flow rate of 3 to 5 ft per day is maximum for successful freezing operations (NUREG/CR-2854, p.21) while maximum calculated velocities for unfractured material calculated in our comments for Sect. 3.3.2.2. are less than 3 ft per day. Fractures and faults, which undoubtedly will be encountered, may increase this flow rate considerably. Blasting in this saturated and frozen zone may increase the disturbed rock zone considerably beyond the shaft walls.

p. 5-26, Sect. 5.1.2.5, para. 1. The need for a feeder/breaker is questionable. If continuous miners are used, then a feeder/breaker may not be necessary, as mine run rock will be small fragments of salt.

p. 5-29, Table 5-4. No information is presented in the EA as to how the re-excavation estimate was calculated. Presumably it is the result of some type of creep analysis, but no reference is given in the EA.

p. 5-34, Sect. 5.1.3.3, paras. 1 and 2. Retrievability in salt is unlikely to be demonstrated during the repository lifetime (NUREG ICR-3489). The retrieval environment after 5 years consists of canisters at 130°C to 240°C and salt temperatures of 80°C to 120°C at a distance of 2 meters. These high temperatures will cause enhanced salt creep and cannister movement. Radiation will be present in the salt backfill from the volatile radionuclides of H-3, I-129, K-85, and C-14. The equipment to achieve retrieval in this environment does not exist and is therefore unproven.

[NWPA Title 1, Subtitle A, Section 112(b)(1)(i)(ii); 10CFR60.133(c)(a)(b); 10CFR60.111(b); 10CFR960.5-1(a)(3); 10CFR960.5-2-9(c)(3)(d)]

p. 5-34, Sect. 5.1.3.3, para. 2. If backfilling is not done at an early phase of operations, the salt will need to be stored at the surfacrior to backfilling. If this is the case, studies will need to focus on the effects of emplacing crushed salt into the repository which has been sufject to a wet and oxidizing environment. Increased moistrue content within backfill could have a significant effect upon modeling of waste caniseter corrosion. Other factors may be unavoidably present within the salt, including windborne debris, organics, and other contaminants due to salt handling, mixing, storing and exposure.

p. 5-36-37, Sect. 5.1.4.1. The discussion of disposal of contaminated equipment and materials in the subsurface repository during decommissioning does not nclude a description of how radioactively contaminated liquids will be disposed of. They cannot be disposed of within any landfill, nor can they be diposed of within the repository without adversely affecting repository performance. The subject is not discussed anywhere within the draft EA.

p. 5-39, Sect. 5.2.1.1, para. 1. The EA implies that subsurface subsidence and uplift will be minor at the Vacherie Dome site; however, the effects of long-term subsidence and thermally-activated uplift are based respectively on studies at the WIPP bedded salt site in New Mexico, and a theoretical study performed for the Paradox Basin bedded salt sites. There may be a poor correlation between the sites, particularaly when neither the Paradox Basin nor the Vacherie Dome sites have been properly characterized.

p. 5-39, Sect. 5.2.1.1, para. 3. The effect of dissolution upon tectonics has not really been addressed, as it may affect the repository. although the Vacherie Dome area may have been historically seismically inactive and active faults are not present nearby, the evidence indicates that collapse, possibly due to dissolution over the dome has occurred. If dissolution has continued to occur, cavities may be present within the caprock, thus slowly buildin up the potential for further overdome collapse. Without adequate characterization of such dissolution features, prior to shaft sinking, repository activities could possibly trigger such collapse.

p. 5-39, Sect. 5.2.1.1, para. 4. The potential repository impacts on dissolution have not been investigated thoroughly enough in the EA. Problems with liners, grouting, and seals have been already discussed in comments for Sect. 3.2.5.2, sect. 4.1.2.2.2, and sect. 3.3.2.2. The EA estimate of 0.002 inches of salt stock dissolution is neither conservative nor realistic.

p. 5-42, Sect. 5.2.1.3. Same comments as Sect. 3.2.8.2.

p. 5-42, Sect. 5.2.2. This section discusses several effects upon ground and surface water during construction operation and decommissioning. It fails to discuss one detail which may have major significance and which has not been discussed anywhere in the EA except for long term post closure. That is the potential for radioactive contamination of fluid during operation. At several places throughout the report, pathways for possible inflow to the repository are discussed (eq. anomalous zones, brine prockets, shaft disturbed zones, etc.). The possibility for fluid contamination exists. Fluid entering the repository will need to be pumped to the surface. The handling of such fluid will need to be addressed as it may affect surface or ground waters.

p. 5-43, Sect. 5.2.2.1.1, para. 1. The EA states that "impacts on surface water will be confined to minor alteration of the surface hydrologic regime." These "minor" alterations include relocation and channelization of Bashaway Creek and its tributaries, elimination of a flood plain, devegetation and major disruption of a large part of the drainage basin, fill of 1/7 of the drainage basin, changes in run off and ground water flow due to fill, paving and compaction, high sediment input to streams, alterations of aquatic species and several other impacts. It is questionable whether any of these alterations are "minor."

p. 5-44, Sect. 5.2.2.1.2, paras. 2 and 3. The EA suggests that only "half of the salt quantities deposited in watersheds adjacent to the repository site may be expected to enter surface water bodies." Some studies have suggested that as much as 90% of the salt may enter the watershed (Rumer et al., 1980, p. 409). It is unclear how the value of a 10-ppm increase in salinity was calculated as there are no data to back it up. Bashaway Creek probably has low flow during drier periods (no data are given in the EA for this) and would be most susceptible to increased salinity during this period. The values for salinity by Hutchinson (1973) are much less than pre-repository values for Bashaway Creek and thus have limited value.

p. 5-45, Sect. 5.2.2.1.2, para. 3. The use of multiple-effect evaporators would create vapor plumes visible at some distance. The vapor clouds would be most prevalent during cool winter months, creating "visual pollution."

p. 5-45 to 5-46, Sect. 5.2.2.2.1, paras. 1 and 2. The EA states that the Sparta sand will "yield sufficient water for peak demand without stressing the groundwater system." The Sparta is already stressed due to heavy withdrawals. Dresser Mineral Industries, 2.5 miles north of the Vacherie Dome, pumps 1.5 million gallons per day for use in hydraulic mining operations. Using data supplied on p. 5-46 (T = 250m/day, S = 0.01, Q = 45 /s (3,888m^3/day), t = 6.25 yrs (2,281.25 days)) it is possible to calculate the drawdawn experienced at Dresser Minerals, 4 km away, due to pumpage at Vacherie Dome by solving the Theis equation:

$$\text{Drawdawn} = \frac{Q}{4\text{pi}T} \left[-0.5772 - \ln u + u - \frac{u^2}{2\;2!} + \frac{u^3}{3\;3!} + \ldots \frac{u^n}{n\;n!}\right]$$

$$\text{Where } u = \frac{R^2S}{4Tt} = \frac{(4{,}000\text{m})^2 * .01}{4(250\text{m/day} * 2{,}281.25 \text{ days}} = 7.0 \times 10^{-2}$$

Solving the infinite series term (known as the well function (w(u)): results in w(u) = 2.15.

Substituting back into the original equation results in:

$$\text{Drawdawn} = \frac{3{,}888 \text{ m}^3\text{/day}}{4\text{pi } (250\text{m}^2\text{/day})} (2.15) = 2.65 \text{ meters } (8.7 \text{ ft}).$$

From the above calculations it can be seen that the Dresser Minerals site will have a drop in ground water levels of 8.7 ft at the end of the construction period, in addition to declines due to pumpage at their quarry. An additional drop will occur with continued pumpage during the 26 yr repository lifetime. The above estimate is probably conservative because it is based upon the single-level, repository design, water estimates and does not include any pumping that probably will be required in surface fill borrow areas. The average thickness of the Spartas between 21 and 58m, so that a drop of 2.65m represents 5 to 10% of the potentially available water in the Sparta.

Residences close to the site may experience a drop of 16 ft due to construction. Bashaway Creek discharge will be decreased during low flow periods. The large amount of potentiometric level drop at the end of construction and operation will cause settlements at the ground surface, as well as cause down-drag forces to develop along the shaft perimeter. Unless accounted for, after a given period (dependent upon the time-rate of settlement of materials above the Sparta Formation), the surface may subside below its design elevation. The down drag forces may become significant at some stage of shaft construction, and may lead to cracks in shaft liners. The magnitude of subsidence due to groundwater withdraw and compaction will be far more significant than subsidence due to actual mining procedures.

[10CFR960.5-2-6]

p. 5-46, Sect. 5.2.2.2, para. 3. The EA states that there "should be no drastic change in recharge or discharge rates since the 162 hect acre site area is small compared to the total aquifer unit outcrop." There are several faults with this logic. Pumpage from the site will decrease discharge rates; the area of surface facilities is currently 530 acres; page 5-47 of the EA states that 2,400 acres of land will be deforested; Vacherie Dome is located in a prime recharge area; and, the use of the entire area of the Sparta outcrop in the EA's logic masks local effects. There will be abrupt changes within 10km of the repository.

[10CFR960.5-2-6]

p. 5-46, Sect. 5.2.2.2, para. 4. The EA states that "repository shafts will be designed and constructed to avoid potential impacts to the surrounding groundwater system." Shafts will act as long term sinks, because they are not constructed of completely impervious materials. If freezing techniques are used in the construction of some of the shafts, flow will be halted or greatly reduced around and into the shafts. Upon ground thaw, pathways may exist along the periphery of the shafts that may allow aquifer interconnection. Additionally, grout is referred to as a "concrete" grout. (Presumably, they mean Portland cement grout, since concrete and grout are different things.) Other than that, the mix is unknown. The performance of the grout under freezing techniques is not analyzed in the EA. The shafts and seals represent thepath of least resistance for radionuclide release into the surrounding ground water system. More attention should be focused on this pathway.

p. 5-47, Sect. 5.2.3.1. The EA states that approximately 2,400 acres of forested land will be lost at Vacherie Dome, and that this represents but a small portion of the total forested land in Webster and Bienville parishes. The loss of nearly 4 square miles of forested land (4 sections) is a substantial adverse effect. The EA had neglected to state that this much land would be disturbed in previous sections.

p. 5-47, Sect. 5.2.2.2.3, para. 2. The EA states that the hydrologic regine will not be impacted in a major way. Comments are the same as for p. 5-43 Sect. 5.2.2.1.1. para. 1.

p. 5-50, Sect. 5.2.4.2, para. 2. It would be very difficult to relocate Bashaway Creek tributaries to the south of the site, judging from a topographic map of the site.

p. 5-78, Table 5-13. It is unclear whether accident analysis incorporated national statistics for a data base or Louisiana statistics only. Local experiences are what are most important. The effects of mixed mode transport on risk analysis are not presented. The number of starts and stops was not considered in the risk analysis, nor the number of railroad interchanges or other factors affecting transportation safety.

p. 5-83, Table 5-15. Regional risk calculations are nearly the same for shipments from the east and west coasts. It is obvious that most nuclear waste will be transported to the site through the eastern route, as most reactor sites are in the east. The Table does not reflect this.

p. 5-86, Table 5-16. Same comments as p. 5-83, Table 5-15.

p. 5-92, Sect. 5.35, para. 10. It is stated that mine disposal of salt requires some technological development. Mine hoisting systems for rock are not designed to operate in reverse - that is, to put bulk materials back underground. To re-engineer a mine to accept large quantities of salt for backfill would require a new load-out facility at depth or a separate shaft for direct transfer underground. This makes a considerable investment on downtime for the mine, which has probably not been considered. Present salt mining costs are $14.00 per ton f.o.b. mine. Salt disposal costs would probably be about $10 to $12 per ton not including rail transportation. Disposal costs alone would be at least 120 million dollars. Transportation costs could double this figure.

p. 5-93 to 5-117 Sect. 5-93. Comments regarding expected repository effects on socioeconomic conditions are the same as those for Sect. 4.2.2.

p. 5-117, Sect. 5.5, para. 1. Since the repository design is still evolving as of this EA draft, the direction in which the repository design is evolving is necessary information for realistic analysis of the EA.

p. 5-120, Table 5-25. The increase of the underground repository area to 3,734 acres represents a 152%-increase over the EA reference design. The extrapolated quantity of excavated salt would be 64 million tons, all of which would be "brought to the surface prior to final disposition." The size of the salt pile would be unusually large. To place this quantity perspective, it is about 10 times greater than the amount of fill used in site preparation. Jacoby and Lefond (1984) report that the 1983 U.S. salt production was 37.7 million tons. The amount of salt excavated for the repository represents about twice the total 1983 U.S. salt production from all sources, including solar evaporation and brine. The EA has not presented analyses of the effects of exposing salt to the outside environment prior to backfill. Exposure of the salt may introduce excess moisture into the repository. Analyses of potential changes in backfill properties under the new conditions should have been presented.

p. 5-121, Sect. 5.5, Geologic Conditions. There is no mention of increased stress and strain effects caused by the "alternate design" repository.

Thermal effects will encompass a much greater area. The chance of anomaous zones interfering with mining will be increased.

p. 5-121, Sect. 5.5, Hydrology. Water quality effects for the two designs will not be similar as stated. Degradation of surface waters will be enhanced due to the larger scale of construction activities and the large salt pile.

p. 5-121, Sect. 5.5, Terrestrial and Aquatic. It is highly unlikely that there will be similar effects upon biota from the two designs. The amount of wind-blown salt will be greatly increased due to increases in salt handling and the size of salt piles. Construction will increase erosion and sedimentationturbidity. The borrow pits will intrude on natural habitats over a greater area.

p. 5-123, Table 5-26, I.1. It is unclear how the EA estimate of 68 tons of soil loss per acre per year was calculated. This estimate results in a loss of 36,040 tons from repository construction over the surface repository area alone. The only exit for this material is through Bashaway Creek.

p. 5-123, table 5-26, I.2. The EA states that "mineral and hydrocarbon resources development will be excluded from the controlled area." If the controlled area extends 6.2 miles from the repository (EA, p. 3-1), then several gravel pits, proven mineable lignite resources, hydrocarbon fields, Dresser Mineral Industries, the towns of Heflin and Fryeburg, and many residences are included in this area. The definition of controlled area must more precise.

p. 5-123, Table 5-26, I.3. The EA states that "flood storage capacity of Bashaway Creek may be reduced due to repository construction in a flood plain." Not only will flood storage capacity be reduced, but eliminated, because of the elimination of the flood plain.

2.6 Chapter 6.0 - Suitability of the Vacherie Dome Site for Site Charaterization and for Development as a Repository

2.6.1 Detailed Comments

p. 6-2, Sect. 6.1.2. The EA discusses the use of siting guidelines in evaluating site suitability. Each site receives a level of finding for each guideline, with disqualifying conditions ranging from level 1 to 2 and qualifying conditions ranging from level 3 to 4. The lack of supporting data for a definite level of finding suggests that these findings are arbitrary. In fact, Table 6-1 in all of the Environmental Asseessment for all nine sites shows the same level of finding for qualifying and disqualifying conditions for each siting guideline. These uniform findings indicate how superficial the evaluation is.

[NWPA Title I, Subtitle A, Section 112(b)(1)(E)(i)(ii)]

p. 6-13, Sect. 6.2.1.4.1. No consideration is presented in the EA regarding truck and rail shipments during tornadoes, hurricanes and other extreme weather. Although the presence of these adverse conditions is admitted in the EA, their consequences are not fully analyzed.

p. 6-25, 26, Table 6-2. DOE projects an ability to comply with Executive Orders 11988 and 11990 which require minimizing impacts, and restoring and preserving flood plain values. Guidelines "prohibit the location of potential pathogenic and toxic sources on the flood plain, such as sanitary landfills and septic tanks, etc." We believe the floodplain must undergo extensive modifications. Development of the ESF will require extensive cut and fill for site preparation, with maximum fill of about 43 ft in the channel of Bashaway Creek. Additional excavation of 2 million cubic yards is needed for drainage ditches up to 30 ft deep around the north end of the site. Total affected area is closer to 200 acres rather than the estimated 26 acres. The re-routing of Bashaway Creek and its tributaries is not in the spirit of the Executive Orders, as the beneficial value of the flood plain will be lost and surface hydrology will be disrupted.

p. 6-37 to 6-40, Table 6-2. Several water pollution acts are related to salt disposal and sediment increases; however, radiological issues were not addressed by the EA in relation to these acts.

p. 6-50, Sect. 6.2.1.6.4. The qualifying condition states that the public will be adequately protected from "the hazards posed by the disposal of radioactive waste." The EA does not address these hazards. "DOE believes that the quality of the environment in the affected area can be mitigated to an acceptable degree," yet, the EA has failed to address major issues. Beliefs alone will not adequately protect the environment.

[NWPA Title I, Subtitle A, Section 112(b)(1)(E)(i)]

p. 6-57, Table 6-5. The data or life cycle transporation costs in Table 6-5 are not documented well enough to determine underlying assumptions and approaches used in obtaining them. The reference for highway and rail accident statistics actually covers Southern Mississippi and therefore may be very inaccurate. The life cycle transporation costs presented in Table 5-12 differ from those in Table 6-5, as do total risk figures for rail and truck in

Table 5-13. Life cycle risks appear to be a fixed percentage of waste transport mileage one way. This percentage is the same for each proposed site, implying it is based on national experience. Nevertheless, an analysis using a fixed percentage of distance implies a straight line relationship for risk over distance, whereas risk may vary exponentially due to travel time, population centers passed, number of railroad interchanges, and other factors.

[NWPA Title I, Subtitle A, Section 112(a)]

p. 6-59, Sect. 6.2.1.8.2, paras. 1 and 2. Not all of the five characteristics regarding access availability are addressed in reading the conclusion that the favorable condition is met. Specifically avoided is the point regarding the necessity of federal condemnation of land.

p. 6-72, Table 6-7. An evaulation of favorable conditions for transporation guidelines is presented in Table 6-7. The assessment of results states that four of five characteristics [10CFR960.5-2-7] are present. We can only find three of five, not resolving status of rights of way for access routes, and the requirement for grading, tunnels, or bridges. The analysis in this area is apparently incorrect or incomplete.

[NWPA Title I, Subtitle A, Section 112(b)(1)(E)(i)(ii)]

p. 6-78, Sect. 6.2.2.2.1. Assumption 5. It is far from clear that existing shaft sealing technology will provide adequate protection for the long time period.

p. 6-84, Table 6-8. The assessment of transportation system guidelines is summarized in Table 6-8. It is stated, "Transportation risks are predominantly non-radiological." However, Table 6-5 shows radiological deaths far outnumbering non-radiological deaths for rail transport. The assessment in this area is misleading. More detailed analysis are necessary to resolve this issue.

[NWPA, Title I, Subtitle A, Section 112(a)]

p. 6-85, Sect. 6.3.1.1.1, para. 4. The EA states that little water is available in salt domes and that it is not hydraulically connected to ground water systems. Kumr (1981) discusses mine brines at length and finds that there are three types - meteric waters, waters from surrounding formations taken in by the salt, and original connate waters. He also discusses the disturbance effect mining has on mine leaks in the salt and the decrease in leaks with depth (to 1,400 ft). The water situation is complex, with likely connections to surrounding ground waters in some instances.

p. 6-86, Sect. 6.3.1.1.1, para. 1. The discussion of the geohydrologic assessment states that anomalous zones are occasionally associated with fluid leakage (Kupfer, 1980). The presence of anomalous zones would effectively destroy the entire discussion. Fluid flow rates of orders of magnitude larger than estimated can be expected in these zone. The connection of these zones to the dome sheath is highly likely and more data would be needed to assure that the dome is hydrologically isolated. One core hole does not provide sufficient exploration for anomalous zones. Kumar (1981) does not state that anomalous zones are "hydraulically" isolated, but states that they contain brines that may have finite volume.

[NWPA Title I, Subtitle A, Section 112(b)(1)(E)(i)]

p. 6-95, Sect. 6.3.1.2.3. If after waste emplacement, the waste leaked through the salt stock and into the surrounding sediments, the statement "the clay and organic rich sediments surrounding the dome are expected to provide a significant sorption capacity", has little bearing. Fluid migration in the surrounding aquifers has not been adequately addressed in the EA. Fluids sometimes migrate faster along fault planes; hydrologic model stuides should be generated using the fault geometry observed at Vacherie Dome.

p. 6-97, Sect. 6.3.1.3, para. 4. The evaluation of rock characteristics relative to postclosure guidelines assumes that salt properties in Gulf Coast domes are similar. Therefore, generic data and experience from mining in other salt domes can supplement existing data for the Vacherie Dome site. If this assumption were valid, then mining experience in salt domes would be enough to prevent a salt dome from consideration as a repository site. The application of generic geomechanical data to the Vacherie Dome site is in effect a misrepresentation of conditions at the Vacherie Dome and should not be used toward site evaluation.

[NWPA Title I, Subtitle A, Section 112(b)(1)(E)(i)]

p. 6-97, Sect. 6.3.1.3.1. There is not enough migrated data available to estimate the shape of the domes flanks below -6,000 ft.

p. 6-97 to 110, Sect. 6.3.1.3.1. The presence of anomalous zones and elevated temperatures can cause a large number of associated problems. Differential stress due to differing coefficients of thermal expansion in different materials could lead to spalling or other failure which greatly exceed those found in non-thermally stressed mines. In particular, the high coefficients of expansion which characterize gases present should be expected to lead to blowouts even under conditions which normally do not lead to such events. Differential motion could lead to enhanced porosity in what is the most likely area of leakage. While the salt may flow in response to stress, the anomalous zone material would have a much greater tendancy to fracture.

p. 6-112, Sect. 6.3.1.7.3, para. 4. The EA concludes that there are no potentially adverse effects on waste isolation from earthquakes near the Vacherie Dome site. Based upon a comparison of surface accelerations, it is concluded that damage to underground facilities is not likely, although "minor" damage may occur at acceleration of 0.2G and higher. No quantification of the extent of this surface damage is presented in the EA. The surface acceleration is not the same as bedrock acceleration due to changes in the amplitude and frequency of velocity waves as they pass through the overburden. Nuttli and Hermann (1978, p. 88) state in fact that horizontal accelerations calculated using their equation may not represent bedrock motions. Horizontal and vertical accelerations may differ in the various overburden strata, producing potential for shaft liner failure. Th LSU tiltmeter studies should be introduced to show that no systematic domal movement has occurred from 1975 to 1979.

p. 6-113, Sect. 6.3.1.7.3, para. 6. EA states that Quaternary tectonic folding, faulting, and subsidence are not known to have occurred in the region. However, the collapse feature which may be associated with dissolutions may have occurred during the Quaternary as previously impled in the EA (p. 3-35).

p. 6-114, Sect. 6.3.1.7.5, para.2. When discussing the stability of Vacherie Dome during the Quaternary, the evidence of salt dissolution (local downwarp of terrace deposits, abnormally thick Quaternary section) should be introduced.

p. 6-116 to 6-117, Sect. 6.3.1.8.3. The presence of hydrocarbon shows was never addressed in any of the exploratory tsts. Minden Dome should be analyzed in greater detail to determine why it is the only North Louisiana piercement structure to be productive.

p. 6-126, Table 6-11. The EA states that Vacherie Dome is sufficiently large to ensure isolation of waste. We believe the dome is not large enough, even by DOE's interpretations of gravity surveys, hence a multi-level repository concept. There most likely will be areas lost to anomalous zones thereby reducing the areal extent of the repository available for storage to a level below that required by the guidelines. These zones cannot be distinguished by either gravity or seismic methods and therefore will be found during mining or by advance drilling.

[NWPA Title I, Subtitle A, Section 112(b)(1)(E)(i)]

p. 6-126, Table 6-11. The statement, "Minor methane in fluid inclusions within domes indicates a chemically oxidizing potential is not present." This conclusion is without basis. Previously on page 6-96, "There is little direct evidence on the oxidation state of fluids in potential host rocks." Even if conditions prove to be reducing, the EA fails to consider that as soon as passageways and waste panels are mined, an oxidizing environment will exist due to ventilating air from the biosphere. This air will saturate voids in the backfilled rooms, thereby increasing canister corrosion potential.

In the Weeks Island Mine, bodies of red (oxidized?) sandstone occur. At one location in this mine (B-1 North), dark soots of iron ixide films were observed on the surface of the water that flowed from a borehole. Brown stains (an indication of oxidation) were common near leaks.

[NWPA Title I, Subtitle A, Section 114(a)]

p. 6-143. Groundwater travel time to the accessible environment is estimated at 107,000 years. This assumes ideal conditions of homogenous material and the absence of discontinuities and anomalous zones. Hydraulic conductivities range to 0.4 ft/day in the EA, whereas (Hassman, 1978) reports values of 30.24 m/day. The EA's estimates of total dissolved solids range from 44,500 to 125,500 ppm. These values do not include the Wilcox or Sparta Formations whose water quality is suitable for irrigation or human consumption. These discrepencies show the lack of understanding of the site's hydraulic properties.

[NWPA Title I, Subtitle A, Section 112(a) and Section 112(b)(1)(E)(i)]

p. 6-158, Sect. 6.3.3.2.4, para. 1. The EA states that "conceptual design of repository pillars has employed safety factors of greater than two." The factors of safety do not include any consideration of stress redistributions caused by the proposed multi-level repository design. The effects of this design on stress in the rock is unclear and should be evaluated. These stresses may have an impact on room stability and may affect the results of thermal analysis (where initial in situ stresses are always considered lithostatic).

p. 6-158, Sect. 6.3.3.2.5, para. 3. The EA states that Vacherie Dome salt is "clean and uniform." This statement is not substantiated by any evidence.

According to Nance et al. (1979), salt is 90% halite 10% anhydrite in varying concentrations, and displays a broad spectrum in textrues that reflect differing styles and stages of deformation. Anhydrite also occurs in concentrations that form steeply inclined, continuous, segmented or folded layers. There are three principal textural forms of halite: inequidimensional, equidimensional, and megacry stalline.

Anomalous zones and inclusions of other lithologies may also be present in the dome.

p. 1-176, Table 6-17. The data for the integrated releases due to salt mining during construction over an 8-year period given in Table 6-17 do appear to be in rough agreement with similar data from DOE/ET-0029 (Table 4.4.1-6, accompanying).

The resulting calculated doses presented in Table 6-20 are not given in the usual terms of whole-body, doses to specific organs and so on, and, therefore, are not directly comparable to doses reported in DOE/ET-0029. This is unfortunate because it gives the reader no frame of reference to interpret the EA results. This is a problem with all the calculated radiological doses presented in the EA.

TABLE 4.4.1-6 Annual Radionuclide Releases to Air for Construction of Geologic Repository for Spent Fuel as Waste, Ci (DOE/ET-0029)

GEOLOGIC MEDIA

NUCLIDE	SALT	GRANITE	SHALE	BASALT
220_{Rn}	9.3×10^{-4}	2.0×10^{1}	6.1	3.1
222_{Rn}	1.3×10^{-3}	1.9×10^{1}	7.0	2.7
210_{Pb}	1.1×10^{-7}	1.6×10^{-3}	5.9×10^{-4}	2.3×10^{-4}
212_{Pb}	1.4×10^{-6}	3.0×10^{-2}	9.2×10^{-3}	4.7×10^{-3}
214_{Rb}	1.3×10^{-3}	1.9×10^{1}	7.0	2.7
210_{Bi}	1.3×10^{-3}	1.9×10^{1}	7.0	2.7

p. 6-176, Table 6-18. The repository as conceptually designed has a total capacity of 72,000 metric tons of heavy metal. The stated design basis is that 50% or 36,000 tons is spent fuel (SF). Over the 26-year life of the facility this would imply an average rate of SF emplacement of about 1,400 tons/year. The annual release data in Table 6-18 of the EA for the more volatile redionuclides is stated as having come from DOE/ET-0029. The accompanying Table 4.2.2-2, however, shows releases that are roughly 100 times greater than those in the EA. Even allowing for the differences in processing rates, (2,000 MTHM/year in the reference vs. 1,400 MTHM/year in the EA) there appears to be a serious underestimate in the radiological releases from the receiving, consolidation, and repackaging operations.

TABLE 4.2.2-2 Radionuclides Released to the Atmosphere During Planned Operation of the Modified Independent Spent Fuel Storage Facility (DOE/ET-0029)

Releases, Ci/yr

Radionuclide	Receiving	Storage	Packaging	Total
^{3}H	1.3	1.1	1.3	5.9
^{14}C	3.3×10^{-3}	1.9×10^{-5}	6.6×10^{-3}	1.0×10^{-2}
^{58}Co	6.3×10^{-4}			6.3×10^{-4}
^{60}Co	1.6×10^{-3}		6.3×10^{-4}	2.2×10^{-3}
^{85}Kr	8.7×10^{2}	1.7×10^{1}	8.1×10^{2}	1.7×10^{3}
^{90}Sr	2.0×10^{-4}	8.8×10^{-5}	9.9×10^{-5}	4.1×10^{-4}
^{91}Y	2.9×10^{-4}			2.9×10^{-4}
^{95}Zr	1.7×10^{-3}			1.7×10^{-3}
^{95}Nb	3.0×10^{-3}			3.0×10^{-3}
^{106}Ru	1.0×10^{-3}		2.6×10^{-4}	1.3×10^{-3}
^{125m}Te	1.4×10^{-5}			1.4×10^{-5}
^{127m}Te	1.3×10^{-5}			1.3×10^{-5}
^{129}I	5.0×10^{-5}	8.9×10^{-7}	9.9×10^{-4}	1.0×10^{-3}
^{134}Cs	1.8×10^{-2}		7.2×10^{-3}	1.9×10^{-2}
^{137}Cs	9.9×10^{-3}	2.4×10^{-3}	5.4×10^{-3}	2.3×10^{-2}
^{144}Ce	1.8×10^{-3}	2.5×10^{-5}	3.9×10^{-4}	2.2×10^{-3}

p. 6-181, Table 6-22. The source term for an accidental drop of a canister containing spent fuel down a mine shaft presented in the EA appears to be in approximate agreement for actinide fission products but is significantly different for the volatile fission products compared to Table 4.4.3-2 in

DOE/ET-0029. For example, tritium is about 20 times lower in the EA while the EA value for Kr-85 is almost twice as large. The same problem with the calculated doses mentioned above applies here also.

TABLE 4.4.3-2 Radioactive Material Released to the Atmosphere from a Canister Drop Down Mine Shaft Accident at the Geologic Repository for Spent Fuel (DOE/ET-0029)

Radionuclide	Release, Ci	EA Release, Ci
^{3}H	1.7×10^{2}	9
^{14}C	2.0×10^{-1}	6×10^{-2}
^{85}Kr	3.6×10^{3}	6×10^{3}
^{90}Sr	1.1×10^{-4}	2×10^{-4}
^{90}Y	1.1×10^{-4}	2×10^{-4}
^{129}I	1.8×10^{-2}	9×10^{-3}
^{137}Cs	1.5×10^{-4}	2×10^{-4}
^{238}Pu	3.9×10^{-6}	6×10^{-6}
^{239}Pu	5.2×10^{-7}	9×10^{-7}
^{240}Pu	8.4×10^{-7}	1×10^{-6}
^{241}Pu	1.6×10^{-4}	1×10^{-4}
^{241}Am	2.0×10^{-6}	3×10^{-6}
^{244}Cm	1.8×10^{-6}	2×10^{-6}

p. 6-184, Sect. 6.4.2. The presence of anomalous zones are not considered in the idealized analysis that are presented in this section. Anomalous zones would invalidate all analyses, as these zones may have significantly different hydrogeologic, thermal, and geomechanical properties, and may provide potential radionuclide release pathways.

p. 6-191, Sect. 6.4.2.2.3, para. 2. According to seismic data and published cross-sections, the Austin is not the only aquifer which surrounds the dome at the proposed respository levels.

p. 6-195, Fig. 6-5. The peak temperature of the salt adjacent to the waste canister is given as 180°C in the EA for a power density of 50 Kw/acre. This compares with a value of about 200°C given in DOE/ET-0028 (Fig. 7.3.2) at the same time (10 years). In DOE/ET-0028 (Fig. 7.3.2) the canister temperature is relatively constant from 10 years to 50 years, whereas in the EA it decreases to about 150°C. Since these temperature profiles are largely determined by the radioactive decay, the decrease with time should be similar.

p. 6-196 to 6-197, Sect. 6.4.2.3.2. Modeling of fluid migration in salt has been based on several assumptions which may lead to incorrect brine migration predictions for Vacherie Dome. The history of fluid modeling in salt has many cases of inconsistant results, and poor correlation of experimental and observed results. Among these, Bradshaw and Sanchez (1982 ONWI-415) were not able to accurately predict brine migration rates using both calculated and observed values at Project Salt Vault; Avery Island brine migration tests (ONWI-190.4, 1983) used approximated properties of salt and brine instead of measured values, resulting in a model which had poor input and which is of limited use; Olander (1984, ONWI-538) was able to determine inclusion response to grain boundaries. A quantitative basis for inclusion migration could not be predicted from Olanders observations. The program BRINEMIG assumes salt to be homogeneous and isotropic. These conditions are probably not met in Vacherie

Dome. Furthermore, the variability of naturally occurring salts makes them difficult candidates for experimental measurements. The EA should recognize a greater degree of uncertainty in brine migration.

p. 6-206, Sect. 6.4.2.3.3, para. 2. Boundary stresses were not adequately considered in analysis by the WAPPA code. The creep law shows that steady state creep depends on the deviatoric stress level. These stresses depend on initial in situ stresses and stress changes that occur during construction and with time. These deviatoric stresses (vertical stress minus horizontal stress) were arbitrarily assumed, implying that their effect is insignificant. Further, comparison of the results of a creep analysis for data at one site (Asse Salt Mine, West Germany) does not verify the creep law model. Verification implies that a constitutive law describes the complete behavior of a material under general conditions. All that can be stated is that the stresses at Asse are "always compressive;" hardly a verification.

p. 6-220, Sect. 6.4.2.3.5, para. 3. The EA states that the performance of engineered barriers at Vacherie Dome are "insensitive to variations in parameters." This statement is unsubstantiated because parametric study results were not presented, if ever performed.

p. 6-224, Sect. 6.4.2.3.5, Conclusion. The EA states that no fluids will leave the salt dome, "even including the estimated disturbed zone." Mechanical disturbances caused by excavation procedures may potentially cause a much larger disturbed zone than anticipated. Because this effect is not considered, the conclusion is tentative.

p. 6-230, Sect. 6.4.2.6.1, para 4. The orogenic activity and regional uplift in the Gulf Coast Province should be discussed by itself. It should not be compared with orogenic areas elsewhere such as the Colorado Plateau.

p. 6A-2, Construction and Operation Related Changes. Kupfer (in Acres American, Inc., 1977, p.24) states that "the salt fractures and disaggregates for some 20 or more ft (6m) back from the working face." This is considerably higher than the "1 to 2 meters" stated in the EA.

2.6.2 Comments on Guidelines Applications

2.6.2.1 Pre-and Post-Closure Technical (guidelines not requiring characterization.

		Condition	Subject	DOE EA Finding Favorable for Repository	Critique
p.6-64 Site Ownership & Control					
	(a)	Qualifying	Control	Yes	No Comment
	(b)	Favorable	Ownership	No	No Comment
	(c)	Adverse	Unresolve Ownership	Yes	No Comment
	(d)	Disqualify	None	--	No Comment
p.6-64 Population Density and Distribution					
	(a)	Qualifying	Radiation Dose	Yes	All potential pathways have not been identified. Anomalous zones, fractures and faults will decrease travel time;

Condition			Subject	DOE EA Finding Favorable for Repository	Critique
					geochemistry is poorly known. Expected radiation doses may exceed allowable limits of 10CRF960.5-(a)(1)
(b)	(1)	Favorable	Remote	Yes	No Comment
	(2)	Favorable	Low Population Density	Yes	No Comment
(c)	(1)	Adverse	High Onsite Population	Yes	No Comment
	(2)	Adverse	Near Highly Populated Area	Yes	Sibley, 6.2 miles away is at the edge of the 6.2-mile controlled boundry

	Condition	Subject	DOE EA Finding Favorable for Repository	Critique
				(10CFR 60.2). Minden is 10 miles north of the repository. A 6.2-mile boundary may be necessary if EPA guidelines (40CFR part 191).
(c)(1)	Adverse	Transport to highly populated areas	Yes	Disagree. Radioactive release from shaft accidents has not been taken into account by the EA.
(2)	Adverse	Extreme weather	No	No Comment
(d)	Disqualify	None	--	

	Condition	Subject	DOE EA Finding Favorable for Repository	Critique
p.6-67 Offsite Installations and Operations				
(a)	Qualifying	Interactive Effects	Yes	No Comment
(b)	Favorable	Radioactive Release from other installations	Yes	No Comment
(c)(1)	Adverse	Potentially Hazardous Installation	No	No Comment
(2)	Adverse	Presence of other nuclear installations	Yes	No Comment
(d)	Disqualifying	Atomic Defense Activities	Yes	No Comment
p. 6-68 Environmental Quality				
(a)	Qualifying	Adequately Protected	Yes	Disagree. The EA has not demonstrated that environmental quality will be adequately protected.

	Condition	Subject	DOE EA Finding Favorable for Repository	Critique
				Analyses of fractures and faults hydrologic travel times and flow paths, geochemistry, anomalous zones, and geomechanical properties have not been adequate.
(b)(1)	Favorable	Able to meet Requirements	Yes	No comment
(d)(1)	Disqualifying	Facility in highly populated area	Yes	No Comment
(2)	Disqualifying	Adjacent Area highly populated	Yes	No Comment
(3)	Disqualifying	Emergency Plans	Yes	No Comment

p.6-66 Site Ownership and Control

(a)	Qualifying	Control	Yes	Disagree. Analysis of possible release mechanisms

Condition		Subject	DOE EA Finding Favorable for Repository	Critique
				has not been thorough. Anomalous zones, faults, and fractures represent radionuclide release pathways.
(b)	Favorable	Ownership	Yes	No Comment
(c)	Adverse	Unresolveable ownership	Yes	No Comment
(d)	Disqualifying	None	--	

p.6-66 Meteorology

(a)	Qualifying	Meets release limits	Yes	Disagree. Winds transport radionuclides to unrestricted areas due to waste canister breach during loading, unloading, and shaft transport.

	Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(b)	Favorable	Atmospheric Dispersion	Yes	Disagree. Nearby residences and Dresser Mineral industries may receive high doses due to prevailing winds. Severe weather conditions exist 27 to 45 days per year.
(2)	Favorable	Mitigateable Effects	No	No Comment
(c)(1)	Adverse	Potential Conflicts	Yes	Disagree. Potential conflict with E.O. 11988
(2)	Adverse	Unmitigateable effects	yes	Disagree. Mitigative measures for floodplain elimination, ground water level lowering deforestation, sediment pollution and other impacts have not been adequately described.

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(3) Adverse	Conflicts with federally protected areas.	yes	No comment
(4) Adverse	Conflict with State protected areas	yes	Disagree. Sedimentation, turbidity, and salt pollution may potentially affect Black Lake Bayou, a state-designated scenic and natural waterway.
(5) Adverse	Native American Resource	yes	No comment
(6) Adverse	Critical Habitats	yes	No comment
(6)(1)Disqualifying	Unacceptably Mitigated	yes	Disagree. Mitigative measures for the diversion and channelization of Bashaway Creek and its tribu-

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
			taries, the elimination of the floodplain, adverse hydrologic impacts and other impacts have not been adequately described.
(2) Disqualifying		yes	No comment
(3) Disqualifying		yes	Disagree. Pollution potential for Black Lake Bayou, a state-designated natural and scenic waterway.

P. 6-70 Socio-economic Impacts

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(c) Qualifying	Can be mitigated	yes	Disagree. Projections of in-migrants and work force are presented without error margins and are based on out-moded designs.

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(b)(1) Favorable	No Distruptions	yes	Disagree. Models of in-migrant and worker residences are highly subjective.
(2) Favorable	Available Work Force	no	No comment
(3) Favorable	Increased Revenue	yes	No comment
(4) Favorable	No distruption	yes	Disagree. Removal of 2,400 acres of forestland is a significant impact.
(c)(1) Adverse	Impacts on Communities	yes	No comment
(2) Adverse	Lack of Labor Force	no	No comment
(3) Adverse	Water Rights	yes	No comment
(4) Adverse	Major Disruptions	yes	No comment

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(d) Disqualifying	Water Degradation	yes	Disagree. Local groundwater supplies will be depleted. Offsite supplies will be affected.

p. 6-72 Transportation

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(a) Qualifying	Adequate and of Low Risk	yes	Disagree. Transportation analyses have not been thorough in the EA.
(b)(1) Favorable	Access Routes	yes	Disagree. Federal condemnation may be required for some access routes; cuts, fills and bridges will be required; routes may pass through cities and towns.

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(b)(2) Favorable	Proximity	yes	Disagree. Local and regional railroad conditions have not been adequately described.
(3) Favorable	Regional Lines	yes	No comment
(4) Favorable	Interchanges	yes	No comment
(5) Favorable	Costs	yes	Disagree. The costs are not significantly lower.
(6) Favorable	Availability	yes	No comment
(7) Favorable	Legal	no	No comment
(8) Favorable	Disaster Plans	yes	No comment
(9) Favorable	Meterological	no	No comment
(c)(1) Adverse	Cost	yes	No comment

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(2) Adverse	Terrain	yes	Disagree. Terrain includes streams and low grade slopes; potential hazard at Bashaway Creek crossing.
(3) Adverse	Upgrading	yes	Disagree. The conditions of rail lines are not adequately presented in the EA.
(4) Adverse	Unusual Risks	yes	No comment
(d) Disqualifying	None		

2.6.2.2 Postclosure Technical Guidelines Requiring Site Characterization

p. 6-122 Geohydrology

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(a) Qualifying	Compatible	yes	Disagree. The EA analysis is not adequate to determine whether waste will be contained.
(b)(1) Favorable	Travel Time	yes	Disagree. Travel time analysis has not taken into account anomalous zones.
(2) Favorable	Quaternary Processes	yes	Disagree. Uncertainties in the magnitude and linearity of Quaternary processes are evident in the EA.
(3) Favorable	Stratigraphy	no	No comment
(4) Favorable	Saturated Zone	yes	Disagree. None of the pre-waste emlacement conditions exist.

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(5) Favorable	Unsaturated Zone	Not Applicable	
(c)(1) Adverse	Changing Hydrology	yes	Disagree. Disturbed zones will be created around shafts; dewatering of upper aquifers will induce upward flow; changes in surface hydrology may affect dissolution.
(2) Adverse	Useable Groundwater	yes	Disagree. Vertical flow may occur along faults, fractures, and disturbed zones to potable upper aquifers.
(3) Adverse	Faulting	no	No comment

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(d) Disqualifying	Long Travel Time	yes	Disagree. The EA does not present enough data to calculate travel times. Anomalous zones, fractures, and thermal convection have not been considered.

p. 6-124 Geochemistry

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(a) Qualifying	Compatible	yes	Disagree. Ground water chemical analyses presented in the EA are of limited value; clay properties and types have not been investigated, oxidizing environment may exist upon opening of shafts, passageways, and rooms.

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(b)(1) Favorable	Quaternary Rates	yes	Disagree. Not enough information is available to accurately determine dissolution rates. Collapse of caprock may reoccur.
(2) Favorable	Inhibit Transport	yes	Disagree. Volatile radionuclides may be transported through convection and anomalous zones; geochemical properties have not been adequately investigated.
(3) Favorable	Alteration	yes	No comment

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(4) Favorable	Solution	yes	Disagree. Brines and steam will concentrate at waste canisters; release may occur along anomalous zones. Oxidizing conditions may occur after repository opening.
(5) Favorable	Retardation	no	No comment
(c)(1) Adverse	Barrier Systems	yes	Disagree. Modeling of canisters under repository conditions has involved very short time intervals relative to the repository life time.

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(2) Adverse	Reduce Sorptem	yes	Disagree. Data are too limited to make predictions. Repository conditions are insufficiently know.
(3) Adverse	Oxidizing	yes	Disagree. Introduction of air into the repository may create oxidizing conditions.

p. 6-126 Rock Characteristics

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(a) Qualifying	Capability	yes	Disagree. Domal size is too small to ensure waste isolation; thermal behavior of anomalous zones is unknown; coefficient of thermal expansion is not low.

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(b)(1) Favorable	Lateral Extent	no	No comment
(2) Favorable	Thermal Properties	yes	Disagree. Thermal properties of anomalous zones have not been analyzed. Thermal properties of salt stock under repository conditions are highly variable.
(c)(1) Adverse	Rock Conditions	yes	Disagree. Rock characteristics under repository conditions have not been adequately analyzed.
(2) Adverse	Isolation	no	No comment

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(3) Adverse	Decrease Isolation	yes	Disagree. Convection has not been adequately analyzed; mechanical properties are poorly known; structures are poorly known.
p. 6-128 Climatic Conditions			
(a) Qualifying	Adverse Impacts	yes	Disagree. Changes in climatic regime may be expected to increase erosion, infiltration and dissolution. The EA analysis is insufficient.
(b)(1) Favorable	Suface Waters	yes	Disagree. Quaternary streamflow and precipitation were much higher than present, as evidenced by paleo-channel dimensions.

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(2) Favorable	Quanternary Hydrology	yes	Disagree. Quaternary hydrologic conditions were much different than present.
(c)(1) Adverse	Water Table	Not Applicable	
(2) Adverse	Changes in Properties	yes	Disagree. Changes in precipitation, infiltration and erosion will affect hydrologic properties.

p. 6-129 Erosion

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(a) Qualifying	Unaffected	yes	Disagree. The EA assumptions of erosion rate are incorrect. Erosion rate is not a linear process. Site specific erosion rates are unknown.

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(b)(1) Favorable	Depth	yes	No comment
(2) Favorable	Erosion Rate	yes	Disagree. Site specific erosion rates are unknown.
(3) Favorable	Stability	yes	Disagree. Caprock is 550 ft below the surface. Erosion rate of 0.8 ft/1,000 yrs will remove overburden in 685,000 yrs. Dissolution rate will increase rapidly as overburden is removed and caprock is exposed.
(c)(1) Adverse	Extreme Erosion	yes	No comment
(2) Adverse	Process Rates	yes	Disagree. Rates of erosion are poorly analyzed or unknown.

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(d) Disqualifying	Depth	yes	No comment

p. 6-130 Dissolution

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(a) Qualifying	Insignificant Dissolution	yes	Disagree. Domal area is too small for the design repository. Dissolution rate estimates make invalid assumptions of process linearity and do not analyze temperature effects on dissolution.
(b) Favorable	Quanternary Dissolution	no	No comment
(c) Adverse	Significant Dissolution	no	No comment
(d) Disqualifying	Loss of Waste Isolation	yes	Disagree. Dissolution rates have not been adequately determined.

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
p. 6-131 Tectonic			
(a) Qualiftying	Future Tectonism	yes	No comment
(b) Favorable	Not Detrimental	yes	No comment
(c)(1) Adverse	Active During Quanternary	no	No comment
(2) Adverse	Earthquakes	yes	Disagree. The ground motion is a surface motion. No consideration is given to subsurface motions.
(3) Adverse	Frequency	yes	No comment
(4) Adverse	Higher Activity than Surroundings	yes	No comment
(5) Adverse	Natural Phenomena	yes	No comment
(6) Adverse	Regional Tectonism	yes	No comment

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(d) Disqualifying	Waste Isolation Loss	yes	Disagree. No consideration was given to seismic effects on shaft liners.

p. 6-133 Human Interference/Natural Resources

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(a) Qualifying	No Interference	yes	Disagree. Resources are present at the site; and long time periods are involved; potential instrusion is possible.
(b)(1) Favorable	Extractable Resources	no	No comment
(2) Favorable	Ground Water	yes	Disagree. Water may flow upward along fractures to potable aquifers.
(c)(1) Adverse	Extractable Resources	no	No comment

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(2) Adverse	Previous Extraction	yes	No comment
(3) Adverse	Previous Drilling	yes	No comment
(4) Adverse	Rare Resources	yes	No comment
(5) Adverse	Potential Human	yes	Disagree. The site is compatible with many human activities.
(d)(1)Disqualifying	Previous Exploration	yes	No comment
(2) Disqualifying	Future Development	yes	Disagree. Future mineral exploration may affect waste isolation.

2.6.2.3 Preclosure Technical Guideline Requiring Site Characterization

p. 6-165 Surface Characteristics

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(a) Qualifying	Adequate for Construction	yes	Disagree. Terrain includes a valley, streams, and a flood plain, extensive fill will be required. There is no consideration of fill settling in the EA.
(b)(1) Favorable	Flat Terrain	yes	Disagree. Low-grade slopes and valley are present. Valley will requie extensive fill.
(2) Favorable	Well Drained	yes	Descriptions of flood plain soil conditions were not provided, no soil moisture analysis in EA. Hawkins (1978, p. 21, 189, 190, 191, 193,

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
			200, 201) describes equipment problems caused by poorly drained soil.
(c) Adverse	Flooding Potential	no	No comment
p. 6-165 Rock Characteristics			
(a) Qualifying	Adequate Dome Size No Undue Hazards	yes	Disagree. Vacherie Dome is too small to accomodate the EA reference designs. Hazardous conditions will exist during construction, operation and closure due to rock failure and salt creep, radionuclide volatile release, and high working temperatures.

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(b)(1) Favorable	Extent	no	No comment
(2) Favorable	No Supports	yes	Disagree. Artificial supports may be required. Creep closure is the highest of all salt sites.
(c)(1) Adverse	Extent	no	No comment
(2) Adverse	Technology	yes	No comment
(3) Adverse	Maintenance	no	No comment
(4) Adverse	Retrieval	no	No comment
(5) Adverse	Anomalies	no	No comment

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(d) Disqualifying	Undue Risk	yes	Disagree. Vacherie Dome has the highest creep rate of all salt sites. Hawkins (1978 p. 208, 213) indicates salt may readily fracture due to the "nature of the salt" and decreasing anhydrite content. Temperatures are adverse to worker safety; ventilation systems are inadequate.
p. 6-166 Hydrology			
(a) Qualifying	Compatible	yes	Disagree. The repository is located under a saturated zone and a flood plain. These are not compatible with

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
			construction. Flood plain filling and stream diversions increase difficulty and costs of construction. High seasonal precipitation will cause delays and increase costs.
(b)(1) Favorable	Aquifers	no	No comment
(2) Favorable	Flooding	no	No comment
(3) Favorable	Water Availability	yes	Disagree. Withdrawal of aquifer waters is competitive with local usage.
(c) Adverse	Ability to Control	yes	Disagree. All dome mines leak. Technology to totally stop all infiltration is undemonstrated in the EA.

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
(d) Disqualifying	Ability to Control	yes	Disagree. It has not been demonstrated in the EA that all infiltration will be prevented.
p. 6-167 Tectonics			
(a) Qualifying	Will not affect Isolation	yes	Disagree. The effect of seismicity on liners has not been analyzed in the EA.
(b) Favorable	Low Seismicity	yes	No comment
(c)(1) Adverse	Active Faulting	yes	No comment
(2) Adverse	Will affect Isolation	yes	Disagree. Ground motions reported in the EA are surface motions. Response of shaft liners to seismic

Condition	Subject	DOE EA Finding Favorable for Repository	Critique
			events has not been adequately addressed in the EA.
(3) Adverse	Larger Earthquakes	yes	No comment
(d) Disqualifying	Will not affect Isolation	yes	Disagree. The effect of seismic events on shaft liners has not been adequately analyzed in the EA.

2.7 Chapter 7.0 - Comparative Evaluation of Sites Proposed for Nomination

p. 7-3, Sect. 7.1.2. Qualifying conditions, the favorable and potentially adverse conditions, and the disqualifying conditions of each guideline (as applicable) are used to compare the five sites. Diqualifying conditions are not directly used in the comparison although their components, one or more potentially adverse conditions, are. The EA insists that comparing potentially adverse conditions among sites is indirectly comparing the disqualifying conditions of each site. We do not believe this logic is correct.

The disqualifying condition is the result of combined effects of potentially adverse conditions, any of which by themselves are not disqualifying conditions. Therefore, the comparison of individual potentially adverse conditions will not represent the complete character of the site, and the combined effect of these conditions will be lost during the comparison process. The whole is the sum of its parts; therefore comparing parts of one with parts of another neglects or gives a misleading representation of the whole.

p. 7-10 to 7-11, Sect. 7.2.1.1. The section discusses the geohydrologic setting of five sites and rank sites accordingly. Transmissivity values must be identified to estimate groundwater travel time, an important issue in siting. The status of hydrologic information for each site is as follows:

SITE	HYDROLOGIC INFORMATION ORGIN
Hanford	Based on probability distribution of 50 known site specific values.
Yucca Mountain	Assumed Values
Davis Canyon	Data from testing in one well
Deaf Smith	Some values from tests, some assumed
Richton	Assumed

Data collection methods vary considerably for each site and in some instances were entirely assumed. In light of this, it appears questionable if any valid comparison between sites can be made.

p. 7-121, Table 7-21. Tables present ranking of sites by a number of criteria. The text broadly discusses where there are significant differences between rankings, that is the degree of difference between two successive numbers. However, these differences are not reflected in the tables nor are they explained in detail.

p. 7-126, Table 7-23. The sites are ranked according to three types of analyses. A footnote states, "The listing of more than one site for any particular rank indicates a tie." Consequently, sites can be ranked 1 through 5 in one method or 1 through 3 in another if several sites "tie." Firstly, given the number of evaluation criteria, we find it difficult for any sites to "tie" in a thorough analysis. Secondly, if two sites tie, the numbering should shift such that the last site will always be ranked 5. That is, if two sites tie for second place the next site should be ranked 4, not 3. The aggregating method would be particularly susceptable for shifting ranking numbers thereby giving a false impression of where a site stands relative to others for a given condition. For example, a site can rank 5, 4, and 3 for an average of 4 where as it may in fact have placed last (5th) in each category.

2.8 EA Appendix A - Transportation

p. A-7. The only discussion in the EA on safeguards and sabotage is a small section in Appendix A that talks about sabotage during transporation of waste to the site. There is no discussion or consideration given to providing sectурity of the operating facility. This appears to be inconsistent with the elaborate security measures currently required by the NRC at nuclear power plants. The inventory of accessible spent nuclear fuel elements in the above grade handling and packaging hot cells at Vacherie Dome would probably be greater than found at a typical power plant fuel storage pool. Since the spent fuel elements (and contained fission products) are just as accessible in the Vacherie Dome repository to a potential terrorist or insider saboteur, a consistent approach dictates that some precautions be taken at the repository.

3.0 MISSION PLAN (VOL. 1) COMMENTS

The Draft Mission Plan provides a framework for the HLW Program, and as such, can be used to evaluate the EA thoroughness.

3.1 Detailed Comments

p. 3-A-9. The technical suitability of a site for a geologic repository depends on answers to two basic questions:

1. Are geologic and hydrologic characteristics of the site capable of isolating waste from the environment in the long term?
2. Is it possible to engineer, construct, operate, and permanently close an underground facility within that geologic and hydrologic environment so that it will not adversely affect the site's geologic and hydrologic characteristics in an unacceptable way?

These two basic questions appear to be concerned with long term effects of storage. The first question clearly states this, and the second question implies this by including "permanently close," and "affect the site's .... characteristics in an unacceptable way?" That is short term effects may be corrected whereas long term effects may be more serious. (How to retrieve?) Nevertheless, it is DOE's admission that long term and short term siting criteria are given equal weight or very nearly equal weight. This does not appear to be consistent with the Mission Plan strategy.

p. 3-A-19. "An important aspect of this approach [for the first repository] is a quality assurance program. This program is to be used during site characterization to assure data for siting decisions are accurate, verifiable, and retrievable." There is no mention of quality assurance in the EA. Shouldn't data collection for the EA be subject to QA review? We have found many references used incorrectly or incomplete use of a reference and thereby altering its meaning.

p. 3-A-31. "For potential sites in salt, the Department will determine the location of the exploratory shafts by sinking a number of exploratory boreholes." Several proposed salt dome sites have limited lateral extent thereby restricting placement of the ES. Further constraints on location arise from a centrally located ES. Central shaft locations are said to be ideal, due to need for less space than dome perimeter locations (although this is not understood) and a more uniform heat load on shaft pillars. As the ES is intended to be integrated with the repository, the central location is best.

p. 3-A-33. Many scenarios are presented here, dealing with possible reasons for delays in the repository ES site selection and repository construction phases. There are many reasons for delays and not all are technical in nature. Nevertheless the EA does not discuss the potential for delays and includes none in their construction schedules.

p. 3-C-3. This section states that sabotage is a major concern of the public and state governments. This topic is not considered in detail in the EA, but is only mentioned very briefly.

Sec. 2.3.3. This section discusses testing to be done in the ESF. This includes:

Monitoring shaft behavior.

Monitoring subsurface deformation.

Monitoring subsurface environment.

Laboratory characterization of samples.

In-situ measurement of stress.

In-situ measurement of thermal properties.

In-situ measurement of permeability.

In-situ measurement of thermomechanical response.

Testing is only briefly described, and confined to in-situ materials characterization, shaft monitoring, mechanical and thermomechanical properties, and brine migration. Test details are not included which make it difficult to judge if the TEF is adequate for testing.

3.2 Mission Plan Issues

Issue 1.1: Will the present and expected geohydrologic setting at a site be compatible with waste containment and isolation?

Analysis:

1.1.1 The present nature and distribution of aquifers and aquitards has been grossly overgeneralized for the Vacherie Dome region. Water-bearing and non-water-bearing units have been grouped together in the EA, reducing the quality of information. Data for the lower units is scarce due to poor well control. The interrelationship of geohydrologic units is similarly poorly defined due to an avoidance of structural influence on the regional properties of aquifers.

1.1.2. Descriptions of the lithology, stratigraphy, and structure of the geologic and formations in the vicinity of the site are of a poor quality. Regional descriptions, having a wide range of properties, were used for local descriptions. Faults in the dome area are poorly understood; their age, extent, and number are unknown. The nature of the dome flanks is similarly only a qualitative description.

1.1.3. The geochemical characteristics of ground water in the region and near the site, including variations with depth, are only qualitative due to widely spaced data points and the complexity of regional and near dome structure and lithology.

1.1.4. The nature of the potentiometric surface, present hydrologic properties (e.g., hydraulic conductivity and gradient), and distribution of the geologic deposits and formations in the vicinity of the site is poorly understood. Regional information is presented in the EA for the geology of surrounding strata in the vicinity of the site, representing a gross overgeneralization. Actual geologic properties may be significantly different due to diapirism. Hydrologic properties are similarly poorly characterized.

1.1.5. Estimates of ground-water flow directions, velocities, and travel times for the paths between the repository and the accessible environment are presented in the EA and supporting documents; however, bounds have not been calculated, and local structural features which may influence travel times were not included in calculations. The aquifers surrounding Vacherie Dome are highly anisotropic; the use of average hydraulic gradients and hydraulic conductivities may result in a much longer travel time than may be actually be present due to the presence of paleochannel deposits in Eocene-age formations, interconnections between aquifers due to faulting and fracturing, and steep dips of dome flanks. Travel times through the dome disregard worst case scenarios of anomalous zones, leakage from waste containers before backfill consolidation, and the presence of disturbed zones around shafts and other entries.

1.1.6. Estimates of and bounds on; effects of man-induced changes on the present hydrologic flow system at the site, including those caused by site characterization, repository construction, and ground-water withdrawal from nearby aquifers are based on oversimplified data. True bounds are not presented because of the use of average aquifer properties. The potentiometric surface of the Sparta aquifer will be adversely affected by withdrawals during construction and operation, causing a decline in levels at Dresser Minerals, 2.5 miles north of the site, and will affect well levels for residences in the vicinity.

Conclusion:

The determination of ground water travel times adjacent to Vacherie Done is critical to the resolution of Issue 1.1. The estimates provided in the EA are based on average hydrogeologic parameters derived from regional analysis, which, at best, are poor estimates for conditions actually present at the dome. Calculations show a disregard for geologic formation anisotropy, numerous near vertical faults which will decrease travel time, and probable higher hydraulic gradients due to higher structural relief caused by diapirism. Post-emplacement ground water flow conditions were neglected in the EA. No consideration was given to ground water convection caused by thermal effects from waste emplacement, nor long term changes in potentiometric levels in the vicinity of the dome. In our estimation, changes in potentiometric levels due to heavy pumpage in the vicinity of the site are of greatest concern because of steepening of hydraulic gradients, which will decrease travel times, and increased upward leakage from lower aquifers.

In conclusion, the EA fails to answer Issue 1.1 because analyses used average regional values for geohydrologic parameters. The information needs, therefore, outline site investigation and design activities necessary for site characterizations. The EA does not acknowledge the lack of information from which it can build an information gathering plan.

Issue 1.2: Will the expected geochemical characteristics of the site be compatible with waste containment and isolation?

Analysis:

1.2.1. Estimates of the present geochemical conditions at the repository site are based on a single borehole into the salt stock (DOE Smith et al. No. 1), characteristics of other domes in the Gulf Coast and elsewhere. Because data from only a single borehole at Vacherie Dome exist, bounds on geochemical conditions at the repository levels can not be established. The presence of methane, brines, and seeps, associated with fluid inclusions, interstitial grain boundaries, and anomalous zones domes may be present at Vacherie Dome and are poorly characterized. Reducing conditions are assumed to exist in the salt stock at Vacherie Dome, however, upon opening of shafts and passage ways, the atmosphere rich in oxygen may create oxidizing conditions. It will be nearly impossible to remove trapped air from the repository, and it will be present as interstitial air, air voids, and possibly inclusions in backfilled rooms and passage ways, enhancing corrosive potential of brines.

1.2.2. Estimate of, and bounds on, the geochemical change that will occur after repository construction and waste emplacement are poorly characterized for Vacherie Dome. Thermal effects will produce brine migration toward canisters, however, the true quantity and corrosive potential are only estimates. The actual water content in Vacherie Dome is unknown; and calculations neglect additional moisture which will be introduced from the air used for repository ventilation, and brines in the salt stock or associated with anomalous zones.

1.2.3. Estimates of the processes that affect the retardation of radionuclide transport relative to the velocities of water flow along the path from the repository to the accessible environment are given in the EA; however, the bounds of these processes are not determined because of limited data. At best, they are qualitative estimates.

Conclusion:

The EA fails to answer Issue 1.2 because analyses used limited data. No range of geochemical characteristics can be determined for the site at this time because dome data relies on only a single borehole, neglecting the probable wide range of characteristics present at the dome due to anomalous zones, gas inclusions, and the introduction of air during repository construction. The EA does not acknowledge the lack of information from which it can build an information gathering plan.

Issue 1.3: Will the waste packages meet the performance objectives of a) waste containment for the 300 to 1,000 years after waste emplacement and b) an acceptable rate for radionuclide releases from the engineered-barrier system after the containment barrier is breached?

Analysis:

1.3.1. Estimates of the flow of water, steam, and air in the waste-package environment are given in the EA; however, these estimates are based on modeling of data derived from other domes and from laboratory simulation; hence they are only qualitative at best. Conditions which may exist over the entire area of the two-level repository are unknown.

1.3.2. Estimates of the chemical properties of the water, steam and air to which waste packages will be exposed are provided in the EA, however at best, they are qualitative. Estimates do not consider the presence of potential oxidizing conditions introduced by ventilating air, and assume that the salt stock is homogeneous.

1.3.3. Estimates of the thermomechanical stresses acting on the waste packages are at best qualitative for the above reasons.

1.3.4. Estimates of the rate of radionuclide release from the waste form after the containment barrier is breached are provided in Ch. 6 of the EA; however uncertainties exist due to probable large variations in salt stock geochemistry and the rate of fluid movement.

1.3.5. Estimates of the rates and mechanisms of containment-barrier degraduation in the repository environment presented in the EA may be in error because of probable variations in Vacherie Dome due to anomalous zones, moisture seeps, and introduction of outside atmosphere during construction.

Conclusion:

The EA fails to answer Issue 1.3 because analyses used limited data. Bounds on performance of waste packages are strongly dependent on repository conditions at Vacherie Dome. These conditions may only be known after the repository is fully developed.

Issue 1.4: Can the underground facility be placed at a depth such that surface erosion will not lead to releases greater than those allowed regulations?

Analysis:

1.4.1. Descriptions of the stratigraphy of the soils, deposits, and rocks that lie above the repository horizon are presented in the EA, however much of the information is based on regional interpretations. Soil types are identified, however their mechanical properties may differ significantly from the qualitative, empirically-based descriptions presented in Chapter 3.0. Over dome stratigraphy is at best poorly characterized for Vacherie Dome.

1.4.2. Past rates of erosion for Vacherie Dome are based on wide regional estimates in Chapter 3.0. We find no analysis based on loss of potential overburden (post-Eocene) at the site.

1.4.3. Mechanisms of erosion are poorly stated in the EA; however, they

are probably due to fluvial erosion.

1.4.4. Estimates of future climate and fluvial conditions are difficult to predict for any area. The EA's prediction of estimates may or may not be accurate.

1.4.5. Bounds of future geomorphic processes in the geological setting are equally difficult to predict, and, as above, the EA's prediction of estimates may or may not be accurate.

Conclusion:

The underground facility is most likely to be unaffected by surface erosion for at least the required time. However, the EA's analysis is insufficient to prove this, if in fact it can be proven.

Issue 1.5: Will future climatic conditions at Vacherie Dome lead to radionuclide releases greater than those allowed by regulations?

Analysis:

1.5.1. Estimates of the distribution of precipitation, including geographic occurrences, amounts, rates, and durations are presented in the EA and are available from the U.S. Weather Bureau for the region.

1.5.2. The water budget for the site appears to have been determined in the EA.

1.5.3. Terrace deposits are described in the EA and supporting documents, however, depth of scour, and channel gradients are not characterized.

1.5.4. No discussion of post ground-water levels in the geologic setting is presented n the EA.

1.5.5. While geomorphic features are described in the EA, descriptions are qualitative. The site has been described as "flat" and classified as "plains." This characterization is inconsistent with the 140 feet of relief present at the site.

1.5.6. Directions of streamflow in the drainage basin during the Quaternary Period appear to be well known, however, rates of streamflow over this period were not calculated. Similarly the present streamflow discharge of Bashaway Creek, along with its dimensions, is unknown.

1.5.7. Descriptions of soil horizons are present in the EA, and to a much greater extent in supporting documents.

Conclusion:

Based on the data presented n the EA, insufficient information is available to make a confident answer to issue 1.5. The most serious omissions are in streamflow data and Quaternary potentiometric levels and aquifer properties.

Issue 1.6: Will any subsurface rock dissolution within the geologic setting of the site lead to radionuclide releases greater than those allowed by regulations?

1.6.1. Definition of the structural, hydrologic, geomorphic, and stratigraphic framework of the site vicinity is based largely on broad regional interpretations. Overdome stratigraphy is poorly characterized and collapse features may be present as indicated in the EA and in Kolb et al. (1982) hydrologic properties of dome-flanking strata were poorly determined and presented; and geomorphic properties similarly are lacking in quality.

1.6.2. Locations and characteristics of dissolution fronts on other dissolution features are poorly identified for the repository site in the EA. Collapse features, of several hundred feet displacement, may be present over the dome. It is unknown when and if collapse occurred, nor if dissolution is presently occurring.

1.6.3. Geochemical analysis of the Wilcox Formation shows elevated salinity surrounding the Vacherie Dome. The EA discounts this by stating that it may be due to "upward leakage" of saline waters from lower aquifers.

1.6.4. Fracture and fault analysis of the Vacherie Dome overburden is seriously lacking in quality in the EA. The nature of faulting, its age, and the number and location of faults and fractures are unknown. The entire overdome and surrounding area is probably heavily fractured based on the identified faults.

1.6.5. Estimates of future climatic conditions in the geologic setting which may affect dissolution rates are not well known.

1.6.6. Estimates of future tectonic activity in the geologic setting are based on historical earthquake records, relative seismic stability of the area, and rates of uplift/subsidence derived from terrace elevations and releveling.

Conclusion:

Dissolution may have resulted in collapse structures at Vacherie Dome; the timing and extent of dissolution is unknown. Present dissolution is indicated by high salinity levels in the Wilcox aquifer. Changes in potentiometer levels due to repository development may enhance dissolution. In conclusion, as presented in the EA, the information about dissolution of Vacherie Dome is insufficient to answer Issue 1.6. This lack of information should be acknowledged in the EA in order to develop an information gathering plan.

Issue 1.7: Will future igneous activity or tectonic processes or events within the geologic setting of a site lead to radionuclide releases greater than those allowed by regulations?

Analysis:

1.7.1. Patterns of near and overdome tectonic features in the geologic setting are poorly known. The nature, extent, and age of faulting over and near the dome is poorly known. There are discrepancies between rates of vertical movements between studies. The relation of faults and near dome structure to the hydrologic system has not been analyzed.

1.7.2. Ages of tectonic features are only approximately known in the immediate area of Vacherie Dome. Extrapolations of future tectonic activity are dependent on the unresolved issue of fault timing and causation.

1.7.3. Records of historical seismicity are available for the region. They indicate that the area is relatively stable seismically.

1.7.4. Earthquakes appear to be non-correlatable to any known faults in the area. Some appear to be related to oil and gas development.

1.7.5. Estimates of in-situ stresses at and near the site are based on regional estimates. Fault plane solutions were not undertaken at the site, nor was fracture analysis. In situ stresses in the salt stock and surrounding strata are unknown.

Conclusion:

The pattern of tectonic features, vertical movement, and age of these features are largely open to question due to lack of data or conflicting results. This complicates any ability to extrapolate any tectonic activity. Historical seismic records show the area is relatively stable. The EA needs to acknowledge the lack of data to answer this issue and propose an information gathering plan.

Issue 1.8: Is it possible to protect the repository from future human activities that could adversely affect waste containment and isolation?

Analysis:

1.8.1. Mineable resources are present at the repository in the form of sand, gravel and clay, lignite, and the salt itself. Sparta sand is presently being mined by Dresser Minerals 2.5 miles north of the site; several gravel pits are located in the vicinity. Lignite is present in the Wilcox formation which has exploitation potentials. The shallow, high quality salt stock is a mineable resource, and can be developed for natural gas storage. Oil and gas fields exist in the vicinity of the dome, indicating potential for future exploration at the site.

1.8.2. The value of the various natural resources at the repository site has been discounted by the EA by stating that they are available at other areas of similar size in the geologic setting. This comparison, however, does not diminish the value of the probable and proven resources at the site; a value that may increase as resources elsewhere become depleted.

1.8.3. There is no indication that geologic or geophysical exploration is likely to discover a significant concentration of any naturally occurring material that is not widely available from other sources.

1.8.4. Subsurface mining and exploration has occurred at other salt domes in the Gulf Coast region. Several are pierced by petroleum exploration boreholes (including Vacherie Dome). Several domes are used for LPG storage.

1.8.5. Natural phenomena such as sedimentation, and human activities may result in the loss of surface markers and monuments designed to warn future generations of the existence of the repository. Of course concern of natural effects on surface markers assumes that the markers would be effective if unharmed.

Conclusion:

Protecting the repository from future human activities that could adversely affect waste containment and isolation is doubtful. Valuable resources are present at the repository site, some of which are being developed in the vicinity. The site has great potential for future LPG storage.

Issue 1.9: Will the long-term containment and isolation capability of the site be compromised by repository construction, operation, and closure?

Partial Analysis:

1.9.2. Estimates of the mechanical properties of the host rock and surrounding units have been stated in the EA. The mechanical properties of the surrounding units are guessed and do not reflect actual properties of the nonhomogeneous, fractured, surrounding units. Mechanical properties of the host rock need to be quantified more fully in terms of effects of anomalous zones, variations across the dome, and response to differential termal effects.

1.9.6. The underground layout and configuration is now based on a two level design because of the limited lateral extent at the proposed repository horizon. Our estimates of domal area indicate that the cross-sectional area may even be too small for this design. Avoidance of anomalous zones during repository development may further reduce the net storage area available. More detailed heater tests in the ESF may require greater pitch of canisters than originally planned, therefore requiring a greater storage area that may not be possible in the small Vacherie Dome.

1.9.7. Estimates of mining-induced effects on hydrogeological properties of rock immediately surrounding repository openings must be based on mining method. The EA suggests continuous mining machines but allows for drill and blast in drift development if miners prove inefficient. Drill and blast will also be used in developing large diameter shafts, and the disturbed rock zone associated with this conventional method, is of primary concern. The EA makes no attempt to estimate the disturbed rock zone during repository development. The need for post closure monitoring has not been determined.

Issue 2.1: During repository operation and closure (1) will the expected average radiation dose to members of the public within any highly populated area be less than a small fraction of the allowable limits and (2) will the expected radiation dose received by any member of the public in an unrestricted area be less than the allowable limits?

No additional comments.

Issue 2.2: Will the metorological conditions prevailing during operation closure lead to radionuclide releases to an unrestricted area that are greater than those allowed by regulations?

No additional comments.

Issue 2.3: Will the present and projected effects from nearby industrial, transportation, and military installations and operations, including atomic energy defense activities, significantly affect repository activities or lead to radionuclide releases to an unrestricted area greater than those allowed by regulations?

No additional comments.

Issue 2.4: Can buildings, underground areas, and waste-handling operations be designed, constructed, operated, closed, and decommisioned so that the quality of the environment will be protected and waste-transportation operations can be conducted without causing unacceptable risks to public health or safety?

No additional comments.

Issue 3.1: Can a site be located such that the quality of the environment will be protected during repository siting, construction, operation, closure, and decommissioning and can significant adverse environmental impacts in the affected area be mitigated by reasonable measures?

Analysis

3.1.1 Existing air-quality levels and trends are available from surrounding metropolitan areas.

3.1.2 Existing surface-water and ground-water quantity and quality trends are available for a broad regional area. Site specific surface-water and ground-water quantity and quality trends are very poorly known or presented in the EA.

3.1.3. Existing terrestrial and aquatic vegetation and wildlife, including evidence of threatened or endangered species and their critical habitats have been characterized by the EA.

3.1.4 Preliminary analyses of existing levels of background radiation have been presented by the EA.

3.1.5 Trends of land use patterns have been poorly analyzed in the EA.

3.1.6 Site characterization noise levels will have an adverse effect on Black Lake Bayou, a state-designated natural and scenic waterway.

3.1.7 Black Lake Bayou, a state-designated natural and scenic waterway is located one mile from the repository site. The effects of site characterization and repository construction on Black Lake Bayou have not been adequately analyzed in the EA.

3.1.8 No native American resources or other cultural resources have been identified in the preliminary analysis presented in the EA.

3.1.9 No components of the National Park System, National Wildlife Refuge System, National Wild and Scenic Rivers System, National Wildlife Preservation System, or National Forest Land are located in the immediate area of Vacherie Dome.

Conclusion:

The EA analyses have not adequately demonstrated that the quality of the environment will be protected. Primary data deficiencies include surface and ground water quality and quantity trends, trends of land use patterns in the vicinity of the dome, and environmental impacts on Black Lake Bayou. Because of the indicated deficiencies, the EA fails to answer issue 3.1.

Issue 3.2: Can access routes from existing local highways and railroads to the site be constructed with reasonably available technology, accomodate transportation system components with the performance standards specified in applicable DOT and NRC regulations, and allow transportation operations to be conducted without causing unacceptable risks to public health and safety or unacceptable environmental impacts?

No additional comments.

Issue 4.1: Will the waste package designed for use at a site be cost compatible with the regulatory requirements for safe transportation, handling, emplacement, and retrieval?

No additional comments.

Issue 4.2: Will the surface characteristics and conditions at the site allow the construction and closure of the repository to be accomplished with available technology and a reasonable cost?

Analysis

4.2.1 Topographic characteristics described by the EA include a flood plain, tributary streams, and a relief of 140 ft. In spite of these characteristics, the site is described as "flat" and "plains" in EA Chapter 6.0. The relief of the site implies that considerable grading is necessary to provide proper drainage. Bashaway Creek and its tributaries will have to be diverted around the surface facilities and entrenched 20 to 40 ft into surrounding formations, effectively destroying the flood plain. Because of the scope of fill, excavation, and diversion required at the site, time estimates given in the EA may be off by a year from surface preparation, and costs will not be comparable to other sites, except Cypress Creek, where costs are probably underestimated considerably.

4.2.2 Soil properties important to the location of surface facilities and the design of foundations are poorly presented in the EA. Values are derived empirically from Richton dome data and are not representative of Vacherie Dome. High variability is expected at Vacherie because of complex faulting. The wide ranges presented in the EA are of little value. The engineering report of DOE Smith et al. No. 1 (Hawkins, 1978) indicates that boggy conditions exist because of equipment problems mud and the like.

4.2.3 Local meteorological conditions important to the design of the surface facilities are hurricanes, high winds, high PMP, high runoff, and negative evaporation balance. The high PMP hurricanes and winds will undoubtedly cause damage, or at the least, disrupt the surface facilities. Salt runoff may occur during these events. The effects of these events on the diverted streams are unknown.

4.2.4 Surface characteristics that could lead to the flooding of underground facilities include the siting of the repository in a topographic low, subject to flooding, and the presence of aquifers above the salt dome. The aquifer are probably fractured, faulted and brecciated, indicating a danger of flooding of the underground facilities if not considered.

Conclusions:

The surface characteristics and conditions at the site will not allow the construction and closure of the repository to be accomplished at reasonable cost. Extensive measures must be used to grade the site to prevent flooding of surface facilities creating a high cost and long time frame for surface preparation not reflected in the EA. The presence of fractured, saturated strata over the dome calls for special measures to insure that seepage will not occur over the lifetime of the shafts.

Issue 4.3 Is the repository horizon of sufficient lateral extent, thickness and depth, and are the planned operations of sufficient flexibility to allow cost effective repository to be developed?

Analysis:

4.3.1 The host rock of Vacherie Dome consists of a number of bedded units dipping away from the dome. The size and configuration of these beds is of secondary importance compared to the degree of hydrologic isolation. Dissolution of the caprock however, could effect its competence as experienced in salt domes exposed to solution mining. Our analysis indicates that the dome-intercepted bed interface was misinterpreted and, therefore, the dome has less lateral extent than appears in the EA.

4.3.2 The quantities of waste of various types appear in the EA, although specific characteristics are not discussed.

4.3.3 Specific methods of waste emplacement and retrieval are not discussed in the EA, although the canister is defined to some extent which suggests handling procedures. We anticipate retrieval conditions to be extremely hot, while contending with high pressure water vapor, and creep-displaced canisters. Hence, we do not think retrieval in salt is within present technology and this may be why the EA hardly discusses the issue. Repository plans show vertical hole waste canister placement at a spacing to maintain a uniform heat load. If detailed testing suggests the spacing to be increased, then there may not be enough room for the required amount of waste.

4.3.4 The repository development plan does not include the occurrence of anomalous zones, which should be avoided. This will almost certainly effect the final repository layout. Special ground support plans for mining through shear zones are also not discussed in the EA. The ESF may not be large enough to resolve, geologic uncertanities, and contingency plans for unexpected ground conditions are not given. It may be beneficial to mine the perimeter return air drifts first, in order to characterize the boundaries of the repository. No such plans are presented.

4.3.5. No methods are presented in the EA for backfilling and sealing drifts, shafts, and boreholes. There is only mention of backfilling with salt and using appropriate seals. Information necessary for developing effective backfilling and sealing systems are not presented.

Conclusion:

The above issues are not resolved in the EA; in fact, they are only marginally addressed. The EA does not acknowledge the lack of information from which it can develop an information gathering plan for method of waste emplacement and retrieval, mine development contingency plans, or methods for backfilling and sealing excavations.

Issue 4.4 Are the hydrologic conditions at the site compatible with the construction and operation of a cost-effective repository?

Analysis:

4.4.1 Hydraulic characteristics of units between the repository and the ground surface, as presented in the EA, are based on regional determinations which ignore aquifer anisotroph and variations in lithology. The diapirism activity of the dome most likely influenced local lithology. This has not been addressed in the EA. The influence of faults, fractures and steeply dipping beds similarly has been ignored in the EA.

4.4.2 The construction of the large exploratory shaft will use freeze blast techniques. This procedures will cause a potential for radionuclide release along the outside of the liners, through the creation of a disturbed zone around the shaft enhanced by fracture propogation in the frozen materials, and the increased pore sizes due to freezing water.

4.4.3 Bounds of the effects of hydrologic conditions on the repository design cannot be calculated from the information presented in the EA, because bounds of hydrologic conditions are unknown.

Conclusion:

The hydrologic conditions at the site are not compatible with cost effective repository development. Leakage of ground water into the repository through shafts, and leakage of nuclides outward from the repository are possible.

Issue 4.5 Natural and man-induced phenomena expect at the site.

No additional comments.

Issue 4.6 Can a repository be designed, constructed and operated to perform its functions of waste receipt and disposal and protect the health and safety of the workers in a cost effective manner?

No additional comments.

Issue 4.7 Can the repository be closed in a cost-effective manner?

Analysis:

4.7.1 Characteristics of stratigraphy, geohydrology, geochemistry and other factors must be established for any design of plugs and seals to be successful. That is, geotechnical data are necessary both for repository performance confirmation and assurance of long term isolation. The EA is preoccupied with concerns of repository siting and operation, but is weak in areas of data collection and post closure performance.

4.7.2 The character and extent of damage caused by the excavation of access shafts and underground workings must be identified and incorporated in real designs. Even if continuous mining methods are used along with drill and blast (controlled techniques) there will be disturbed rock zones, particularly in shear zones near anomalous areas that will be present. The EA does not address excavation damage in this regard.

4.7.3 Performance characteristics and long term stability of sealing materials is not adequately addressed. In fact, sealing materials are not discussed at all. The EA apparently is not concerned with topics that may be resolved during site characterization. Nevertheless, a data collection plan could be outlined for information gathering. In effect, sealing materials cannot be addressed without examining site conditions, and site conditions cannot be addressed without relating how they effect real material performance.

4.7.4 Emplacement techniques and operational procedures for acceptable materials and real geometries are not discussed in the EA.

4.7.5 Repository design information, as presented in the EA, was relative to the dome and surrounding environment, rather than its importance to the design and analysis of the sealing system. Information needs for the sealing system were not presented in the EA.

4.7.6 Detailed closure requirements and implementation plans were not presented in the EA, however, many of the plans such as continual monitoring have not been finalized. Therefore, to present such discussion in the EA may be premature.

Conclusion:

For the most part, the EA did not address the issue as to whether a repository can be closed in a cost effective manner. A data collection plan to resolve this issue was not presented either. It is our belief that a site assessment must include the final objective of closure along with construction and operation possibilities.

4.0 IMPORTANT VACHERIE DOME SITE EA ISSUES

The following subsections describe issues which are major flaws in the EA for the Vacherie Dome Site and, if not resolved, would, in our opinion, force the Vacherie Site out of consideration as a location for a high-level nuclear waste repository.

4.1 Dome Size and Shape

The depth and cross-sectional area of salt domes have been incorporated in siting criteria over the duration of the search for acceptable dome sites for nuclear waste repositories, resulting in the elimination of many domes from repository consideration. Early conceptual designs for repositories in salt domes suggested that a minimum domal working area of 1,000 acres with a 500-ft salt barrier around the boundary of the repository was required (Stearns-Roger, 1977). The width of the salt barrier was later enlarged to 800 ft (Stearns-Roger, 1981, ONWI-283, p. 3-31), and minimum working domal area, excluding this buffer zone, was expanded to 1,500 acres (ONWI-109, p. 41).

Estimates of Vacherie Dome cross-sectional area have varied as a result of increasing data acquisition and refinement. Spooner (1926, p. 244) described the central salt core as "slightly elongate northwest and southeast," with a diameter of 2,500 ft at a depth of 800 ft. Measurement of domal area at -2,500 ft MSL from Crowe (1977, p. 98, Fig. 26) indicates a total of approximately 1,775 acres.

LETCo's (1982, ONWI-119, V. IV) interpretation of domal geometry was based on gravity surveys, seismic data, and well control. Five seismic lines provided information concerning domal shape at depth. Three of these were single-fold Arco lines shot in 1946 but later processed into variable-density time sections in 1975. Two of the lines were shot and processed by Petty-Ray in 1975 using 12-fold CDP stacking techniques. All time sections were converted to depth sections using a velocity function of $VZ = 7{,}500$ ft/sec $+ 0.78Z$, where V is velocity and Z is depth. None of the data were migrated. Three of the five lines were displayed in the 1976 LSU report by Martinez et al. (1976). The shallowest continuous reflection occurred near the top of the Upper Cretaceous Annona horizon. The deepest reflections recognized were probably near the top mother-salt horizon, the Luann Salt. Several Lower Cretaceous reflections which are interpreted to be the Ferry Lake, Rodessa-James, and Sligo horizons were also noted.

The outer edge of the salt stock is extremely difficult to determine using stacked seismic data alone. Thus, the Martinez et al. (1976) interpretation of the dome's outer limits and the structural geology immediately adjacent to the salt stock are highly questionable. Data gaps make the location of the dome's edges uncertain at several key places. Bedding terminations and disruptions were used to delineate dome boundaries, overestimating the lateral extent of the salt stock.

Domal area was estimated to be 2,379 acres at -2,500 ft MSL by LETCo (1982, ONWI-119, V. IV, p. 10-2). ONWI (1982, ONWI-109, p. 42) indicated that the net available acreage at the "repository depth" (assumed to be -2,500 ft MSL) was 1,760 acres plus or minus 10%, excluding the 800-ft buffer zone.

Four high-resolution shallow seismic lines were shot for Ertec in 1983 by SSC and processed by Baird Petrophysical (Ertec, 1984, ONWI-520). Unlike the 1975 LSU (Martinez et al., 1976) data, the Ertec lines were recorded under a broader bandwidth of seismic frequencies. Throughout the entire processing sequence, Baird's primary objective was to improve the signal-to-noise ratio and to preserve the high frequency content. According to Baird, several interval velocities were used in the migration process. These were derived from stacking velocities and all available sonic logs. However, they apparently did not list which velocities were utilized over each portion of the geologic section which make it difficult to check the accuracy of their migrated data. To convert time to depth, Baird used a slower velocity function than was used by Martinez et al. (1976): VZ = 5,500 ft/sec + 0.78Z. Synthetic seismograms were also generated from the available sonic logs which helped in recognizing characteristic seismic reflections.

Ertec's positioning of the salt stock was based on terminations of strata reflections. Domal area at -3,000 ft MSL was estimated to be 2,184 acres, including the 800-ft buffer zone (Ertec, 1984, ONWI-520, p. 48). Based upon the Ertec interpretation, the EA estimates that domal areas at -2,250 ft MSL and -2,725 ft MSL are

2,080 acres and 2,400 acres, respectively, including the 800-ft buffer zone (EA, p. 3-32, Sect. 3.2.5.6, para. 5).

4.1.1 Critique of Ertec (1984, BMI/ONWI-520)

Several key assumptions were incorrectly applied to high-resolution seismic data for Vacherie Dome. The following is a critique of several parts of the Ertec report.

BMI/ONWI-520, p. 10, Sect. 1.3.1. The Ertec report states that the processing sequence used in their survey "did not include migration to account for dipping layers." In the absence of such processing, all dipping beds will be displaced downdip (This is also mentioned on p. 22, Sect 3.5., point 4). Inasmuch as all beds dip away from the dome, beds will be mislocated, appearing farther from the center of the dome. This effectively enlarges the dome on seismic sections relative to its actual size.

BMI/ONWI-520, p. 22, Sect. 3.5, Points 1 to 3. The true dip is not represented on the seismic profiles. The apparent dip will underestimate the true dip. This has implications for the identification of any dome sheath material.

BMI/ONWI-520, p. 23, Sect. 3.5, para. 1. The Ertec report states that lines were assumed to be "perpendicular to the strike of the dipping line." This assumption presents great problems if any dome sheath material is present. If portions of the sheath are lithified prior to diapirism, coherent blocks of this material may be oriented in several possible directions, leading to out-of-line reflectors. The coherence of the signal can be greatly reduced in such areas, resulting in a seismic signature very similar to that of salt for the sheath.

BMI/ONWI-520, p. 23, Sect. 3.5, para. 2. The Ertec report states that "relatively high velocities in the shallow part of the section made the migration very sensitive to the velocity used." Accurate analysis of any overdome structures due to faulting or dissolution is crucial to interpretations in lower areas of a section. While the Ertec report presents comments on shallow over-dome structures, it does not thoroughly analyze the effects of these structures on the section directly below them, nor in areas below this horizon where ray paths sampled structures.

BMI/ONWI-520, p. 33, Sect. 4.2.1, para. 2. The Ertec report states that "locations of the steeply dipping flanks of the salt stock are inferred based on the interpreted terminations of strong reflections." This criterion should be used to determine the edge of the salt dome (which may include any intricately-entrained sediments). This assumption, given correct migration, yields the largest possible salt stock size. Any sheath material would reduce the width of the salt stock by an appropriate amount.

BMI/ONWI-520, p. 34, Sect. 4.2.1, para. 1. The Ertec report states that the "absence of reflections above the dome is not caused by processing, but may indicate the sedimentary units are discontinuous or distorted." Unless these areas are properly migrated, the entire downsection migration is highly questionable.

BMI/ONWI-520, p. 34, Sect. 4.2.1, para. 2. Ertec suggests that irregularities in reflections may indicate irregularities in the caprock. Another interpretation to these irregularities may be that improper, or "mismatched" velocities were used.

BMI/ONWI-520, p. 34, Sect. 4.2.1, para. 3. The Ertec report states that "reflection from the top of the salt is weak." This indicates that the extent of dissolution cannot be determined from these data.

BMI/ONWI-520, p. 35, Sect. 4.2.2, para. 2. Inasmuch as "the presence or absence of a caprock sheath and/or deep caprock can not be stated," assumptions used by Ertec will yield the greatest possible salt stock size. The true size may be much smaller.

4.1.2 Interpretation of High-Resolution Seismic Lines

4.1.2.1 Line ELV-S1.

Ertec interprets "line-ups" on the western half of the migrated section to be "artifacts of migration" (p. 35, para. 3). A more probable interpretation of the "line-ups" is that the signal was diluted and dispersed by structures above the dome. In this case, they should not appear on the migrated section, but should become more "focussed" as processing removes disruptions caused by Tertiary strata. This may be interpreted as meaning: 1. Tertiary structures are causing down-section interpretations to be questionable; 2. Better migration of the upper part of the section will "bring out" these deeper reflectors; and 3. The extent of the salt stock is greatly overestimated in the Ertec report.

The shallow Tertiary strata data on this and the other three seismic sections is not continuous over the dome. This could either be due to improper velocity functions applied during the migration process or that the Tertiary strata are severely faulted as suggested by Letco (1982, ONWI-119) and Kolb st al. (1983, ONWI-467).

4.1.2.1.1 Specific Interpretation of Line ELV-S1

SP220 to SP225; 0.84 seconds. At the -3,000 ft level, the reflections appear to terminate, indicating that this may be the edge of relatively undisturbed rock. The actual salt dome edge may lie between SP225 to SP230, 500 to 750 ft from the edge of the -3,000-ft LETCo (1982) contour.

SP230, 0.19 seconds. The fault which is mapped here does not appear to extend to SP220, 0.46 seconds, or beyond; hence, it is dubious.

SP240. The loss of signal at this area is probably due to up-section problems in migration, or to a possible shallow structure. The reflector at SP101, 0.54 seconds, and those immediately below it, appear to extend all the way across the section, casting further doubt upon the fault interpretation.

SP243 to SP255, 0.3 to 0.4 seconds. This area lacks a well-defined caprock "signature," casting doubt on the Ertec interpretation. Due to density similarities between caprock and salt, it is unclear how Ertec make the distinction between the two rock types.

SP255, 0.86 seconds. This area has the exact signature as areas to the west. The match of apparent dips in this area to those to the west is too great to be coincidental. This area may represent bedded strata.

4.1.2.2 Line ELV-S2.

Migration and processing problems are evident on Line ELV-S2. A loss of energy from CDP's (common-depth-points) is an indication of errors in processing or migration. Several such areas are discernible. There are many horizontal and vertical discontinuities in the upper 0.2 seconds of this section. Unless this area can be migrated "correctly," no part of the signal below that level can be reconstructed accurately. The clearest interpretation of the edge of any salt dome is the recognition of reflections from caprock, which produce a strong "signature." A clear caprock signature is seen on the northwestern portions of this section at about 0.2 seconds; however, the reflector cannot be followed to the Ertec-drawn boundary. The actual termination of the caprock may be 1,000 ft to the southwest of their interpretation.

4.1.2.2.1 Specific Interpretation

SP196, 0.70 seconds. The loss of energy from the CDP in this area is an indication of problems with processing or migration. The area at approzimately 1.1 seconds is enhanced and shows a similar dip to points at 0.3 to 0.4 seconds. The fault at SP200 thus may not actually be present; The CDP in this region, both above and below the interpreted fault, show definite problems.

SP185 to SP160. The interpretation of this area is highly subjective; the faults and steep dips are most likely due to processing and migration problems. There is a fair amount of signal distortion and breakup at about SP178, 0.9 seconds. There is a possibility that some fairly-steeply dipping reflectors are present to the southwest. The "dead zone" in the vicinity of SP175 to 175, 0.45 to 0.9 seconds makes differentiating the outer edge of the stock difficult. A minor continuous reflection at 0.6 seconds extending from SP180 northeast to SP155 suggests that the subsurface reflections may terminate between SP160 to SP165 at the -3,000 ft level.

SP155 to SP165, 0.84 seconds. One possible interpreted edge of the salt stock may lie in this region, some 1,200 ft from the edge of the -3,000-ft Letco (1982) contour.

SP155, 0.16 seconds to SP140, 0.10 seconds. A processing or migration problem is clearly evident in this area. Interpretations below this region should be made with extreme caution.

SP145 to SP100. There is a change in caprock signature at SP145; this may represent the actual limit of the dome. The "criss-cross" patterns noted in the zone above the dome on p. 41, para. 1, may be the result of dissolution collapse structures.

4.1.2.3 Line ELV-S3.

A very distinct caprock signature is seen in the northwestern portions of this section. The data quality below the caprock and extending to SP160 in very poor; the Ertec interpretation of the dome edge in this area and beyond is very subjective. Data quality below 0.7 seconds is poor, no salt boundary can be picked with any confidence. Ertec extends the caprock beyond what the data indicate. This leads to incorrect assumptions in velocities below this region. If incorrect velocities were used, the entire section below these points may be disrupted. Thus the terminations mapped by Ertec may not be structural in nature, but instead artifacts produced by processing assumptions.

4.1.2.3.1 Specific Interpretations

SP235, 0.7 seconds to SP170, 0.65 seconds, to SP155, 0.26 seconds, to SP105, 0.22 seconds. Interpretation below this level are very subjective due to loss of energy upsection.

SP185 to SP190, 0.84 seconds. A highly interpretive salt-sediment boundary may be present in this area, nearly coincident with the LETCo (1982) -3,000-ft contour. The actual terminations of bed reflections may be near SP185 to SP190 at this level.

SP160, 0.16 seconds. The deeper structures are not apparent on the CDP gather in this area.

SP155, 0.72 to 0.98 seconds. The apparent coherence in this region matches the upsection dip. This may be interpreted to represent sedimentary layers.

SP140, 0.20 seconds. This appears to be the true end of the caprock on the section. If the salt stock is assumed to be near vertical, the salt stock edge may be at SP147 at 0.84 seconds (-3,000-ft level).

SP125, 0.35 to 0.45 seconds. The reflectors in this area do seem to exist. Their shape may well be due to a concave-upward reflector at 0.18 seconds. Irregularities in the caprock signature may indicate solution features.

4.1.2.4 Line ELV-S4

Line ELV-S4 has no definitive caprock signature on either the migrated section or on the CDP gather, in marked contrast to the prominent signature on line ELV-S3. Because of the lack of a caprock signature, the salt stock may not be present on this section. In general, this section has similar problems with shallow structure interpretations as do the other three lines.

4.1.2.4.1 Specific Interpretations

SP200 to SP105. The data quality away from the dome edge is good down to a depth of 1.1 seconds (-4,500 ft).

SP205, 0.19 seconds to SP182, 0.58 seconds. The fault in this area disrupts the signal to the southwest, wiping out reflections. Beds below 0.58 seconds at SP198 appear to be truncated. This may represent the edge of the dome or, more likely, a processing problem. At the -3,000-ft level, the reflections terminate at SP190 to SP195. If these terminations are real, then the salt-sediment boundary can lie between SP195 to SP200, approximately 800 ft from the -3,000-ft LETCo interpretation. However, between SP195, 0.8 seconds, and SP215, 0.75 seconds, reflectors seem to be continuous through the zone of energy loss.

SP185 to SP195, 0.85 seconds. There is a possibility of a local unconformity within the Mooringsport based on reflector terminations.

4.1.3 Domal Extent

In determining the extent of the salt stock, all available well data and the re-interpreted Ertec lines were used. Original Arco seismic lines and Petty-Ray lines were not used, primarily because the data quality is too poor and the salt-sediment interface is too difficult to determine using stacked data alone. Interpretation of individual seismic sections are shown in Figures 4.1-1 through 4.1-4. Two separate lines are plotted on these figures, representing conservative bounds on the limits of the salt stock, based on interpretations in Section 4.1.2. These two interpretations are plotted as probable -3,000-ft MSL contour lines on Figure 4.1-5. Total domal areas for these two interpretations are 1,900 and 1,585 acres. Subtracting the 800-ft buffer zone from these estimates yields 1,280 and 910 acres, respectively.

4.1.4 Conclusions

The Ertec interpretations of domal area are much higher than those interpreted in this report. Total available area at -3,000-ft MSL ranges between 910 and 1,280 acres, excluding the 800-ft buffer zone. These estimates of available domal area are far below the 1,500 acre minimum used by ONWI (1982, ONWI-109, p. 41) to eliminate salt domes from consideration for nuclear waste

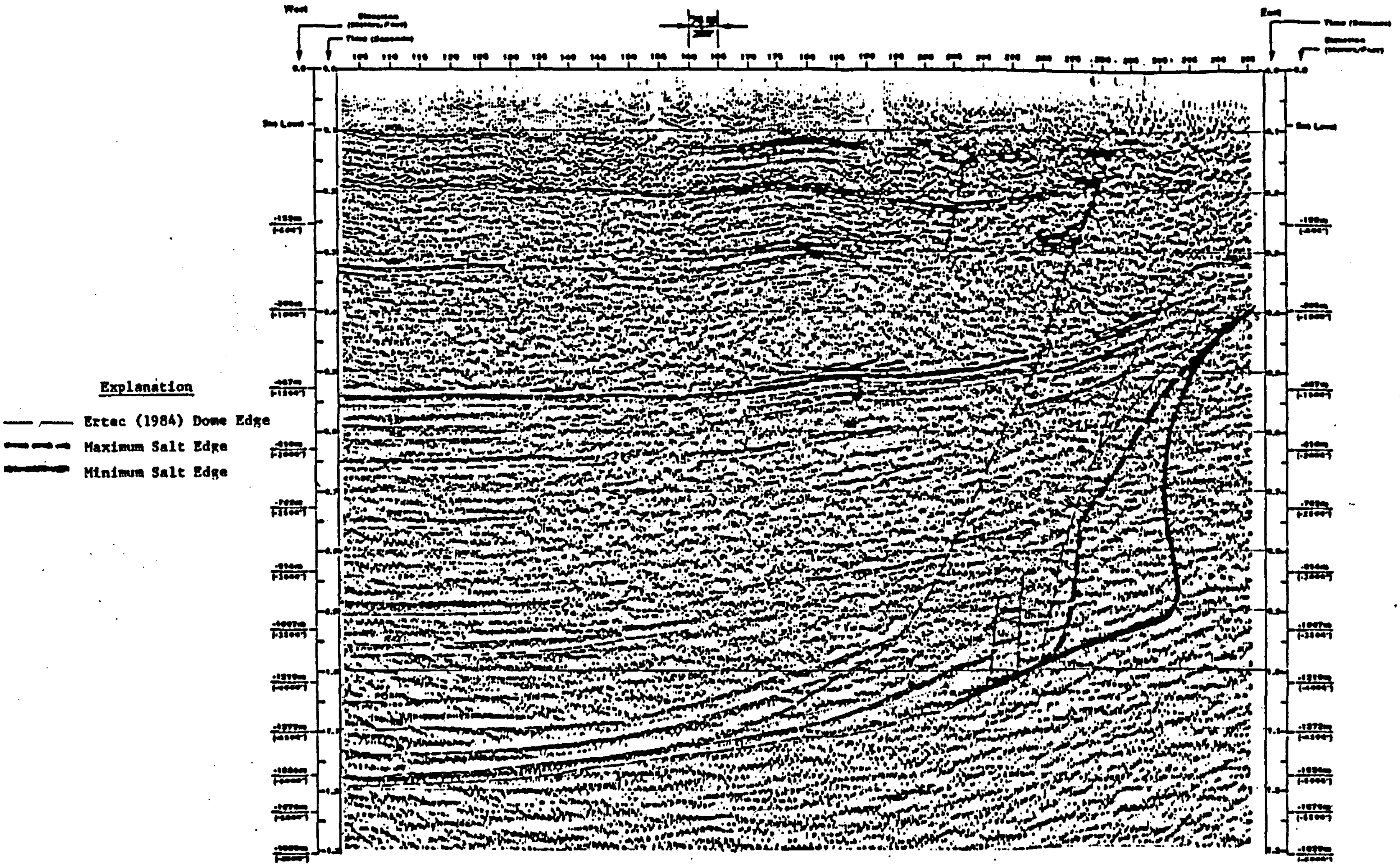


Figure 4.1-1. Line ELV-S1. Adapted from Ertec (1984, ONWI-520, Fig. 4-4).

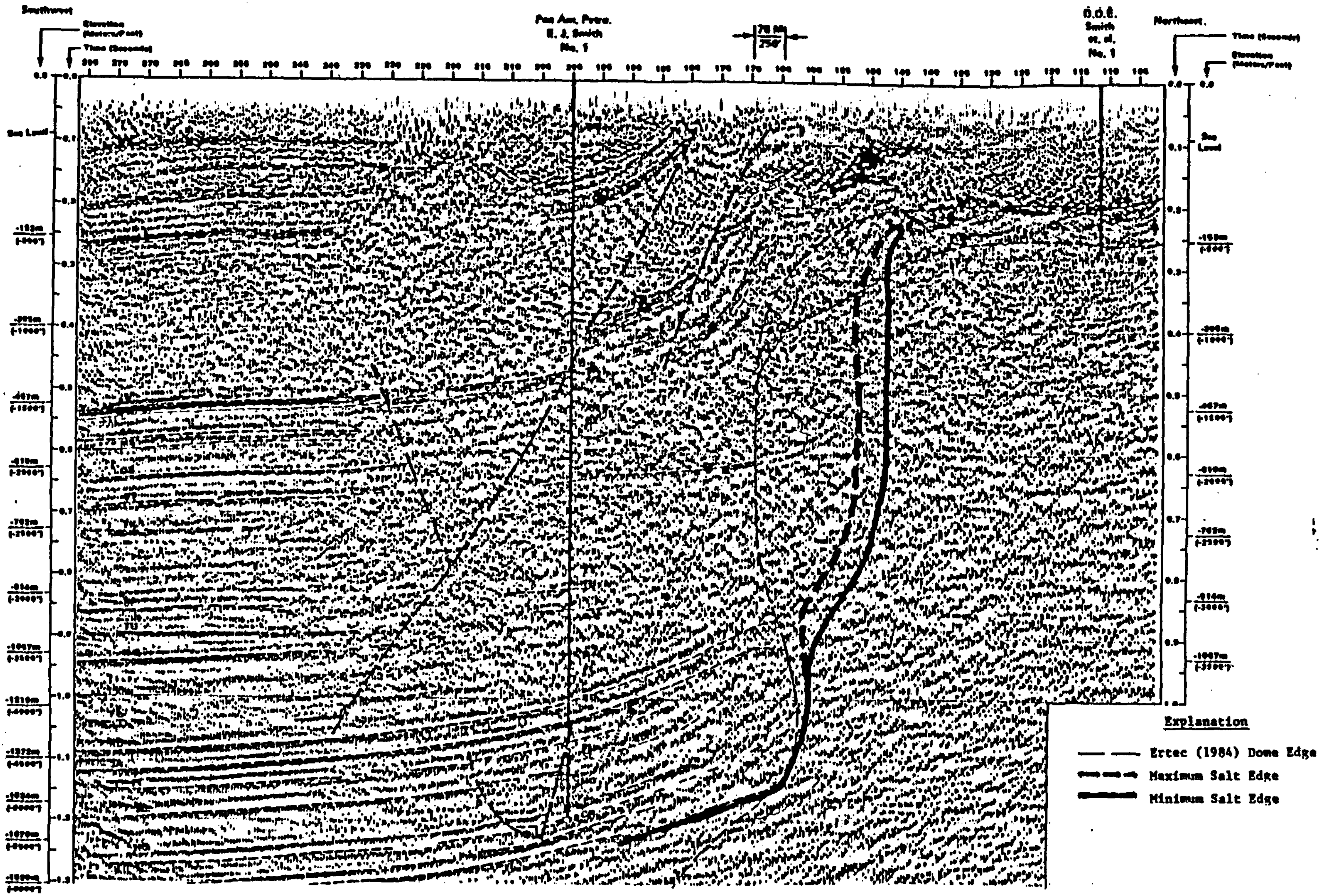


Figure 4.1-2. Line ELV-S2. Adapted from Ertec (1984, ONWI-520, Fig. 4-5).

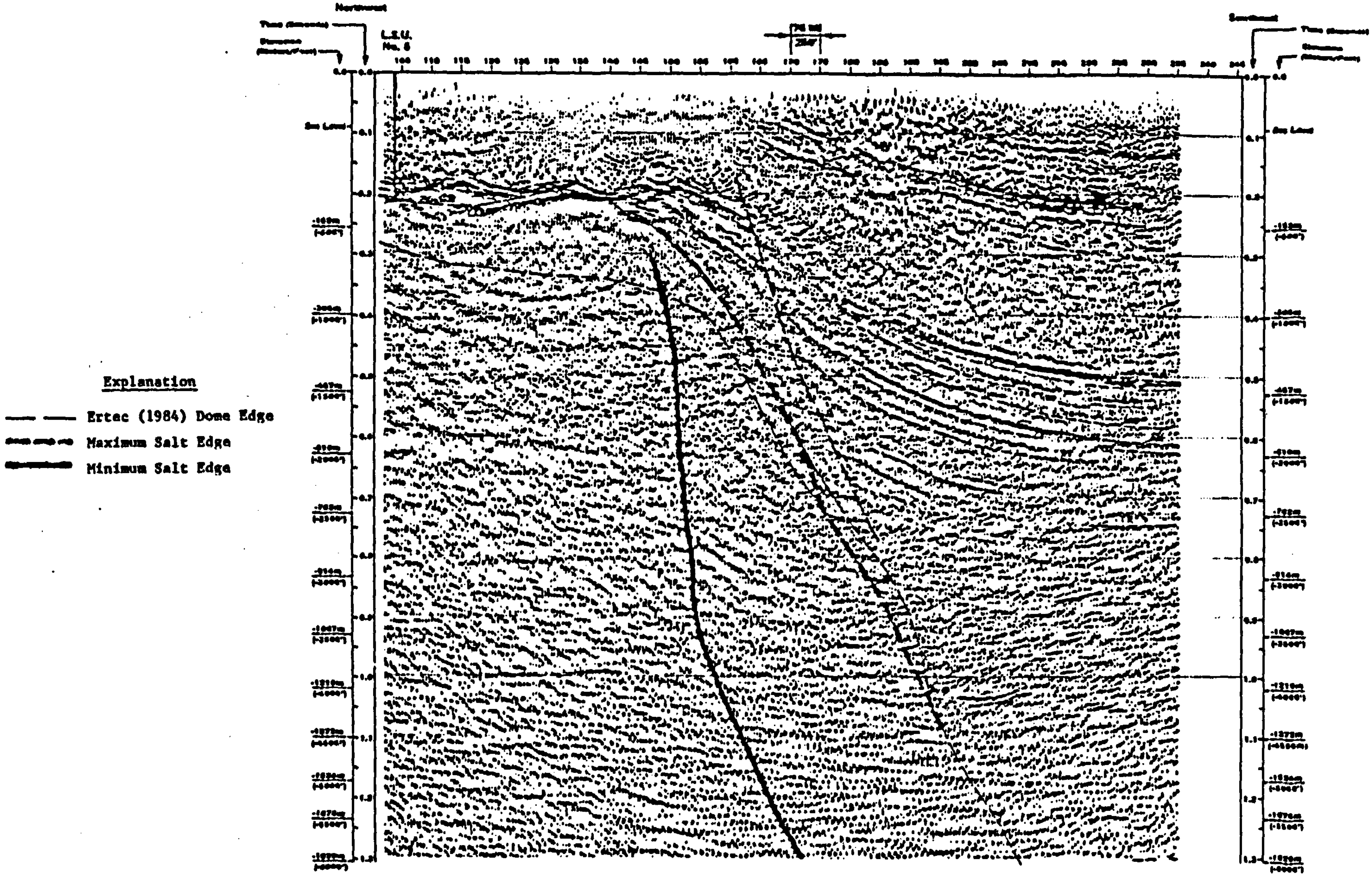
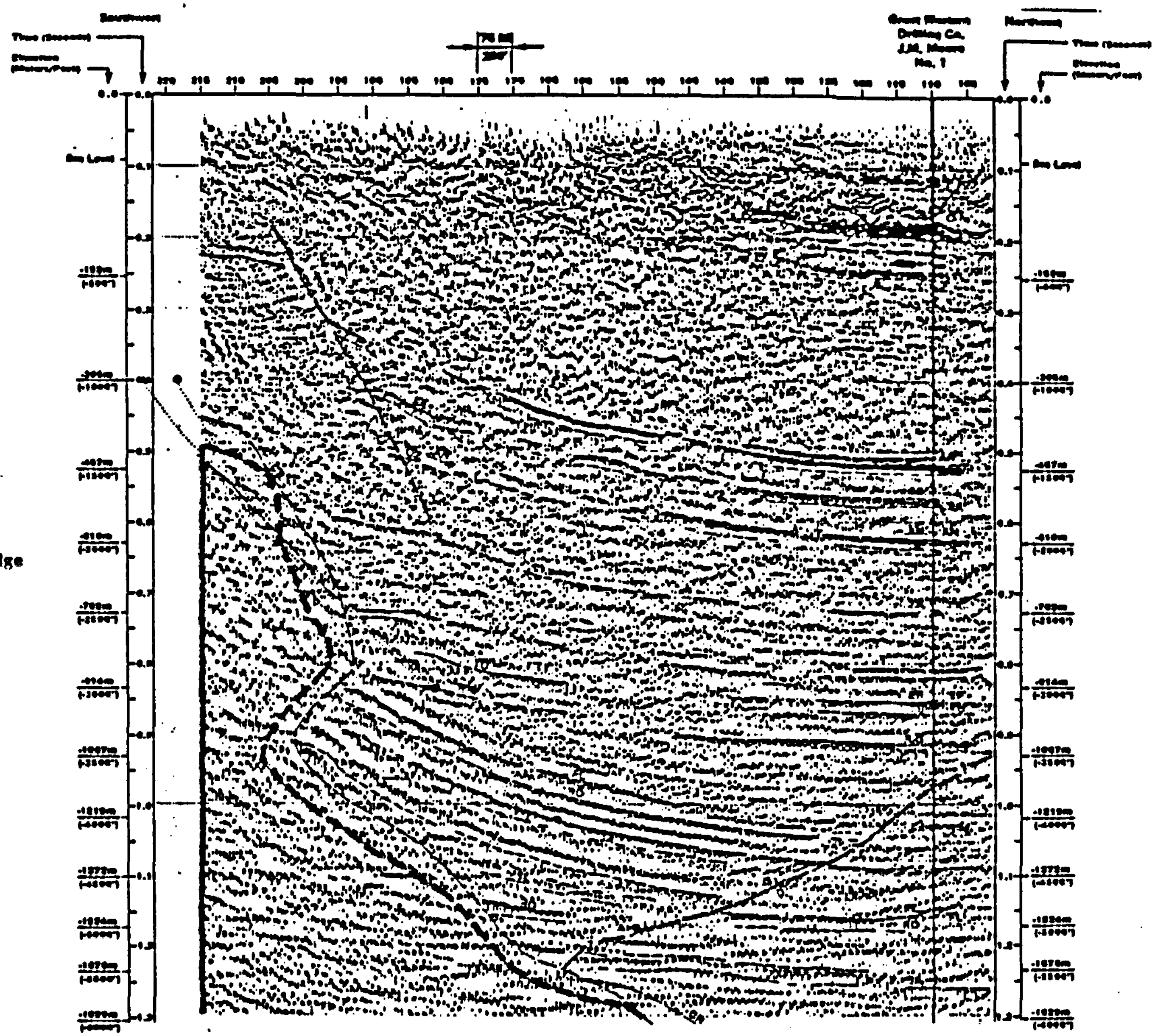


Figure 4.1-3. Line ELV-S3. Adapted from Ertec (1984, ONWI-520, Fig. 4-6).



Explanation

Ertec (1984) Dome Edge

Maximum Salt Edge

Minimum Salt Edge

Figure 4.1-4. Line ELV-S4. Adapted from Ertec (1984, ONWI-520, Fig. 4-7).

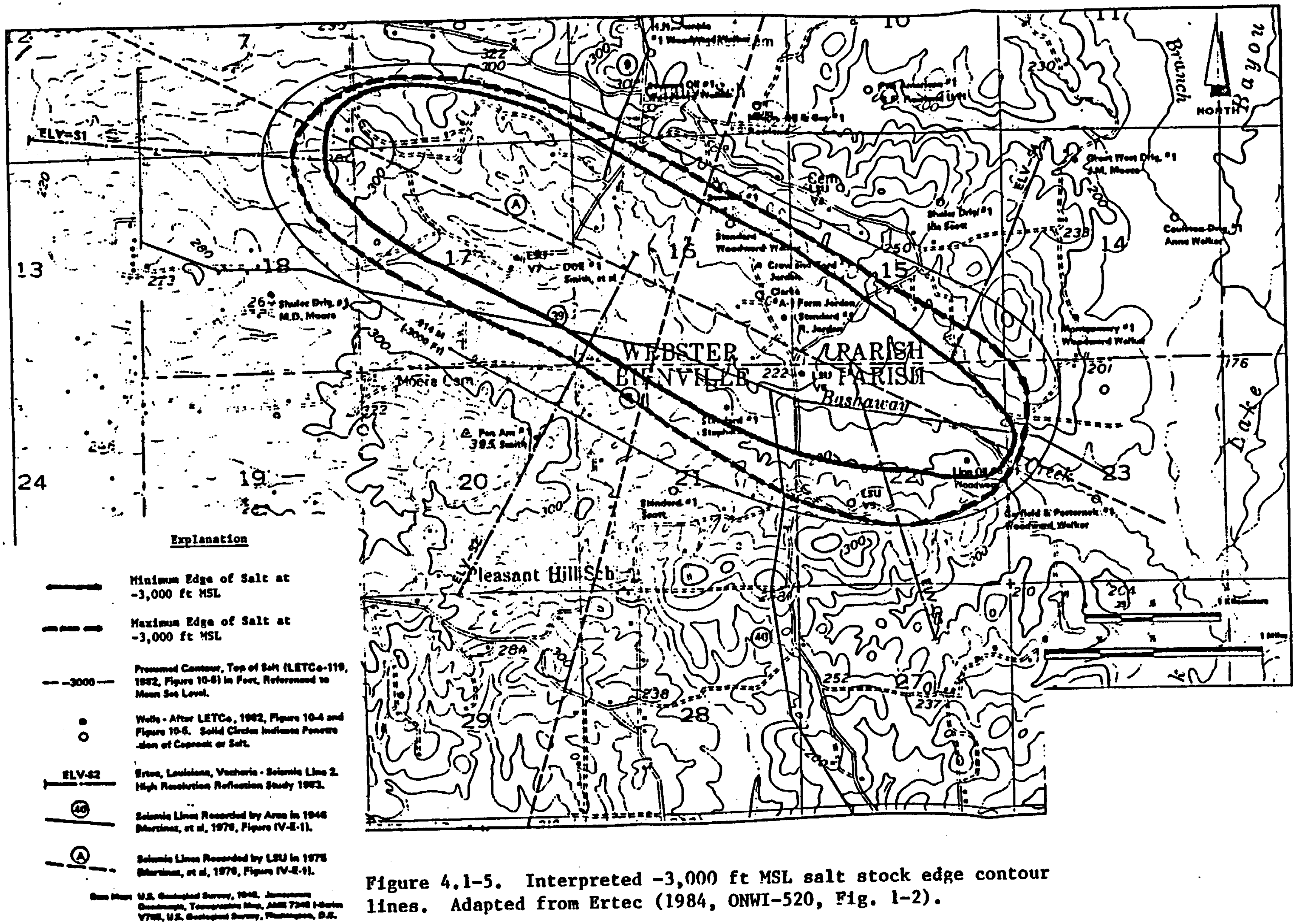


Figure 4.1-5. Interpreted -3,000 ft MSL salt stock edge contour lines. Adapted from Ertec (1984, ONWI-520, Fig. 1-2).

repositories. Vacherie Dome should be eliminated from further consideration for use as a repository.

We believe that this degree of uncertainty that has not been recognized in the EA is not in accordance with NWPA Title I, Subtitle A, Section 112(b)(1)(E)(i); 10CFR60.113(c)(a); 10CFR960.5-2-9(6)(1).

4.2 Hydrologic Uncertainties

Surface and subsurface hydrologic data and analyses, as presented in the EA, are incomplete, misleading, and of limited value. Data are too haphazard and sparse to allow making predictions of effects of site characterization and repository construction, operation, and closure on surficial and ground waters, or to assess the potential for radionuclide release to the accessible environment.

4.2.1 Surface Hydrologic Uncertainties

Major uncertainties regarding surface hydrology as presented in the EA include exclusion of flow data and channel/floodplain geometries of Bashaway Creek and its tributaries, insufficient analysis of sediment and salt pollution of Bashaway Creek and Black Lake Bayou, a state-designated natural and scenic waterway. The environmental effects of relocation and channelization of Bashwaway Creek have not been sufficiently analyzed in the EA. Optimistic claims of aquatic biota recovery following channel relocation are not based on the aquatic biota characteristics at the site. No consideration of topography was included in EA analyses of relocated channels; the indicated location of the exploratory shaft facility (EA, p. 4-31, Fig. 4-10) would necessitate 20 to 30 ft of channel entrenchment, and elimination of Bashaway Creek floodplain in the vicinity of the surface facilities. Changes in surface flow due to construction and operation have been poorly addressed in the EA. Without data for pre-contruction streamflow, it is hazardous to guess the effects of repository construction and operation on surface waters. It is unwise to begin construction activities during site characterization without this information.

We believe that this degree of uncertainty regarding surface waters is not in accordance with NWPA Title I, Subtitle A, Section 112(b)(1)(E)(iii); E.O. 11988 Part I, Section 1; 10CFR960.5-2-5; 10CFR960.4-2-1; 10CFR960.4-2-4(b)(1).

4.2.2 Subsurface Hydrologic Uncertainties

Data and analyses of subsurface hydrology as presented in the EA are of limited use in assessing the potential of radionuclide release and the potentials for subsurface water degradation. Aquifer properties are derived from a broad regional data base, with little or no consideration of the effects of Vacherie Dome on subsurface hydrology. Aquifers are overgeneralized as homogeneous without regard to facies changes in the vicinity of the dome. Site specific potentiometric level, hydraulic conductivities (both vertical and horizontal), effective porosities, hydraulic gradients, rates of potentiometric decline, and other properties are either not presented, poorly defined, or based on regional and empirical relationships. The EA has grouped several hydrologic units into single units, creating a greater uncertainty.

The EA has discounted subsurface water level and quality degradation by stating "The hydrologic regime will not be impacted in a major way" (EA p. 5-47, Sect. 5.2.2.2.3, para. 2). The effects of ground water withdrawal and changes in the local water budget have not been adequately addressed in the EA with respect to impacts on local residences and industries. Drawdawn due to construction and operation will have an adverse effect on well water levels in the surrounding area and may affect local surface hydrology. Calculations of the amount of salt entering the hydrologic system need to be reanalyzed.

We believe that the degree of uncertainty regarding subsurface hydrology is not in accordance with NWPA Title I, Subtitle A, Section 112(b)(1)(E)(iii); 10CFR960.4-2-6(c).

4.3.3 Hydrologic Modeling and Travel Time Uncertainties

Accurate representation of site-specific subsurface hydrologic properties, structural discontinuities, rates of water decline, and other factors are crucial to quantitative modeling of a hydrologic system as complex as that surrounding Vacherie Dome. Hydrologic modeling by INTERA (1984) is of limited use for predicting ground water flowpaths, and the rates of radionuclide transport through the hydrologic system. Analyses presented in INTERA (1984) and the EA ignore aquifer anisotrophy, interconnectiveness of aquifers along faults and fractures, domal influence on hydraulic gradients, the probable presence of anomalous zones in the salt stock, and the creation of disturbed zones along shafts.

We believe that the degree of uncertainty regarding subsurface hydrologic modeling is not in accordance with NWPA Title I, Subtitle A, Section 112(b)(1)(E)(iii); 10CFR960.4-2-1(b).

4.3 Anomalous Zones

Section 3.2.3.2.3 of the EA recognizes the probable occurrence of anomalous zones in the Vacherie Dome, but no further discussion whatsoever is provided on their effect on repository development and radionuclide isolation. DOE core hole DOE-V (vertical) did not encounter any features definitively diagnostic of an anomalous zone, but anomalous zones tend to be vertical or steep, and a single vertical hole has a minimal chance of such an encounter. Anomalous zones have often been ecountered while mining salt domes in the Gulf Coast Region. These zones can range from 3m to 100m wide and run hundreds of meters long at the edge or interior of a dome. Their vertical extent is difficult to determine.

Anomalous zones usually contain bands of "low-grade" dark salt, inclusions and gas pockets throughout shear zones (Kupfer, 1979). Gas pockets can contain pressurized CO_2, CH_4, CO, N_2, or H_2S that "blowout" when intercepted by the mining front. Case histories indicate that some domes are more prone to blowouts than others, although the reasons are not clear (Thoms and Martinez, 1979). This may be due, in part, to mining practices.

Repository design will need to allow for the presence of anomalous zones and define barrier pillar widths to avoid peripheral anomalous zones which are almost certain to exist. This designed width will no doubt change during mining as experience and knowledge about the dome is acquired. Thus, repository designs do not appear to be flexible and allow for changes during limited and the interception of anomalous zones will certainly reduce the estimated storage area.

Methane and hydrogen sulfide gases associated with anomalous zones will also effect repository design. Gassy mine regulations require crosscuts at intervals less than 100 ft, making the proposed storage room design inadequate, and more frequent crosscuts will increase the extraction ratio, thereby affecting rock stability. Emergency capability is also relevant implying the need for refuge stations for personnel; such stations are not shown in repository plans.

Avoiding anamalous zones is of primary concern. Blasting into a gas pocket could release large amounts of gas, although personnel could be far enough removed to be unaffected. Most gas pockets blowout during a mine blast. However, continuous mechanical mining into a gas pocket would present a high risk to the mining quipment operator.

Research to predict gas outbursts in advance of mining is ongoing (Mahtab, 1982). These techniques are based on drill and blast methods, as drill holes form the basis for future gas outburst prediction equipment. Continuous mining methods proposed in the EA do not offer advance examination of rock conditions beyond the face and, therefore, may not aid gas outburst prediction without special drill holes used for probing.

Anticipation of or occurence of anomalous zones adversely affects mining schedules for a number of reasons. Advance drilling is slow and will impede drill development from approaching average rates obtained in industry. In addition, mine development may stop due to geologic studies to decide how to best avoid an anomalous zone. Weak roof near these zones will require extra roof cleaning and roof support.

It is not clear how anomalous zones will react to heating by the stored canisters. However, even improved mining techniques or gas production methods will not regain lost storage space resulting from avoiding anomalous zones. In the Vacherie Dome, this storage space can only be recovered by developing more levels. A multi-level repository will be very complex in design and operation.

As a summary of Chapter 3, Section 6.4.2.3 discussed radionuclide containment and summarizes the travel times to the accessible environment, and the salt, being considered nearly impermeable, is the key natural barrier. Anomalous zones, however, are known to be more permeable than the salt itself ("normal" salt). Kupfer (1980) describes anomalous zones as allowing gas migration several hundred meters into the dome from the edge, and liquid migration a hundred meters or so. He goes on to state that "Leaks commonly flood mines or introduce dangerous gases."

Iannacchione et al. (1984) in a major study of anomalous zones conclude:

"1. Compared with normal salt, anomalous zones may represent a higher potential methane emission hazard. This is substantiated by previous information from various studies of anomalous features of Gulf Coast salt mines and by this study at the Belle Isle Mine.

2. The anomalous zone is permeable when compared with the generally impermeable nature of the adjacent normal salt. (emphasis added)

3. Permeability variations may depend on the orientation of banding and fracture planes within an anomalous zone."

Thus it is essential to consider anomalous zones in radionuclide migration, or to plan to avoid or seal the anomalous zones, none of which are considered in the EA or other studies to our knowledge.

Avoidance of anomalous zones by not mining in or near them and consequently not storing HLW in them results in a cool zone within a heated zone. Creep of salt is very strongly dependent upon thermal gradient and stress gradient. Both gradients will be higher in and near an unloaded anomalous zone giving greatly increased creep deformation. The effects of this have not been considered at all in the EA nor anywhere in the modeling or field work in the DOE program to our knowledge.

We believe this lack of consideration of anomalous zones is not in accordance with NWPA Title I, Subtitle A, Section 8(b)(3)(B), 112(b)(1)(E)(i); 10CFR60.113(a)(2), .131(g); 10CFR960.4-2-1(b)(1), 10CFR960,5-2-9(d).

4.4 Retrievability

The NWPA, Section 122 requires that the retrievability option be maintained during an appropriate period of facility operation. Operations shall be designed so that retrieval can be performed on a reasonable schedule.

We believe the EA does not adequately address and severly under-estimates the technical difficulties and uncertainties of retrieval. We expect salt to creep toward the canister thereby increasing canister and salt stresses. Salt temperature is expected to approach 150 degrees to 300 degrees within 5 years, with salt temperatures 5 m away will be 90 degrees to 130 degrees (EA Figures 6-5, 6-6, and 6-7). During this time, canisters will be moved by salt creep in various unpredictable patterns making their detection, prior to retrieval, very difficult. This areal heat loading will accelerate creep and place increased pressure upon waste canisters. If storage rooms were backfilled, the induced stress will reconstitute the backfill toward virgin salt properties. Should a canister be breeched (broken or failed), the immediate area would contain vented volatile radionuclides of H-3, C-14, K-85, and I-129 (NUREG-3489). In addition, brine migration toward canisters will become confined, superheated vapor that will be released upon retrieval excavations.

It appears then that the retrieval environment can be hostile enough to preclude successful operations. Technology does not exist for manually-operated or remote-controlled equipment that can operate in such an environment and development of such equipment in the given time schedule is not likely.

Because of the uncertainties and the uniqueness of retrieval, we believe the EA retrieval plan is insufficient and not in accordance with NWPA Title I, Subtitle A, Section 122; 10CFR960.5-1 (a)(3), 960.5-2-9(b)(2), (c)(3), (c)(4); 10CFR60.111(b)(1), (b)(2), (b)(3).

4.5 Salt Disposal

Repository construction will require disposing of about 12 million tons of salt. The bulk of the excavated volume is to be used for backfilling storage rooms and decommissioning. Of the proposed six disposal options, the EA prefers mine disposal, that is, the material will be transported to available salt mines within a few hundred miles of the repository.

The ideal salt disposal site is to require minimum preparation, be dry, be hydrogeologically isolated, and be mined out or near completion of reserves for economic justification.(Stearns-Roger, 1983a). Proposed mines include Avery Island, Jefferson Island, Weeks Island, and Belle Isle. Jefferson Island was flooded in 1980, and Belle Isle has been abandoned due to instability. Avery Island is not hydrogeologicaaly isolated, as meteroic and formation water have been identified (Kumar, 1981). Nevertheless, mine disposal is favored as it is relatively economical and environmentally attractive.

We believe close examination will show unsound economics. In addition to hoisting, handling, loading, and transporting salt from the repository, the material must be put into a mine whose facilities were designed to handle material going out. This means that entirely new equipment or completely rebuilt existing equipment will be necessary to move material from the surface to the shaft bottom. Essentially,the shaft loading pocket and headframe dump hopper locations need to be reversed. Essentially, the mine disposal impacts are grossly underrated in the EA.

On site disposal may have problems ensuring long term integrity of the landfill thereby questioning environmental impact. Commercial sale of salt would hurt an already depressed market, and would subject the repository to MSHA and OSHA regulations on a mandatory basis-not voluntary. As the EA also points out, the transportation cost may outweigh the market price of salt, necessitating DOE to subsidize the sale. The deep well injection process would require significant amounts of water to develop brine for injection. This adverse impact, plus a possible change in groundwater flow pattern from large injections make this option undesireable. Offsite disposal in dry lake beds or alkalai flats, or ocean disposal are two remaining options with a possibility for success. However the long term impacts on the environment cannot be ascertained.

The result of a disposal study is inconclusive and therefore the problem remains. The possibility of long term environmental impacts is not in accordance with 10CFR960.3-4, 960.5-2-5.

4.6 Geologic Uncertainties

Siting guidelines (10CFR960) were used to rank proposed repository sites for site characterization. However these guidelines are new and are subject to change. In fact, these guidelines are currently under litigation and therefore may change considerably in scope and detail.

Nevertheless the development of values for siting criteria, later used in a ranking system, is based on incomplete data or extensive assumptions. Premature conclusions were applied indiscriminately as in the use of limited lateral extent criteria during initial site screening. In most instances site screening criteria were applied without adequate data to form any opinion, yet conclusions were used to rank sites. Data for groundwater movement, for example, were obtained by assuming much of the necessary values for calculation, or were obtained by different date collection methods for each site. This data collection strategy complicates comparison attempts and does not follow DOE's own Mission Plan.

Arbitrary values do not add any confidence to any of the ranking systems used (averaging, pairwise comparison, and utility estimation methods). Differences in ranking are explained in the EA in terms of "more than" or "less than", but these judgements cannot be seen in the tables. The reader can only see the order of sites and cannot relate the magnitude of difference in the order.

Several siting issues may not be resolved after site characterization and construction of the exploratory shaft and facility. This facility as planned by the DOE will be no closer than 1,524m (5,000ft) to the first high level waste canister emplaced (Vacherie EA p. 5-28) and no closer than 3,200m (10,500ft) to the last canister emplaced. Phased repository construction is planned such that canisters will be in place when the most distant drift development (exploratory development) is 2,744m (9,000ft) from the last canister emplaced. Therefore a commitment to waste emplacement will be made before the majority of the repository area is explored.

Comparative evaluation tables show Vacherie as having potentially adverse conditions for host rock, and is shown favorable in a number of other criteria such as dissolution, climatic changes, and geohydrologic characteristics simply because evidence to the contrary does not exist.

Screening criteria used by DOE before the passage of the NWPA are similar to those in 10CFR960 siting guidelines but are not as extensive. The sites therefore underwent a disqualifying condition review to establish that sites selected by previous criteria meet current EPA and NRC standards. This evaluation concluded that, "no evidence was found to disqualify any of the identified potentially acceptable salt dome sites as possible repository sites." However, lack of sufficient data for evaluation can hardly be considered toward supporting such a conclusion.

Where adequate data was missing, it was taken from another site and somehow justified. Information for Vacherie may have originated in Mississippi even though rationale for considering the Northern Louisiana and Mississippi Salt Basins the same is unsubstantiated.

It is this questionable application of data that is used to comparatively evaluate similar geohydrologic settings that contain more than one "acceptable" site. The EA's for three such sites (Cypress Creek, Richton, and Vacherie) identified in the Gulf Coast Salt Dome Basin serve as the comparative evaluation on the basis of 10CFR960 disqualifying conditions. Unfortunately the levels of finding for disqualifying conditions and qualifying conditions for siting guidelines (Table 6-1 Vacherie EA p. 65) are identical for all dome and bedded salt sites. This clearly demonstrates the lack of data or the lack of a thorough evaluation among sites. This is further demonstrated in the computer ranking systems where quite often sites may "tie" in rank for a particular guideline. These sites are too complex hydrogeologically and socio-economically to be identical.

4.7 Site Screening

Site screening has essentially been going on since 1955 when the National Academy of Sciences and the National Research Council proposed salt as a viable storage medium for nuclear waste. Figure 4.7-1 illustrates the screening history. However, the execution of the site screening process has not been consistant. Screening has included some arbitrary decisions, that is, equal application of siting criteria has not been applied equally to all sites.

Unequal application of siting criteria is obvious in dome size criteria and population criteria. Limited lateral extent was applied in the 1970's to define potential sites, and was re-applied in 1981 to omit 3 of 7 proposed salt domes. However,

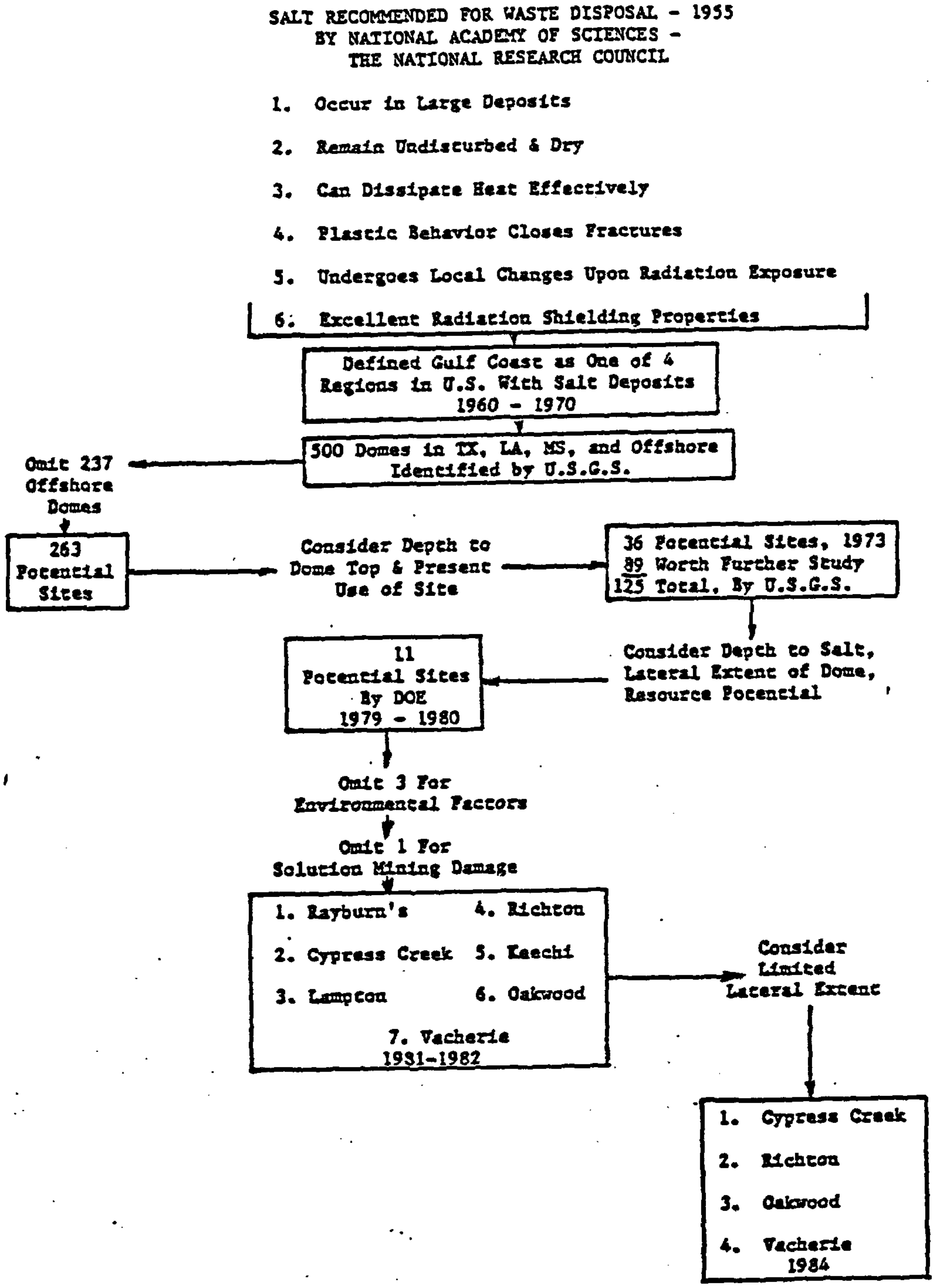


Figure 4.7-1 - Flow Chart of the Site Screening Process

Vacherie is still included as a potential site despite its limited lateral extent, justified by a proposed multi-level repository. This "solution" should then requalify other sites that were eliminated from consideration because of limited lateral extent. The NWPA does not exclude site re-evaluation based on changing siting criteria.

Population considerations is another screening criteria not equally applied. During site elimination, numerical criteria regarding population size or proximity were not in use. Population criteria in 10CFR960 for urban classification is 2,500 persons or more, yet conversation with the U.S. Bureau of Census established that this dividing line between urban and rural is arbitrary and dates back to 1910. Not only population, but socio-economic conditions are also important in distinguishing between urban and rural classifications (Bureau of Census, 1984).

Site penetration by exploratory drilling is another area where criteria were not applied consistently. Vacherie Dome is intercepted by a number of holes that were enough to eliminate other sites. These holes actually have an advantage toward knowledge of the subsurface; knowledge that would not otherwise be known prior to waste emplacement given the site characterization and exploratory shaft programs.

5.0 CLOSURE

This geotechnical review of the Draft Environmental Assessment for the Vacherie Salt Dome Site as a potential high-level nuclear waste repository has identified many uncertainties in DOE's knowledge about the Vacherie Salt Dome site and the development, operation, and closure of the repository.

5.1 Findings

The EA is clearly an impressive and relatively thorough document, especially considering the relatively short time available for its production and eight other EA's. However, two serious problems arise.

While we realize the necessity of freezing the repository design to be described within the EA at a given period in time, apparently shortly after the passage of the Nuclear Waste Policy Act in 1983, the steady evolution of salt repository designs over the intervening two years seriously questions the applicability of much of the material and findings within the EA. The entire performance assessment for stability, operations, retrieval, sealing and isolation of radionuclides is very design-dependent.

The lack of specific knowledge and defensible analyses of the geologic and hydrogeologic setting and performance of the Vacherie

Salt Dome Site is a major factor in the failure of the DOE in the EA to provide a reasonable assurance that a high-level nuclear waste repository located at Vacherie Dome will not adversely affect the public health and safety and the environment of the State of Louisiana.

The uncertainties concerning the salt dome hydrogeologic performance, rock mechanics stability, salt dome size and composition, repository operations, environmental and radiological problems, and site screening and selection arbitrariness, individually and collectively force a conclusion that the Vacherie Salt Dome Site is not suitable for a HLW repository under the provisions of the Nuclear Waste Policy Act of 1982, 10CFR60 and 10CFR960.

5.2 Acknowledgements

This review and report was prepared by the following individuals who contributed primarily in the indicated fields, but also contributed material throughout:

Pieter Berendsen - Geochemistry, General Geology

Antanas Bindokas - Hydrogeology, Hydrology, Stratigraphy, Engineering Geology, Site Screening

Michael F. Dunn - Repository Operations, Exploratory Shaft Facility, General Feasibility, Site Screening

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John F. Hessenbruch - Structural Geology, Geophysics, Gulf Coast Geology, Salt Dome Diapirism

Roberta L. Jennings - Environmental Geology, Surficial Facilities

Francis S. Kendorski - HLW Policy, Repository Operations, Site Screening, Rock Mechanics, General Feasibility, Management

Donald R. MacFarlane - Radiological Health and Safety, Nuclear Engineering, Surface Facility Operations.

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CONSULTING ENGINEER

23 April 1985
Ref. No. T-109

Dr. L. Hall Bohlinger
Department of Environmental Quality
625 North Fourth Street
Baton Rouge, LA 70804

Subject: DEQ Contract No. 23700-85-05, "Geotechnical Review of the Statutory Environmental Assessment (EA) for Vacherie Salt Dome Site, Webster and Bienville Parishes, Louisiana.
Draft Final Report

Dear Dr. Bohlinger:

As required by the subject contract, we are pleased to enclose copies of our Draft Final Report for your review and comment.

We appreciate having had the opportunity to provide these services to the Department of Environmental Quality of the State of Louisiana in furtherance of the high-level nuclear waste program.

Sincerely,

Francis S. Kendorski
Consulting Engineer
Louisiana Registered Professional
Civil Engineer No. 21,590

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FRANCIS S. KENDORSKI
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REGISTERED
PROFESSIONAL ENGINEER
IN
CIVIL ENGINEERING

Enclosure

cc: Secretary
Assistant Secretary

FSK/aj

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