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Paradox Area Characterization Summary and Location Recommendation Report

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Technical Report

August 1982

Bechtel Group, Inc.
50 Beale Street
San Francisco, CA

and

Woodward-Clyde Consultants
Three Embarcadero Center
San Francisco, CA

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Office of Nuclear Waste Isolation

BATTELLE Project Management Division

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Chapter 1

INTRODUCTION AND SUMMARY

Through its National Waste Terminal Storage (NWTS) Program, the Department of Energy (DOE) is responsible for providing facilities to permanently dispose of high-level nuclear waste (HLW) in a manner that will ensure public health and safety and that will be environmentally acceptable. The program has placed principal emphasis on developing deep, underground repositories, with efforts targeted toward having the first facility operational between 1999 and 2006.

To reach this objective, an extensive program has been developed to find sites that would be suitable for a repository. A draft National Plan for Siting High-Level Radioactive Waste Repositories, recently published by DOE (1981b), describes the ongoing and planned program activities that comprise the process DOE is using for finding sites. This siting process involves a stepwise screening of large portions of the United States, identification and detailed study of potential sites, and selection of one or more of these sites for permanent HLW disposal. All phases of the siting process involve state and public interaction.

This report addresses a portion of the siting process. Specifically, it documents the transition from area characterization studies to location characterization studies (both described in Section 2.4.1). The purpose of this document is three-fold:

(1) To condense and summarize information presented in the environmental (ONWI-144) and geological (ONWI-290) Utah Study Area characterization reports (Bechtel National, Inc., 1980; Woodward-Clyde Consultants, 1981a).

(2) To recommend, from portions of the four study areas described in the area characterization reports, one or more study locations of roughly 30 square miles in extent having favorable geological and environmental characteristics for development of a high-level nuclear waste repository. Pending DOE approval, one (or more) of these recommended locations will be characterized during subsequent location studies.

(3) To compare the designated locations in order to recommend a single, preferred location that appears favorable for repository siting. Location characterization activities will concentrate on one or more places within this preferred location.

A stepwise screening procedure, involving a series of map overlays, was applied to the four study areas. Five readily quantifiable screening factors having strong potential for differentiating possible locations within the study areas were used. These factors were depth to salt, thickness of salt, proximity to faults, proximity to boreholes, and boundaries of dedicated lands. The screening procedure yielded two recommended locations, one of 6 square miles in the Elk Ridge study area and one of 57 square miles in the Gibson Dome study area. An extensive comparison of geological and environmental data for the two locations resulted in Gibson Dome being recommended as the location for further study.

The evaluations and recommendations made in this report are based on currently available data, and may change as more information becomes available. Conclusions and recommendations are intended for consideration by the state of Utah, the Office of Nuclear Waste Isolation (ONWI), and the U.S. Department of Energy, and are not intended to be interpreted as final decisions.

Chapter 2

NWTS SITE SELECTION PROCESS

The evaluations made in this document are a step in the national site selection and characterization process. This chapter describes how site selection and characterization proceeds.

2.1 GEOLOGIC ISOLATION SYSTEM

Geologic isolation is the primary method of waste disposal being pursued through the NWTS program. Conceptually, the geologic repository as a waste-isolation system consists of three parts that together provide multiple barriers to the release of the waste into the accessible environment. These parts or subsystems are the waste package, the repository, and the site (Figure 2-1).

The waste package includes the waste form itself and a system of engineered barriers consisting of a high-integrity canister and one or more layers of protective materials selected to minimize interactions among the waste, host rock, and ground water. During the repository operational phase, the waste package will provide safe containment of the waste material during handling and emplacement operations and help ensure that the waste can be safely retrieved, if necessary, from the repository. During the time that fission product decay is dominant and radiation and thermal output are high (i.e., the thermal period), the waste package will contain the waste, delaying the start and slowing the rate of radionuclide release into the surrounding rock. After the thermal period, the repository and the site will provide long-term waste isolation.

The repository is a system of underground excavations similar to a conventional mine. Structures are built for access to the underground corridors and rooms for waste emplacement, but engineered barriers are added to contain and isolate wastes. Construction, emplacement and maintenance

activities will be performed in a manner that preserves the repository containment and isolation capabilities (including repository rock and overburden).

The site includes natural barriers embodied in a variety of geological features. These barriers will (1) maintain the waste in its emplaced location for a given period of time; (2) limit radionuclide mobility through the geohydrologic environment to the biosphere; and (3) assist in keeping humans away from the waste. The site will contain a host rock suitable for construction of the repository and containment of the waste, and surrounding rock to provide adequate isolation.

2.2 WASTE ISOLATION PERFORMANCE OBJECTIVES

The overall goals of the NWTS program are expressed in several general performance objectives. These objectives allow adequate flexibility to meet regulatory requirements for licensing a repository. The objectives do not negate the need for Nuclear Regulatory Commission (NRC) and Environmental Protection Agency (EPA) regulations, but provide interim guidance until comprehensive final regulations are issued.

The performance objectives for the waste-isolation system proposed in the Waste Confidence Rulemaking Statement (U.S. Department of Energy, 1980a) apply to any method of waste disposal (i.e., they are not restricted to geologic disposal). The objectives are:

(1) Waste containment within the immediate vicinity of initial placement should be virtually complete during the period when radiation and thermal output are dominated by fission-product decay. Any loss of containment should be a gradual process which results in very small fractional waste-inventory release rates extending over very long release time, i.e., catastrophic losses of containment should not occur. "Containment" means confining the radioactive wastes within prescribed boundaries (e.g., within the waste package).

(2) Disposal systems should provide reasonable assurance that waste will be isolated from the accessible environment for a period of at least 10,000 years, with no prediction of significant decreases in isolation beyond that time. "Reasonable assurance" means that the preponderance of technical evidence, as interpreted by objective experts in the field, supports the conclusions drawn. Wastes will be considered to be "isolated" if long-term radiological consequences to the public due to the effects of any reasonably foreseeable events or processes are predicted to be within the range of variations experienced in background radiation. Releases with consequences of a few millirem to tens of millirem per year would be considered acceptable provided that the ALARA (as low as reasonably achievable) standard for engineered systems is met.

(3) Risks during the operational phase of waste-disposal systems should not be greater than those allowed for other nuclear fuel-cycle facilities. Appropriate regulatory requirements established for other fuel-cycle facilities of a like nature should be met. "Operational Phase" risks refer to radiological risks either to members of the public or to facility personnel. "Appropriate regulatory requirements" refer to safety standards which are derived for similar quantities of radioactive materials and/or systems subject to similar potential modes of failure and which can, with little or no modification, be applied to a high-level waste disposal facility.

(4) The environmental impacts associated with waste-disposal systems should be mitigated to the extent reasonably achievable. "To the extent reasonably achievable" means that which is shown to be reasonable considering the costs and benefits associated with potential mitigative measures and reasonable alternative courses of action in accordance with requirements set forth by the National Environmental Policy Act (NEPA) of 1969 and the Council on Environmental Quality (CEQ).

(5) The waste-disposal system design and the analytical methods used to develop and demonstrate system effectiveness should be sufficiently conservative to compensate for residual design, operational, and long-term predictive uncertainties of potential importance to system effectiveness, and should provide reasonable assurance that regulatory standards will be met. "Conservatism" means taking a course of action in design, analysis, or operation which tends to overestimate adverse consequences, underestimate mitigating factors, or otherwise provides large margins of safety against undesirable outcomes. Conservative measures might include:

- A careful stepwise approach to design and operation
- Multiple containment and isolation barriers with sufficient independence and residual effectiveness to assure compliance with appropriate radiation standards over the range of credible failures
- Design and operating margins which compensate for the effects of system uncertainties.

(6) Waste-disposal systems selected for implementation should be based upon a level of technology that can be implemented within a reasonable period of time, should not depend upon scientific breakthroughs, should be able to be assessed with current capabilities, and should not require active maintenance or surveillance for unreasonable times into the future.

(7) Waste-disposal concepts selected for implementation should be independent of the size of the nuclear industry and of the resolution of specific fuel-cycle or reactor-design issues and should be compatible with national policies.

Specific criteria for site suitability applied in the decision process are described in Section 2.3.

2.3 REQUIREMENTS OF A REPOSITORY SITE

2.3.1 SITE PERFORMANCE CRITERIA

The NWTS program repository site performance criteria (Table 2-1) have been formulated by the U.S. Department of Energy (1981a). These criteria provide guidance necessary to direct program activities toward its objective in a manner which protects the public health and safety, preserves the quality of the environment and is institutionally acceptable. Therefore, the criteria address all facets of waste isolation. Some criteria are directly relevant to anticipated radiological and nonradiological impacts that must be limited to acceptable levels. Other criteria address residual technical uncertainties that exist in the technology of geologic disposal. Still others address institutional issues such as public involvement and understanding of nuclear waste disposal and its technology options and

licensing. Such criteria are necessary to identify repository sites in a technically defendable, timely, and economical manner. Applying the full range of such criteria supports the development of a repository in an institutionally acceptable manner.

The judgment as to what constitutes an acceptable repository from a regulatory viewpoint will ultimately be made by the responsible agencies (e.g., NRC and EPA) in consultation with state and local governments. These organizations will promulgate policies, criteria, and regulations for the development and operation of repositories. Specifically, the EPA will promulgate generally applicable environmental standards upon which the NRC will judge the performance of the repository. At the present time, however, final repository criteria have not been issued by the NRC and EPA. The NWTS criteria in this document have been developed to protect the health and safety of the public and the quality of the environment, and they are expected to be consistent with the anticipated regulatory standards.

These NWTS criteria will be used on an interim basis to guide the site-qualification process, pending promulgation of NRC, EPA, and other applicable criteria or guidelines. The NWTS criteria are being re-evaluated on a periodic basis to ensure that they remain consistent with national waste management policy and regulatory requirements. A final re-evaluation will be made when final criteria are promulgated by NRC and EPA.

Thus, it can be seen that the NWTS site performance criteria provide a means of assuring that the site-selection decision is reached in a manner consistent with the NWTS requirements for a waste isolation system as described in Section 2.2.

2.3.2 PROPOSED REGULATORY GUIDANCE

On December 6, 1979, the NRC published for comment in the Federal Register (44FR70408) proposed regulations for licensing geologic repositories for the disposal of high-level waste. This proposed rule contained only the procedural requirements for licensing concerning general provisions, licenses, and participation by state governments. This proposed rule was finalized and published in the Federal Register on February 25, 1981, to be effective on March 27, 1981 (U.S. Nuclear Regulatory Commission, 1981a).

The initial proposed procedural rule was followed on May 13, 1980, by publication in the Federal Register (45FR31393) of an advance notice of rulemaking on the technical criteria intended for inclusion in 10 CFR Part 60, "Technical Criteria for Regulating Geologic Disposal of High-Level Radioactive Waste" (U.S. Nuclear Regulatory Commission, 1980). The purpose of the advance notice was to inform the public and interested parties concerning the status of efforts related to the development of technical criteria, and to solicit comments for consideration in the preparation of a proposed rule. This notice has since been updated (U.S. Nuclear Regulatory Commission, 1981b). Thus, the criteria are in a preliminary and formative stage, and the DOE is attempting to conform to the current thinking and technical positions of the Commission in this fluid situation.

Although the technical criteria are preliminary and may not fully represent the regulatory positions that will be applicable during the formal review of an application for licensing, they provide DOE with an insight into the present thinking of the regulatory staff as to what may constitute favorable or adverse site characteristics. These preliminary criteria are, therefore, being used as guidance in the site selection and chacterization process. This guidance parallels the requirements

of criteria developed by DOE for site qualification, and provides assurance that the decisions regarding the screening process will be acceptable when the final regulations become available (U.S. Department of Energy, 1981a).

2.4 THE SITE SELECTION AND CHARACTERIZATION PROCESS

National radioactive waste repository sites will be selected by a systematic process, taking into consideration all applicable factors. DOE's program leading to the selection of sites is carried out in three major steps (refer to Figure 2-2 for a schematic illustration of the siting process):

(1) Site exploration and characterization (site screening)

(2) Detailed site studies

(3) Site recommendation and selection

2.4.1 SITE EXPLORATION AND CHARACTERIZATION

The first of these major steps, the site exploration and characterization process, involves a series of geologic and environmental studies to identify potential sites for mined geologic repositories and to obtain the technical data necessary to determine the acceptability of these potential sites. Acceptability is determined by comparing the site characteristics, as defined during the exploration activities, to the NWTS program and site performance criteria, as described in Sections 2.2 and 2.3. Phases in the site exploration and characterization process include national surveys, regional surveys, area surveys and location studies. As the selection process narrows to more specific locations and sites, more data are developed, resulting in reinforced confidence in technical judgment regarding acceptability of potential sites.

2.4.1.1 National Surveys

Site searches are initiated by national screening surveys. Starting with the contiguous United States, the initial step in site exploration and

characterization is to identify regions that appear to be suitable for waste isolation. (A region, which may be large enough to include several states, is a land area having a particular suitability feature, such as particular rock types or geohydrologic systems.) Early in the NWTS program for example, rock salt was identified as a potentially suitable host medium. Thus, regions in the contiguous United States containing salt domes and bedded salt formations believed to be generally suitable for repository use were identified.

Upon completion of the national screening survey, regions were identified for further investigation. The process will continue through a series of increasingly detailed exploration activities, eventually developing detailed data on characteristics of areas, locations, and sites. These characteristics are evaluated at each phase of exploration, and geologic and environmental characterization reports are prepared.

2.4.1.2 Regional Surveys

Regional surveys investigate the region of interest to obtain further geologic and environmental information. Studies are based primarily on a review of existing data obtained through broad literature searches. Sources for geologic data include published scientific reports and geologic maps; drilling and production records from oil, gas, and mineral exploration programs; records of earthquake occurrences and intensities; and records of water well drilling. The regional studies result in designation of the areas most suitable for further study, while less promising areas are deferred.

2.4.1.3 Area Surveys

Area surveys are conducted to further characterize the areas of prime interest designated by the regional study or designated because of their

current use as DOE reservations. Environmental, socioeconomic, and geologic factors are evaluated, but within a smaller area and in greater detail than in the regional studies. The objectives of area surveys are to confirm the regional observations, narrow the scope of investigations to the most promising locations, and build a data base toward the eventuality of licensing.

Geologic studies conducted in this phase include various field investigations, including drilling of deep boreholes. The objectives of drilling are to (1) collect rock cores for laboratory tests of properties of the substrata; (2) evaluate the characteristics of aquifers; and (3) conduct geophysical borehole surveys to assist in evaluating hydrogeological, geotechnical, energy/mineral resource, and structural characteristics. Environmental and socioeconomic studies are based on literature surveys of data available from local experts and institutions such as universities and local, state, and federal agencies. The scope of area environmental studies includes a description of the hydrosphere; atomosphere; demographic, socioeconomic, and land use characteristics; and ecosystems.

2.4.1.4 Location Studies

The purpose of location studies is to gather additional data needed to further narrow the scope of investigation to one or more potential sites. Location studies will also be used to select a place for an exploratory shaft. Geologic data gathering at this stage may include additional surface studies and drilling to obtain detailed geologic and hydrogeologic information and samples for extensive testing of geologic and geochemical properties. Environmental studies during this phase may include sampling programs at the locations to obtain information sufficient to identify the most promising site from among several locations and to provide data to be used for an assessment of impacts on the environment surrounding the shaft location.

2.4.2 DETAILED SITE CHARACTERIZATION

Detailed site characterization is designed to clarify issues that remain unresolved after regional, area and location studies have been completed. The purpose of detailed site characterization is to assess a site's suitability for a repository. The geologic, environmental, and socioeconomic data obtained to make this assessment are similar to those obtained during the previous screening phase but provide greater detail and are specific to the site. Surface characterization and borehole drilling to the repository depth will be performed to supplement data obtained in previous screening steps. If initial study results are favorable, exploratory shafts may be sunk. Exploratory shafts will allow direct observation of proposed host rocks at depths considered suitable for repositories. Data to be obtained will be used to assess the site's suitability for a repository and a test and evaluation facility.

In 1983, DOE expects to begin constructing the first three exploratory shafts at sites in three different types of rock where studies are furthest along: two federal reservations, the Nevada Test Site (tuff) and the Hanford Site, Washington (basalt); and at a salt site chosen from among those currently under study. By 1985, shaft construction will reach repository depth (2,000 to 4,000 feet) and in situ studies will begin to collect data at depth. Current plans call for construction of a test and evaluation facility at one of the first three sites having exploratory shafts.

2.4.3 SITE RECOMMENDATION AND SELECTION

Several sites will be characterized by exploratory shafts. From among the sites that are judged acceptable, DOE will select one or more for its first construction authorization application to the Nuclear Regulatory Commission. Those sites not initially selected, plus sites that subsequently undergo detailed site characterization, will become candidates for later construction authorization applications.

The remainder of this section describes DOE's present plans for selecting sites. The details are still evolving and subject to further definition in light of legislation that could be established by Congress, recommendations made by the state advisory groups, and agreements adopted by DOE and the states as part of the consultation process. Subject to such revision, the following steps serve as a basis for interim planning.

DOE will make an initial choice of the site it will recommend for construction authorization. Because several sites should be acceptable, this choice will necessarily involve DOE's judgment of the site suitability.

DOE will then issue a Repository Site Recommendation Report, which will present a comparative analysis of the alternative sites' geologic, environmental, and socioeconomic characteristics; a description of the site selection process; and recommendation of a site for construction authorization application. A Draft Environmental Impact Statement also will be prepared in which potential environmental impacts of repositories at the chosen and alternative sites are compared. The report will undergo independent review by the public, by representatives of the state involved, and by other federal agencies. Through this review process DOE will seek comment on the site's technical, environmental, and institutional acceptability. Based on state and federal agency comments, DOE will revise the site recommendation report as appropriate. The final revision, documenting DOE's selection of the site for a construction authorization application, will be issued as a Site Selection Report along with the Final Environmental Impact Statement.

Although DOE will make every effort to address concerns, under current law it has the responsibility for selecting a site(s) for a repository. When it has addressed state and federal agencies' concerns to the best of its judgment, DOE will decide whether or not to go forward.

Disagreement over the site selection decision is possible. DOE, state groups, and Congress are now considering the mechanisms for conflict resolution. The NRC licensing proceeding itself is one mechanism for resolving technical issues bearing on site acceptability from the standpoint of public health and safety. In addition, based on the recommendations of DOE, other federal agencies, interested nongovernmental groups, and state groups, Congress may enact legislation providing further mechanisms for resolving disagreement concerning the acceptability of particular sites. One such mechanism would place the ultimate site selection decision with the president and/or Congress.

2.5 TECHNICAL APPROACH

This section describes (1) the technical approach utilized in the area phase to characterize the geology/hydrogeology and social and ecologic environment of the four Utah study areas (SAs) and (2) the decision process utilized to achieve the primary objectives of the area phase – the recommendation to DOE of the most promising location for further characterization in the location phase.

2.5.1 GEOLOGIC/HYDROGEOLOGIC CHARACTERIZATION

This characterization was planned to investigate, at an appropriate level of detail, those geologic, hydrogeologic and related topics that are pertinent to selecting locations in the Utah study areas. Major topics investigated were stratigraphy, hydrogeology, structural geology, seismology, energy and mineral resources, Quaternary features, tectonic history, and geotechnical factors.

In the area characterization phase, investigation of these topics focused on the following repository siting concerns identified in the NWTS criteria:

- Site geometry
- Hydrogeology
- Geochemistry
- Geologic characteristics
- Tectonic environment
- Human intrusion – resource potential/exploration

2.5.1.1 Site Geometry

Characteristics of site geometry (depth, thickness, dip of strata, lateral extent) were evaluated using well data and stratigraphic and structural geologic information. This information was obtained from surface mapping, remote sensing analysis, continued literature survey, analysis of available geophysical (seismic reflection) data, and subsurface geologic assessments. Subsurface studies utilized available well data and geophysical data, and were integrated with surface geologic data. Specially designed boreholes in three of the study areas provided core and geophysical borehole log data to supplement and calibrate the previously available information.

2.5.1.2 Hydrogeology and Geochemistry

Hydrogeologic characteristics were evaluated by continuing subregional studies and localized detailed investigations. Objectives were to: (1) refine identification of regional trends in potentiometric surfaces and permeability; (2) ascertain whether or not potential repository strata are receiving or discharging fluids to the Colorado or San Juan rivers; (3) gather in situ measurements of critical hydrogeologic parameters in boreholes through potential repository strata; and (4) conduct preliminary modeling studies. Investigations carried out to achieve these objectives included: (1) continued literature search and analysis of available drill-stem test data from oil wells; (2) field studies including outcrop examination and well, spring, and river sampling; and (3) borehole studies – including sampling of core and specially designed drill-stem testing tools – within, above, and below potential repository depths. Salt dissolution features and effects were assessed using results of hydrogeologic, geochemical, structural, and stratigraphic investigations.

2.5.1.3 Geologic Characteristics

Surface and subsurface stratigraphic characteristics were defined using results of surface geologic mapping and subsurface geologic investigations. These data were integrated with available geophysical and oil well data by using cross sections and special purpose maps.

Host rock characteristics were identified from the literature, available well data, and results of coring, geophysical logging, and drill-stem testing in boreholes drilled for this project. Specially designed geotechnical testing provided in situ results of rock deformability that were compared with laboratory tests on core samples. In situ stress measurements were also obtained from hydraulic fracture tests. These host rock characteristics were compared to available data from the literature and previously drilled wells to assess lateral variability within potential repository strata.

Non-tectonic deformation structures and their potential effects were assessed using structural and stratigraphic data collected during this phase of work.

2.5.1.4 Tectonic Environment

Defineability. Tectonic elements were characterized using results of literature searches, stratigraphic and structural studies (surface and subsurface), Quaternary studies, and tectonic history analyses. These studies were also utilized to address the presence of, or proximity to, Quaternary faults and igneous features, and effects of uplift/subsidence rates.

Seismicity. Anticipated seismic ground motions from design earthquakes were evaluated using data from microearthquake monitoring, structural studies, and tectonic history investigations. Critical components of the

existing regional tectonic stress field were identified from fault plane solutions of selected microearthquakes. The potential for mining-induced seismicity was investigated, based on apparent occurrence of such seismicity adjacent to and north of the Paradox Basin.

2.5.1.5 Human Intrusion - Resource Potential/Exploration

This concern includes two separate issues: (1) the potential for human intrusion in search of resource potential; and (2) the potential for existing or future boreholes to provide a shortcut for radionuclide migration to the biosphere. The potential of the study areas was assessed using a literature survey, field verification investigations, and consultations with knowledgeable workers in the region. A separate report addressing this energy/mineral resource concern, prepared by the Utah Geological and Mineral survey, was a key source (Merrell and Utah Geological and Mineral Survey, 1979).

The types of exploratory workings and boreholes, and the locations of boreholes extending below the surface, were identified in the study areas. Data for this study came from a literature search, information purchased from petroleum broker services, and consultations with knowledgeable workers in the region. Sources of additional data were identified for more detailed evaluation during future phases of work.

2.5.2 ENVIRONMENTAL CHARACTERIZATION

The operation of a repository may result in changes in the environment. It is important to select repository sites where such changes can be minimized. Effects or changes of concern include those directly affecting man and other aspects of the environment of immediate value (e.g., livestock, fisheries, agriculture). Also, indirect losses are considered, such as a reduction in the assimilative capacity of the environment for society's wastes (sewage, solid waste, etc.) and the destruction or contamination of resources (air, water).

In the area phase of characterizing the Utah study areas, three broad environmental concerns were evaluated to assist in the selection of a preferred site for the in-depth location investigations. These concerns were ecologic, socioeconomic, and land use factors that might be impacted by repository development and operation.

2.5.2.1 Ecological Characterization

Ecological characterization includes analysis of climatological factors, background radiation, surface geological factors, soil properties, land forms, pollution factors, and specific habitats of flora and fauna. The overall objective is to have sufficient information by the time of the site selection to alleviate or mitigate any adverse effects from waste materials generated during the construction or operation of the repository.

Historic climatological data for the areas of interest were obtained from local National Weather Service reporting stations. Analyses were made of severe weather conditions which could affect repository operations or cause environmental impacts related to the disposal site. Background radiation data were collected from the available literature in the area study phase.

Land forms and surface geology were analyzed and described through the use of aerial photographs, topographic maps, and limited field reconnaissance.

The soils near the study areas were characterized from soil survey maps to provide information on soil type and potential crop yields, woodland suitability, erosion potential, wildlife habitat, soil origin and depth, mechanical analysis, permeability, texture, slope, and use limitations.

Fauna and flora of the biological community were also evaluated. State and federal fish and game agencies provided data on game and nongame wildlife species. Published literature for the study areas were obtained through state forestry, wildlife, and natural resources agencies, as well as universities and private organizations.

Baseline measurements of water quality parameters, including chemical composition and stream flow, were gathered from existing data sources. Analysis of these data has provided the necessary information to make preliminary estimates of loading characteristics and potential impact to existing aquatic ecosystems.

A list of species was compiled from existing literature for both the aquatic and terrestrial environments. An enumeration of all threatened and endangered species was made based on data from the U.S. Fish and Wildlife Service. Commercial and recreational species such as livestock, game, pollinating insects, farm crops, and timber are important in the terrestrial environment. Information was obtained from literature and interviews involving such sources as federal and state government agencies, timber companies, agricultural sources, and conservation organizations.

2.5.2.2 Socioeconomic Considerations

Socioeconomic analyses focus on regional and community social, economic, and institutional factors. Major topics covered include demography, housing, income, community services, labor force, employment, and finance. Baseline data on a number of socioeconomic variables were collected in order to profile the characteristics of the communities and regions of the Paradox Basin. Data on these concerns were obtained from federal, state, county, and local sources, such as the U.S. Census Bureau, state industrial directories, and reports of pertinent state planning agencies. Meetings were held with state officials to obtain up-to-date information on socioeconomic variables.

2.5.2.3 Land Use Studies

Major land use categories examined include agricultural, forest, transportation, residential, commercial, industrial, institutional, recreational, and open space. Aerial photographs provided information on general land use over a wide area, allowing differentiation among agricultural, forested, and urban lands. Of particular concern was the transportation network both in terms of potential risk involved in the movement of nuclear waste and the relative ease of access to study area sites. Topographic maps, prepared by the U.S. Geological Survey, provided useful detailed information on land use. Information from county agencies and regional planning commissions was also used to determine projected as well as current land uses. All study areas were spot-checked to verify published data.

Archaeological and historic resources of the Utah study areas were inventoried with regard to state and federal environmental legislation, including the Historic Preservation Act of 1966, the National Environmental Policy Act of 1969, Executive Order 11593 of 1971, and the latest NRC guidelines. A literature review of known archeological and historic sites was performed. Specific attention was given to listings in the National Register of Historic Places (National Park Service, Title 36, Code of Federal Regulations, Parts 60 and 63; Advisory Council on Historic Preservation, Title 36, Code of Federal Regulations, Part 800), and the appropriate state historic preservation officer was contacted for current information.

As the site characterization process proceeds, varying levels of land use characterization are required. In the area phase, a principal concern has been that repositories should not be located in areas of highly conflicting land uses such as large metropolitan areas, wild and scenic rivers, national parks, wilderness areas, and historic or archaeological sites.

2.5.3 DECISION PROCESS

Considerable information is needed to make the screening judgments involved in repository site selection. The stepwise approach to site selection planned by DOE calls for screening the lands under consideration,

focusing attention and exploration resources on progressively smaller land units that appear to have the most potential for eventual repository development. Sceening factors presented in NWTS-33(2) (Table 2-1) were used in the screening process. The nature of needed information changes as the screening process proceeds; not all factors will be discriminating factors at each step of the screening process. Investigative methods and data used in analyses will likewise depend on the particular factors important at the geographic scale of concern and the physical and institutional conditions in a given area. The eventual determination of site suitability will depend on data collected during regional, area and location surveys, as well as the extensive field measurements and data obtained at specific candidate sites.

The decision process is designed to assure that all pertinent questions are considered and adequately answered before proceeding with repository development. Each step builds a base of understanding for steps that follow. However, only after detailed site studies have been completed can a site be thoroughly assessed according to performance criteria and regulatory requirements. Therefore, screening decisions to focus subsequent exploration on certain areas will be primarily cost-effective decisions which allow resources to be concentrated on places judged most likely, at each stage of the site selection process, to meet existing criteria and regulations. The screening process is not designed to identify all sites in the nation. Rather, it is intended specifically to identify several candidate sites from which one or more sites may be selected for repository development.

The process may identify regions, areas, or locations, some more favorable than others. Further study of all but the favored land units is unnecessary and would be prohibitively expensive. Further studies, then, are focused on only as many favorable alternatives as reasonably necessary to (a) make it likely that several alternative sites are identified and ultimately proved acceptable and (b) to carry a reasonable number of alternatives through each screening step.

Regions, areas, or location also may be eliminated if there is a high likelihood that major siting criteria will not be met. In this situation, resources need not be expended to demonstrate unsuitability. Screening decisions are made to focus efforts on the favored land units.

The general decision-making approach for each of the region, area, and location survey steps consists of the following steps:

Step 1. Factors and information thought to be important to the next screening decision are identified.

Step 2. Required information is gathered in accord with applicable consultation procedures.

Step 3. Possible geographical alternatives are identified, for the level of survey in progress (i.e., regions, areas, or locations).

Step 4. Each geographical alternative is evaluated against previously identified criteria (U.S. Department of Energy, 1981a).

Step 5. Candidate alternatives are compared (at an appropriate level of detail), and one (or more) is recommended.

Step 6. Screening decisions are reviewed in consultation with involved states.

Further explanation and decision of these six steps can be found in the Draft National Siting Plan (U.S. Department of Energy, 1981b).

Table 2-1

NWTS SITE PERFORMANCE CRITERIA

Criterion I. Site Geometry
1. Minimum Depth
2. Thickness
3. Lateral Extent

Criterion II. Geohydrology
1. Geohydrological Regime/Aquifer Characterization
2. Hydrological Regime/Modeling/Surface-Subsurface
3. Geohydrological Regime/Shaft Seals/Flow Rates
4. Subsurface Dissolution Rates

Criterion III. Geochemistry
1. Chemical Interaction
2. Radionuclide Retardation

Criterion IV. Geologic Characteristics
1. Stratigraphy Characterization
2. Host Rock/Stress Phenomena
3. Rock Strength/Development, Operation, and Closure

Criterion V. Tectonic Environment
1. Tectonic Element Evaluation
2. Quaternary Faults
3. Quaternary Igneous Activity
4. Uplift/Subsidence
5. Seismicity/Ground Motion/Credible Earthquake

Criterion VI. Human Intrusion
1. Resources
2. Exploration History/Use
3. Land Ownership/Access

Criterion VII. Surface Characteristics
1. Surficial Hydrological System/Characteristics
2. Surface Topographic Features
3. Meteorological Phenomena
4. Industrial Transportation, Military Installation Effects

Criterion VIII. Demography
1. Population Density/Urban Proximity
2. Radioactive Waste Transportation Risk

Table 2-1 (Continued)

Criterion IX. Environmental Protection 1. Potential Environmental Impacts 2. Air, Water, Land Use Conflicts 3. Consideration of Normal and Extreme Environmental Conditions
Criterion X. Socioeconomic Impacts 1. Social/Economic Impacts 2. Transportation, Access, Utility

Source: U.S. Department of Energy, 1981a.

Note: These criteria were developed as the basis for DOE's determination of what site characteristics will provide protection of public health and safety and should be consistent with anticipated regulatory standards. Similar siting criteria have been developed by the U.S. Nuclear Regulatory Commission; a side-by-side comparison of NRC and DOE criteria is presented in the Appendix.

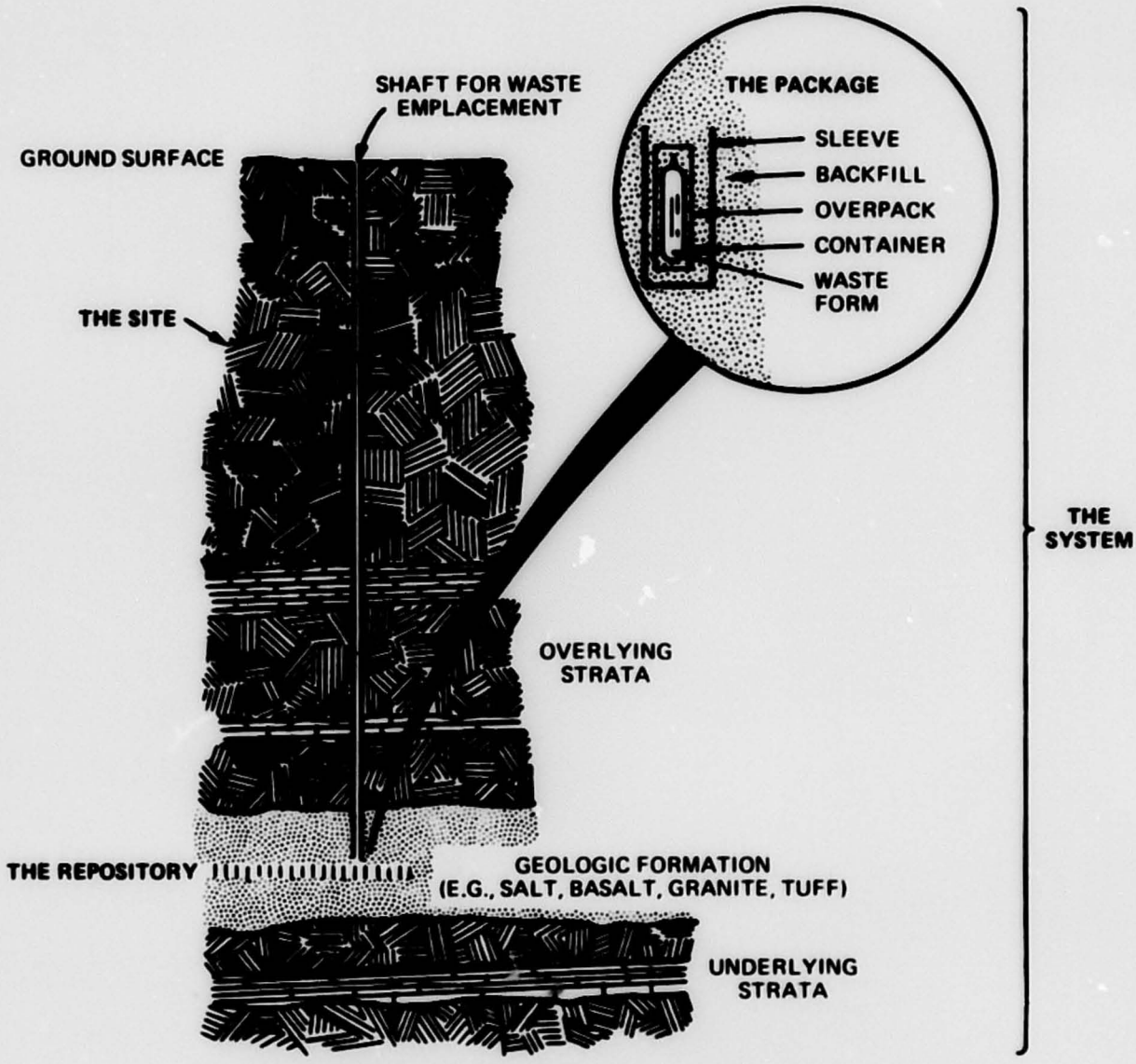


Figure 2-1 SCHEMATIC CROSS SECTION OF A CONCEPTUAL GEOLOGIC WASTE ISOLATION SYSTEM

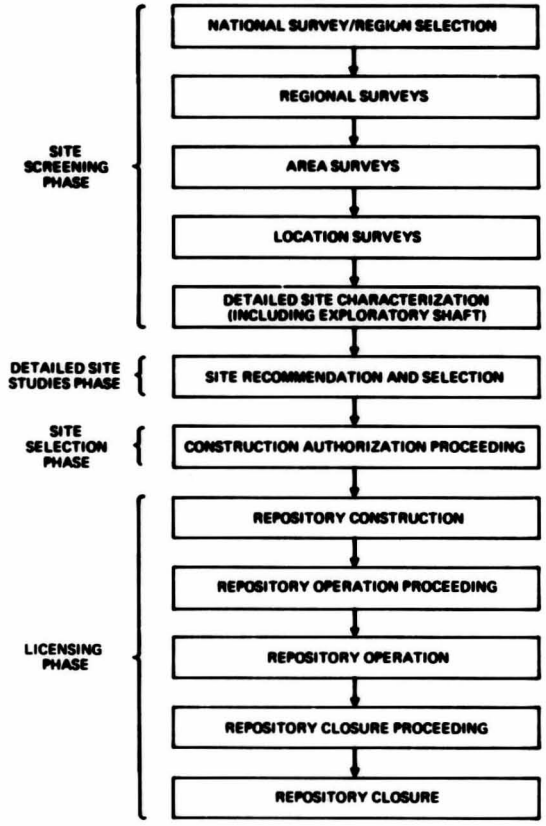


Figure 2-2 REPOSITORY SITING PROCESS AND SUBSEQUENT LICENSING PHASES

Chapter 3

BACKGROUND ON PARADOX REGION

The bedded salt of the Paradox Region in Utah and Colorado is one of several regions that are being investigated as potential locations for a deep-mined geologic repository for high-level radioactive wastes. This section gives the history of the Paradox Basin site characterization efforts, objectives and organization of the project, area characterization activities, and a description of the sites under investigation.

3.1 HISTORY OF THE CHARACTERIZATION PROGRAM

The effort to identify a suitable repository site in salt can be traced from 1954, when the U.S. Atomic Energy Commission (AEC) asked the National Academy of Sciences – National Research Council (NAS-NRC) to look at the problem and recommend solutions. After intensive study, the NAS-NRC recommended geologic disposal in salt formations as the best of the many options that they had considered.

Characteristics of salt deposits that are especially favorable for storage of high-level radioactive waste include the following:

(1) Many salt beds have remained undisturbed and dry for tens to hundreds of millions of years, indicative of their long-term integrity and nondissolution by hydrologic systems.

(2) Rock salt exhibits the ability to dissipate large quantities of heat (as would be generated by high-level wastes).

(3) Owing to its natural plasticity, salt is capable of "self-sealing" any fractures which might develop in it, thus preventing access by fluids along zones of weakness.

(4) Rock salt is comparable to concrete as a gamma-ray-shielding medium, and it has a compressive strength similar to that of concrete.

(5) Salt deposits that are sufficiently deep and thick to be considered as having potential are widespread in this country and generally occur in areas characterized by low levels of seismicity and tectonic activity; thus, the potential for damage to repository structures (shaft, surface plant) resulting from earthquakes is greatly reduced.

(6) Domestic salt resources are great enough so that if sites in several deposits were selected as repositories, there would be no adverse effect on the resource bases; repository sites also could be selected far from existing mines so this would constitute no problem.

(7) Rock salt can be easily mined at relatively low cost, and the technology for the underground excavation of salt is well developed; underground rooms opened in salt have remained stable for long periods of time, provided adequate pillar size is incorporated into the mine design.

Characteristics of salt deposits that are potentially unfavorable for storage of high-level radioactive waste include the following:

(1) Salt is soluble in unsaturated water; however, salt beds have remained, undissolved, for tens to hundreds of millions of years.

(2) Salt, a metamorphic rock, has the potential for mobility, which might cause engineering or safety problems.

(3) Rock salt has low shear strength.

In 1958, the U.S. Geological Survey undertook a study for the AEC to identify those salt deposits in the United States that might contain possible disposal sites. Salt deposits that were identified with large volumes of salt at depths appropriate for construction of a repository included the Silurian salt deposits of the Salina group that underlie parts of New York, Pennsylvania, West Virginia, Ohio, and Michigan; salt domes in the Gulf Coast embayment in parts of Alabama, Louisiana, Mississippi, and Texas;

salt deposits of the Permian Basin underlying parts of Kansas, Colorado, Oklahoma, Texas, and New Mexico; and those of the Paradox Basin in southeastern Utah and southwestern Colorado.

From 1963 to 1967, Oak Ridge National Laboratory conducted a series of research investigations to demonstrate the technical feasibility of the concept of mined geologic disposal in salt, using an abandoned mine near Lyons, Kansas, as a test site (see U.S. Dept. of Energy, 1981b). This study, known as Project Salt Vault, concluded that disposal in bedded salt was feasible and that handling and emplacement equipment could be designed to safely transfer the wastes into a subsurface repository.

In 1976, ERDA announced the formation of the NWTS program, which had as one objective the identification of suitable sites for construction of one or more geologic repositories for radioactive wastes. As part of that program, Woodward-Clyde Consultants was selected by the Office of Waste Isolation (OWI) of Union Carbide Corporation to act as geologic project manager (GPM) for investigations in the Paradox bedded salt region. Simultaneously, Bechtel National, Inc. (BNI) was selected as regulatory project manager (RPM) to conduct environmental studies in parallel to those in geology and hydrology.

In 1978, responsibility for overall management of a large portion of the NWTS program was transferred to ONWI, operated by Battelle Memorial Institute.

In 1980, a regional characterization report was issued that summarized the existing data and previous work in the Paradox Basin (Bechtel National, Inc., 1980). These reports, as well as drafts of a recently published Regional Summary Report prepared jointly by the GPM and RPM (Bechtel Group, Inc., 1982), formed the basis for a recommendation to DOE that four study areas be investigated further. The selection of study areas was based on criteria in existence in 1980.

3.2 AREA CHARACTERIZATION PHASE

3.2.1 OBJECTIVES

The area characterization phase of the Paradox Basin exploration program has two objectives:

1. To obtain adequate geologic and environmental data to recommend a preferred location for more detailed location characterization.

2. To continue building the data base for a licensing application through the process of narrowing geographic focus with an accompanying increase in detail..

3.2.2 ACTIVITIES ACCOMPLISHED

Following the identification of the four study areas in the Paradox Basin, project plans were developed for both the geologic and environmental area characterization.

Environmental studies were begun in August, 1979, to evaluate the suitability of each of the four study areas for a repository site, based on potential impacts, conflicts and risks. Many environmental factors were considered, including geography, surface hydrology, meteorology, land and water resources, terrestrial and aquatic ecosystems, land use, demography, and economic, historical, institutional and societal factors.

At the same time, geologic field studies were undertaken to investigate the geologic and hydrogeologic features of the four study areas. The evaluation considered stratigraphy, structure, hydrogeology, seismicity, tectonic history, Quaternary features, physiography, energy/mineral resources, and geotechnical factors. The work entailed gathering and interpreting pertinent data from surface rock exposures, shallow pits,

earthquakes, well logs, and cores. Available geophysical data were analyzed. Specially designed boreholes were drilled to provide continuous core and testing for important hydrogeologic and geochemical parameters. The potential for uranium, oil, gas, and other natural resources was ascertained.

Details of the technical aspects of the area studies are in the geologic and environmental area characterization reports (Woodward-Clyde Consultants, 1981a; Bechtel National, Inc., 1980) and are summarized briefly in Section 3.3 of this report.

3.2.3 PROJECT STATUS

The Paradox Basin project is in the final stages of the area characterization studies, which began with the selection of the four study areas at the end of the regional characterization study. Draft environmental and geological area characterization reports have been completed and submitted for state review and comment. These comments on the environmental area characterization report have been incorporated into the draft, which has been submitted to DOE for final approval and publication.

3.3 DESCRIPTION OF PARADOX STUDY AREAS

Descriptions of the geologic and environmental characterization of the four Paradox Basin study areas are summarized in this section. These summaries are drawn from the following detailed reports describing geologic and environmental characteristics of the study areas:

- Geologic Characterization Report, Utah Study Areas (Woodward-Clyde Consultants, 1981a)
- Environmental Characterization Report, Utah Study Areas (Bechtel National, 1981)

The location of the study areas is shown on Figure 3-1. Rock units referred to in subsequent discussions are shown on Figure 2-3. Individual location maps of the four study areas are shown on Figures 3-3 through 3-6.

Some environmental characteristics are non-differentiating between study areas. For example, the four study areas share similar meteorological characteristics (a semiarid climate with precipitation produced primarily by summer cloudbursts and winter snowfall); demographic data are similar (population density ranges from 1.2 to 1.8 persons/sq mile, and all are predominantly rural areas); socioeconomic data are based on proximity to Moab, Blanding, and Monticello, the three nearest towns to the study areas; and although there are four plant communities represented between areas, all areas share similar flora and fauna. Site-specific baseline characterizations of each study area would undoubtedly illustrate a greater degree of environmental difference than can be determined by the extant data.

3.3.1 SALT VALLEY STUDY AREA

The center of the Salt Valley Study Area is located about 25 miles northwest of Moab, Utah (Figure 3-3). The following geologic description of the area is derived mostly from U.S. Geological Survey Open File Reports (Hite and Lohman, 1973; Gard, 1976).

Surface landforms of the area are controlled by the Salt Valley anticline. Cuestaform ridges underlain by resistant Mesozoic sandstones define the northeast and southwest flanks of the anticline. A wide valley (Salt Valley) extends along the anticlinal axis coincident with a crestal graben. Salt Valley is 0.5 to 1.5 miles wide and was formed by salt dissolution and structural collapse along the anticlinal crest during the Tertiary period. An unimproved dirt road extends through Salt Valley from U.S. Highway 163 in the northwest to Arches National Park, south of the area.

Drainages in Salt Valley extend northwestward and southeastward from a divide located near the western boundary of Arches National Park. Southeastward drainage flows into Salt Wash, and then into the Colorado River. Northwestward drainage flows into Thompson Wash and eventually into the Green River via Tenmile Canyon. Since Salt Wash has a steeper gradient than Thompson Wash, the drainage divide in Salt Valley will probably migrate slowly northwestward.

Paleozoic strata in the subsurface consist of limestone, dolomite, shale, and sandstone. The Mississippian-age Leadville Limestone is probably the only significant aquifer within the pre-Paradox Formation sequence. Pennsylvanian-age Hermosa Group strata contain upper and lower formations of interbedded limestone, dolomite, shale, and some anhydrite, as well as a middle halite-bearing formation--the Paradox Formation. This formation contains evaporite (mostly halite) cyclically interbedded with black shale, dolomite, and anhydrite. The oldest stratigraphic unit exposed in the area, the Paradox Formation, occurs within Salt Valley in isolated hills. These outcrops contain severely contorted and altered rocks that represent the insoluble residue (caprock) of the halite-bearing Paradox Formation, which forms the core of the Salt Valley anticline. Permian and Triassic-age strata (including the Cutler and Moenkopi Formations) are present only in the subsurface on the flanks of the Salt Valley anticline. Mesozoic strata exposed in the area are dominantly continental bright-colored sandstone, siltstone, mudstone, and conglomerate. The youngest Mesozoic strata, the Late Cretaceous-age Mancos Shale, occurs on the outermost flanks of the Salt Valley anticline, and has been faulted down into the anticline core in the northern part of the area. Quaternary-age sandy alluvium and eolian deposits cover the floor of Salt Valley. Locally, older alluvium containing pebbles of chert from the Mesozoic Morrison Formation occurs as terrace remnants on low hills 10 to 15 feet above the general valley surface.

The principal geological structure in this area is the Salt Valley diapiric salt anticline. This is part of a longer structural trend of diapiric salt anticlines that extends for more than 60 miles into Colorado. This trend is composed of the Salt Valley, Cache Valley, Fisher Valley, and Sinbad Valley anticlines. These structures are located along the northeastern margin of the Uncompahgre Trough (or Paradox Fold and Fault Belt), a structural zone coincident with a zone of northwest trending Pennsylvanian-age normal fault block basins. These basins were sites of thick Paradox Formation salt accumulation that became preferred places for subsequent salt anticline development. At the Salt Valley anticline, salt migrated laterally into the core of the structure, and then vertically pierced the overlying stratigraphic cover. Migration continued from soon after Pennsylvanian deposition to at least Jurassic time, when the Morrison Formation was deposited across the structure. Collapse of the crestal parts of Salt Valley anticline was induced by salt dissolution and occurred during the Tertiary period. This collapse caused downdropping of the sequence of Jurassic-age Morrison Formation through Late Cretaceous-age Mancos Shale into a broad central graben.

The Salt Valley anticline plunges gently to the northwest, causing the more resistant Mesozoic sandstone cuestas to disappear to the northwest beneath the less resistant Mancos Shale. Normal faults bounding the central collapse graben are more complex and numerous on the southwest flank than the northeast flank of the anticline. These faults on the southwest flank probably formed during the second stage of collapse in middle Tertiary time. Within Salt Valley several low hills and ridges consist of downdropped blocks of Jurassic and Cretaceous rocks arranged in a chaotic structural pattern, and resting on top of Paradox Formation insoluble caprock material.

There has been much exploration in this area for oil and gas, potash, uranium, and copper. Many oil and gas shows have been found in the numerous

exploratory holes drilled in the area. The potential is good for future oil and gas development in the shallow Mesozoic units, the Paradox Formation, and Leadville Limestone (Merrell and Utah Geological and Mineral Survey, 1979). The potential for mining potash within the Paradox Formation is believed to be very high, although economics seem to be marginal at present. Small copper and copper/silver mines were operated in the area from the early 1900's through the 1930's. Currently, large low-grade copper reserves are reported to have been drilled, and interest in additional copper exploration remains high. Copper occurs in fault-related deposits within the Morrison Formation and Entrada Sandstone. There are two operating uranium mines in the area, and deep (2000+ feet) and shallow drilling has been conducted for deposits in the Chinle and Morrison Formations (Merrell and Utah Geological and Mineral Survey, 1979).

Hydrogeological studies in the area have been carried out within the last several years by the U.S. Geological Survey. Reports describing these investigations and results are in preparation.

Land ownership in the Salt Valley Study Area consists of approximately 60 percent federal, 35 percent state, and 5 percent private lands. Federal lands in the area are administered primarily by the Bureau of Land Management. Annual precipitation in the study area averages 17.8 cm (7 inches) but varies with elevation. The percentage of floodplain is the highest of the four study areas: of 20,480 total acres, 6,400 acres are contained within the probable 500-year floodplain, a total of 31 percent of the study area.

The topography of the area ranges in elevation from 4,600 to 5,400 feet above mean sea level (MSL). To make the area accessible by rail would require the construction of 4.2 miles of rail (Bechtel Group, Inc., 1981). One interstate highway and one U.S. highway traverse the study area; the

Denver and Rio Grande Western Railroad Company has two rail lines within the Salt Valley Study Area.

The Pershing Missile Launch Facility is located approximately 7 miles northwest of the study area. Industrial facilities in the study area are limited to numerous gravel quarries, oil wells, and the uranium mines. The nearest population centers are Moab, about 25 miles southeast, and Green River, about 25 miles northwest; populations are about 5,000 and 1,000, respectively.

Salt Valley Study Area vegetation consists primarily of the desert shrub plant community with limited pinyon and juniper stands. Arches National Park is located within the southeast section of the study area, as are numerous natural landmarks. No archaeological surveys have been undertaken in the Salt Valley Study Area, although numerous sites are recorded in the vicinity. The archaeological sensitivity of the study area may be considered low to medium, based on the survey conducted by Thompson (1979) southeast of the area.

Rangeland productivity is at the level of 29 acres per animal unit month. Utilities in the Salt Valley Study Area are limited to one 46-kV and one 69-kV electrical transmission line. Two small airports are in the study area.

3.3.2 LISBON VALLEY STUDY AREA

The Lisbon Valley Study Area is located within the Salt Anticlines physiographic subprovince; its center is located approximately 30 miles southeast of Moab, Utah (Figure 3-4). Surface landforms of the area are strongly influenced by the geologic structure of the Lisbon Valley anticline, and are characterized by subparallel cuestaform ridges and hogbacks and flat valley floors. Topographic relief of the Lisbon Valley area is generally less rugged than in many other parts of the Paradox Basin region, although local relief is as much as 1,200 feet.

The Quaternary history of the Lisbon Valley area has been controlled by Cenozoic regional uplift of the Colorado Plateau, fluctuating climatic conditions, and possibly by structural collapse at depth in the Lisbon Valley anticline. This collapse was caused either by faulting or dissolution of salt at depth. Surficial deposits in the area reflect fluvial, mass movement, and eolian processes operating during Quaternary time. Data on soil profile development (cambic B and calcic horizons) on surficial deposits in the western and northern parts of the area suggest that the soils can be divided broadly into a younger soil (probably of Holocene age) and an older soil group that is probably late Pleistocene or older in age. Quaternary rates of the bedrock incision and scarp retreat in the Lisbon Valley area are probably less than rates for the Paradox Basin as a whole. Aligned and offset streams and linear vegetational patterns in lower Lisbon Valley suggest Quaternary faulting.

Subsurface Paleozoic deposits consist of limestone, dolomite, sandstone, and shale. Mississippian Leadville Limestone consists of massive limestone and dolomite. Pennsylvanian-age Hermosa Group deposits include interbedded limestone, dolomite, anhydrite, and shale as well as the salt of the Paradox Formation, which is cyclically interbedded with anhydrite, carbonate, and argillaceous rocks. The oldest stratigraphic unit exposed in this area is the Honaker Trail Formation of Pennsylvanian age (Figure 3-2). Permian rocks are represented by the Cutler Formation, which is composed of red to tan arkosic sandstone, siltstone, and conglomerate. The Triassic Moenkopi Formation is not exposed in the area. Mesozoic rocks are dominated by sandstone, siltstone, mudstone, conglomerate, and lacustrine limestone. Quaternary fluvial and eolian deposits directly overlay Mesozoic and older rocks.

The principal geologic structure within this area is the Lisbon Valley nondiapiric salt anticline. This structure is located near the western

margin of the Paradox Fold and Fault Belt, which is coincident with a zone containing Pennsylvanian and older fault-block basins. These basins were filled with Pennsylvanian-age Paradox salt that subsequently became preferred sites for salt anticline development. At Lisbon Valley, stratigraphic data clearly demonstrate structural growth of the anticline related to lateral salt flowage and upward doming during late Paleozoic and Triassic time.

The Lisbon Valley anticline is terminated on the east by the Lisbon Valley fault zone. This fault zone is believed to be related principally to collapse along the crest of the Lisbon Valley anticline caused by progressive dissolution of deformed Paradox Formation salt within the anticline core (Hite, 1978). Much of this dissolution probably occurred coincident with canyon cutting in the Tertiary, following the initial uplift of the Colorado Plateau. The Lisbon Valley fault zone may have originated during salt flowage in the late Paleozoic/Triassic; it may have partially controlled distribution of the deformed salt mass. Evidence from subsurface analysis indicates that disharmonic structural conditions occur above and below the salt. Disharmonic conditions were probably produced by detachment within the migrating Paradox salt. Available data suggest that the Libson Valley fault zone may not extend below the Paradox salt.

The northwest-trending basement structures that control the Lisbon Valley and other salt anticline locations may have been in existence about 1,500 million years ago. These faults were possibly reactivated during crustal extension in the late Proterozoic and Cambrian times. Another episode of reactivation occurred during the Antler orogeny in the latest Devonian and Mississippian. The Paradox Basin formed during the Middle Pennsylvanian coincident with the main deformation along the Ancestral Rocky Mountains. Large displacements occurred along the salt anticline basement structures at this time.

Rapid upward growth of the salt anticlines began in the late Pennsylvanian and continued through the Middle Triassic, with slow growth occuring through the Late Jurassic. Basement deformation and regional northeast-trending horizontal crustal compression lasted from the latest Cretaceous until the late Eocene, probably producing severe deformation along the Lisbon Valley salt anticline. Early Miocene igneous intrusives in the La Sal Mountains to the north of the area are the youngest igneous rocks recognized in the Paradox Basin. Late Cenozoic displacement along the Lisbon Valley-Moab fault zone may be caused by tectonic forces, salt dissolution in the anticline region, or a combination of the two.

No earthquakes were observed in the Lisbon Valley area during the period 1850 to 1979. During microearthquake monitoring of Gibson Dome and Elk Ridge, no events greater than Richter Magnitude 1.0 were observed in the vicinity of Lisbon Valley.

There are several producing uranium and vandium mines in the area. Oil and natural gas production occurs in the study area as well, and Union Oil maintains a natural gas processing plant. Copper has been produced in the past, but there is no current production. Potash is present, but commercial-scale potash mining has not been conducted to date. Because of the large number of commercial and subcommercial mineral and petroleum deposits above, below, and juxtaposed stratigraphically with the proposed repository site, a major conflict exists between repository siting and mineral resource development.

The hydrostratigraphic unit that includes the saline facies of the Pennsylvanian Paradox Formation is regionally isolated from the groundwater flow systems in the overlying and underlying hydrostratigraphic units. However, some local hydraulic interconnection may exist in this

area through cross-cutting faults juxtaposing overlying and underlying units against the Paradox Formation. The Paradox Formation contains beds of extremely low permeability strata within the Lisbon Valley area, as is the case over much of the western part of the Paradox Basin. Although isolated reservoirs of higher permeability sometimes contain oil, gas and brine, no laterally extensive flow systems have been detected in the Paradox saline facies, and flow directions are generally ill-defined within the unit.

Ground-water flow in the hydrostratigraphic unit above the saline facies of this area is generally controlled by geologic structure and topography. Recharge waters that enter the ground-water system in the highlands on the southwest side of the Lisbon fault move radially down-gradient and merge with regional flow toward major river canyons. Within the strata underlying the salt, the ground-water flow pattern is strongly influenced by oil and gas production from the Leadville Limestone. The regional potentiometric surface within the formations underlying the Paradox (northeast to southwest) is locally altered by pumpage from the Lisbon oil field. The only known ground-water discharge within the area is water withdrawn with production of the hydrocarbons.

Land ownership in the Lisbon Valley Study Area consists of approximately 80 percent federal lands, 10 percent private, and 10 percent state. Federal lands are administered by the Bureau of Land Management. Annual precipitation averages 30 cm (12 inches) and varies with elevation. The percentage of floodplain in the Lisbon Valley Study Area is about 10 percent; of 49,920 total acres, 5,120 occur within the probable 500-year floodplain.

The topography of the area ranges in elevation from 6,400 to 7,100 feet above MSL. To make the area accessible by rail would require construction of 41 miles of rail line (Bechtel Group, Inc., 1981). The study area is linked to two U.S. highways by paved loop-roads to industrial facilities.

Monticello is the nearest populated center, about 20 miles southwest; Moab is located about 30 miles northwest. Populations are about 1,500 and 5,000, respectively.

Vegetation of the study area is primarily part of the pinyon-juniper pines plant community, with some ponderosa pine. No dedicated lands exist within the study area, although one natural landmark/geologic formation occurs there. Archaeological sensitivity in the Lisbon Valley Study Area has been characterized as medium (Thompson, 1979).

Rangeland productivity is at the level of 22 acres per animal unit month, and about 5 percent of the total study area is irrigated land. Approximately 7 percent of the area is dry farmed, the primary crop being wheat. Utilities in the Lisbon Valley Study Area consist of 69-kV, 138-kV (one) and 345-kV (one) electrical transmission lines. Gas and oil pipelines (one each) also cross the study area. One landing strip exists within the area.

3.3.3 GIBSON DOME STUDY AREA

The Gibson Dome Study Area is located in the Inner Canyonlands and Hatch Syncline physiographic subprovince; its center is about 30 miles south-southwest of Moab, Utah (Figure 3-5). Landforms of the area include vertical cliff faces, steep talus slopes, and relatively flat surfaces that are essentially coincident with resistant bedrock layers. Bench- and cliff-style relief often exists on several scales, and local relief reaches 1,500 feet. The elevation of most of the area is between 4,000 and 6,200 feet above MSL, although upland localities reach 6,950 feet MSL.

The Quaternary history of the area appears to have been primarily controlled by Cenozoic uplift of the Colorado Plateau and by fluctuating climatic conditions throughout southeastern Utah. Erosion has dominated in the area, but episodes of alluviation and colluviation are recorded by

deposits along streams and adjacent to cliffs. The resistance of the underlying bedrock has also influenced local erosion rates and processes. Fluvial, eolian, and mass movement processes have been operating in the area throughout Quaternary time.

Quaternary deposits include alluvium, colluvium, talus, landslide deposits, and widespread eolian deposits. The oldest Quaternary deposits are gravels covering pediments on the north side of the Abajo Mountains. These gravels are tentatively correlated with similar gravels on the east and south flanks of the Abajo Mountains. Other similar gravels exposed in quarries near Blanding display reversed magnetic polarity and are therefore considered to be at least 700,000 years old. At least two subsequent episodes of cobble gravel deposition and terrace formation occurred during late Pleistocene time along Indian Creek and tributaries draining the Abajo Mountains. Fine-grained Holocene fill up to 60 feet thick with multiple cut-and-fill structures underlies low terraces in the area. The oldest carbon-14 date obtained from Holocene fill in the Gibson Dome Study Area is 7,760 ±155 years before present.

Rates of bedrock incision and cliff retreat are comparable to those observed elsewhere in the region, or approximately 0.8 foot per 1,000 years and 0.8 to 1.8 feet per 1,000 years, respectively. No significant bedrock incision has occurred in the area since initial deposition of the Holocene fill.

The oldest stratigraphic unit exposed in the Gibson Dome area is the Honaker Trail Formation of late Pennsylvanian age (Figure 3-2). Subsurface pre-Hermosa Group Paleozoic rocks consist of limestone, dolomite, mudstone, siltstone, sandstone, and shale. Pennsylvanian-age Hermosa Group deposits include interbedded limestone, sandstone, siltstone, dolomite, anhydrite, and shale as well as the salt beds of the Paradox Formation, which occur in distinct cycles separated by an interbed sequence of anhydrite, carbonate, and argillaceous rocks. Warping or faulting of Mississippian and low Pennsylvanian rocks into a structural low under the Gibson Dome structure has

allowed for a thicker accumulation of salt in this area than in other parts of the Gibson Dome Study Area. Permian rocks are dominated by marine siltstone, sandstone, and limestone along with intertonguing continental red and purple arkosic sandstone on the northeast. Mesozoic rocks are dominated by Triassic and Jurassic age continental red and tan sandstone, siltstone, mudstone, and conglomerate. Cretaceous rocks are not present in the area. The only Cenozoic rocks present in the Gibson Dome area are Quaternary deposits such as talus, dune sand, stream terraces, and soils. Oligocene intrusive rocks in the Abajo Mountains occur just south of the area.

The Gibson Dome Study Area is structurally a relatively simple homocline that contains a gentle structural fold--Gibson Dome. At the northeast margin of the Gibson Dome area is Lockhart Basin, a structurally complex solution-collapse area. Shay graben, a structure with possible Quaternary movement, borders the Gibson Dome area on the southeast. The Needles fault zone, a zone of structures having Quaternary movement related to gravity sliding and salt flowage, is west of the Gibson Dome area. Northwest-trending faults observable in subsurface data and affecting the Mississippian and early Pennsylvanian formations are located near Hatch Mesa east of the Gibson Dome area. Although bordered by a collapse structure and some faults, the Gibson Dome area contains essentially flat-lying undisturbed strata of less than 5 degrees dip. The strata are locally jointed, particularly along the crest of the Gibson Dome structure.

Precambrian crystalline basement under the Gibson Dome Study Area is 1,700 to 1,800 million years old. The northeast-trending structures of the Colorado lineament (extending through the northwest part of the area) appear to have originated about this time as part of a continental-scale wrench-fault system. The Paradox Basin formed during the Middle Pennsylvanian coincident with the main deformation along the Ancestral Rocky Mountains. Vertical displacement may have occurred on structures within the Colorado lineament west of the area in the Early Triassic.

Basement deformation and regional northeast-trending horizontal crustal compression lasted from the latest Cretaceous until the late Eocene. A major Oligocene thermal pulse coincided with uplift of the Colorado Plateau province and with the intrusion of stocks and laccoliths in the Abajo Mountains (south of the area). Regional uplift of the Colorado Plateau-Southern Rocky Mountains in the Late Miocene-Pliocene resulted in the cutting of the Colorado River canyon system. Shay graben (located along the southern border of the study area) appears to have been reactivated in the Plio-Pleistocene. The Needles fault zone in the western part of the area was produced by a combination of gravity tectonics and salt flowage following the cutting of Cataract Canyon.

No earthquakes were observed within the Gibson Dome Study Area during the period 1850 through June, 1979. Microearthquake monitoring (earthquakes less than Richter Magnitude 3.0) for a period of 17 months since 1979 revealed a zone of seismicity apparently associated with a segment of the Colorado River extending through the northwestern part of the area. The largest event observed to date has been a Richter Magnitude 2.4.

The potential for commercial resource discoveries is relatively low in the Gibson Dome Study Area, and is probably limited to small deposits of uranium, oil and gas, and possibly potash. The potential for conflicts between energy and mineral deposits and repository siting appears to be relatively low in the Gibson Dome area.

The Paradox Formation contains beds of extremely low permeability strata in the Gibson Dome area. Based upon available drill-stem test records and hydrochemistry data, the saline facies are generally isolated from the groundwater flow systems in the overlying and underlying hydrostratigraphic units. Some local interconnection may be provided by igneous intrusions in the Abajo Mountains (south of the area) and by the salt-dissolution collapse structure in Lockhart Basin, on the northern periphery of the area.

The flow system within the Paradox Formation in the area is generally characterized as being stagnant, without well-defined flow paths. Groundwater flow in the hydrostratigraphic units above and below the saline facies is generally controlled by topography and precipitation patterns. Recharge waters that enter the ground-water system in the Abajo and La Sal highlands generally move down-gradient toward the major river canyons. Flow directions across the area are generally toward the north and west. These flow paths merge with ground-water that originates in highlands just outside the perimeter of the basin. Minor springs discharge from the upper hydrostratigraphic unit in the Colorado River Canyon to the north and west of the area. No surface ground-water discharge from the saline facies or from the lower hydrostratigraphic unit has been detected within the area. The nearest known ground-water discharge from the lower unit is at Marble Canyon, Arizona, down the apparent flow path to the southwest (a distance of approximately 150 miles).

Land ownership in the Gibson Dome Study Area consists of approximately 90 percent federal, 8 percent state, and 2 percent private lands. Annual precipitation in the area averages 20 to 28 cm (8 to 11 inches) and varies with elevation. The major surface water in the area is a 15-mile segment of the Colorado River.

Topography of the area ranges in elevation from roughly 4,000 to 6,950 feet above MSL. To make the area accessible by rail would require 32 miles of rail (Bechtel Group Inc., 1981). One state and one U.S. highway pass through the area.

The Gibson Dome location (which contains no part of Canyonland National Park) have multiple land uses, i.e., mining, grazing, oil and gas exploration, and recreational. Several uranium and vanadium prospects exist but they are not currently operational. Isolated ranches are found in the area. Twenty-three test holes have not encountered any hydrocarbon deposits of economic significance. Hydrocarbon shows and minimal production (less 100 barrels total) was reported in one well. Recreation is an important

land use within the area. Access to Canyonlands National Park is gained by driving through the study area on Utah State Highway 211 and jeep trails off of Highway 211. Important recreational resources within the Gibson Dome Study Area include Newspaper Rock State Historical Monument and Canyon Rims Recreational Area plus two Wilderness Study Areas. The nearest population centers are Moab, about 30 miles northeast, and Monticello, about 20 miles southeast, with populations of 5,000 and 1,500 respectively.

The study area consists of roughly equal parts of the desert shrub and pinyon-juniper pines plant communities. A portion of Canyonlands National Park is included within the study area, as is Newspaper Rock State Historic Monument, Canyon Rim Recreation Area, Manti-La Sal National Forest, La Sal Mountain State Forest, two proposed wilderness study areas, and numerous natural landmark/geologic features. Archaeological investigations in the study area and vicinity characterize the archaeological sensitivity as ranging from low to medium (Thompson, 1979).

Rangeland productivity is at the level of 40 acres per animal unit month. Irrigated land is minimal, less than 1 percent of the study area. There are no major utility lines in the Gibson Dome Study Area. Five airports or landing strips exist within the area.

3.3.4 ELK RIDGE STUDY AREA

The Elk Ridge Study Area is located in the Monument Upwarp, Comb Ridge and Blanding Basin physiographic subprovinces; its center is located about 70 miles south-southwest of Moab, Utah (Figure 3-1). Landforms of the Elk Ridge area are controlled by lithologic contrasts and geologic structure. Most of the area consists of a high plateau that is interrupted on the east by the Comb monocline, the major structural and topographic feature of the Elk Ridge Study Area. Comb monocline is interrupted by several deeply incised canyons. Most of the area is fairly high in elevation, ranging from 4,500 to 9,000 feet MSL.

Geomorphology and Quaternary history in this area are generally similar to the Gibson Dome area. The oldest Quaternary deposits within the Elk Ridge area are the Suicide Gravels on the Cedar Mesa surface. Other older gravel remnants occur on high terraces and alluvial fans near Cottonwood Wash. These deposits predate canyon incision, and are correlated with Abajo fan gravels that are paleomagnetically reversed (at least 700,000 years old) near Blanding. Multiple gravel terraces of middle and late Pleistocene age occur along Cottonwood Wash and other tributaries draining the Abajo Mountains. The oldest carbon-14 date obtained from fine-grained Holocene fill in the area is 9,500 ±80 years.

The oldest stratigraphic unit exposed in the Elk Ridge area is the Elephant Canyon Formation of Permian age (Figure 3-2). Subsurface pre-Hermosa Group Paleozoic deposits consist of limestone, dolomite, siltstone, mudstone, sandstone, and shale. Pennsylvanian-age Hermosa Group deposits include interbedded limestone, dolomite, sandstone, siltstone, anhydrite, and shale as well as the salt beds of the Paradox Formation, which occur in distinct cycles separated by an interbed sequence of anhydrite, carbonate, and argillaceous rocks. Because of the area's proximity to the southwestern edge of the Paradox Basin, the salt beds are relatively thin.

Permian rocks are dominated by marine siltstone, sandstone, limestone, and shale, that intertongue on a grand scale with continental sandstone, shale, and siltstone. The Cutler Formation is absent in the Elk Ridge area but is represented by the Elephant Canyon, Cedar Mesa, and Organ Rock formations of the Cutler Group. Mesozoic rocks are dominated by continental sandstone, siltstone, shale, and conglomerate, with minor marine sandstone, shale, and limestone present in the Jurassic and Cretaceous sections. With the exception of the previously mentioned Quaternary material (eolian, alluvial and colluvial deposits), the area is essentially devoid of Cenozoic deposits.

Relative to major structures, the Elk Ridge Study Area is located on the northeastern part of the Monument Upwarp and includes the Comb monocline and the Elk Ridge anticline. The area is extensively jointed, and the

only two faults within the area are Hammond graben and the Cheesebox Canyon fault. There are no known collapse structures within the area.

The tectonic history of the Elk Ridge Study Area is similar to that of the other areas. Uplift of the Monument Upwarp and west-side-up displacement of the Comb structure (in the eastern part of the area) probably took place in Middle Pennsylvanian to Early Permian times. Basement deformation and northeast-trending horizontal crustal compression lasted from the latest Cretaceous until the late Eocene, producing strong uplift of the Monument Upwarp and displacement on the Comb structure. Comb Ridge is a monoclinal drape fold above a steeply west-dipping reverse fault in the basement rocks.

The historical seismicity record of the Elk Ridge Study Area for the period 1860 through June, 1979, consists of four earthquakes with the largest a Richter Magnitude 2.8. Microearthquake monitoring for a period of 17 months since 1979 revealed a low level of activity, with the largest event a Richter Magnitude 2.1 just north of Bears Ears.

The potential for commercial resource discoveries in the Elk Ridge area is relatively low, and is probably limited to small oil and gas accumulations and uranium-vanadium deposits. The potential for conflict between energy and mineral deposits and repository siting here appears to be relatively low.

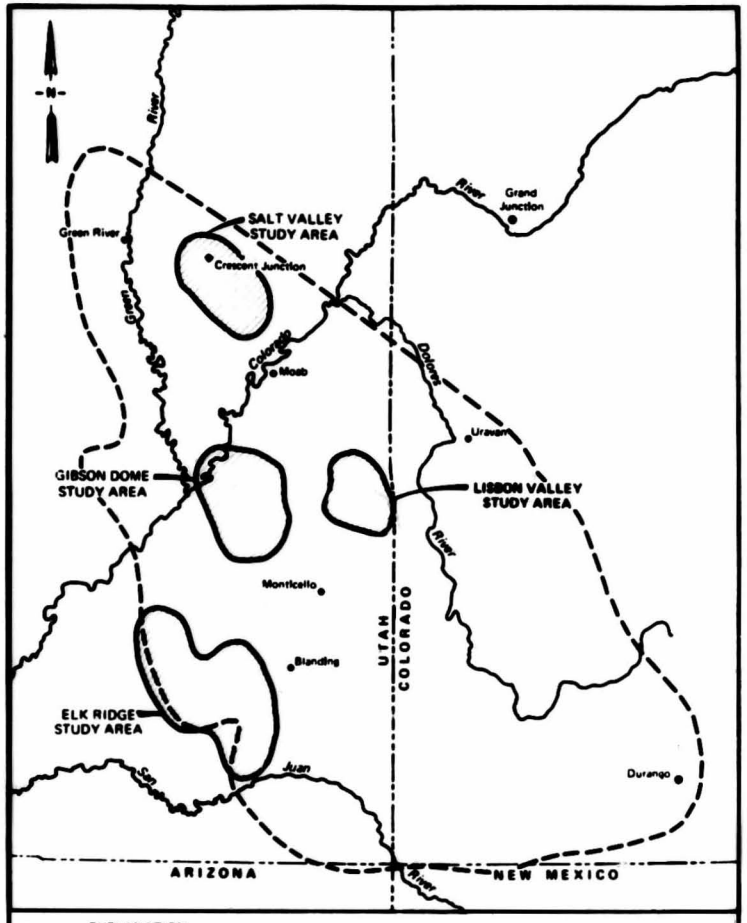
Paradox saline strata range from 400 to 800 feet in thickness and are characterized by extremely low permeability. General characteristics of hydrostratigraphic units in this area are the same as those in the Gibson Dome Study Area. Recharge waters that enter the ground-water system in the Abajo highland move down-gradient toward the San Juan River canyon. Flow directions are generally toward the south and west. Minor springs discharge from the upper hydrostratigraphic unit in the San Juan River canyon. No ground-water discharge has been detected from the lower unit within the area or within the Paradox Basin immediately down the apparent flow path.

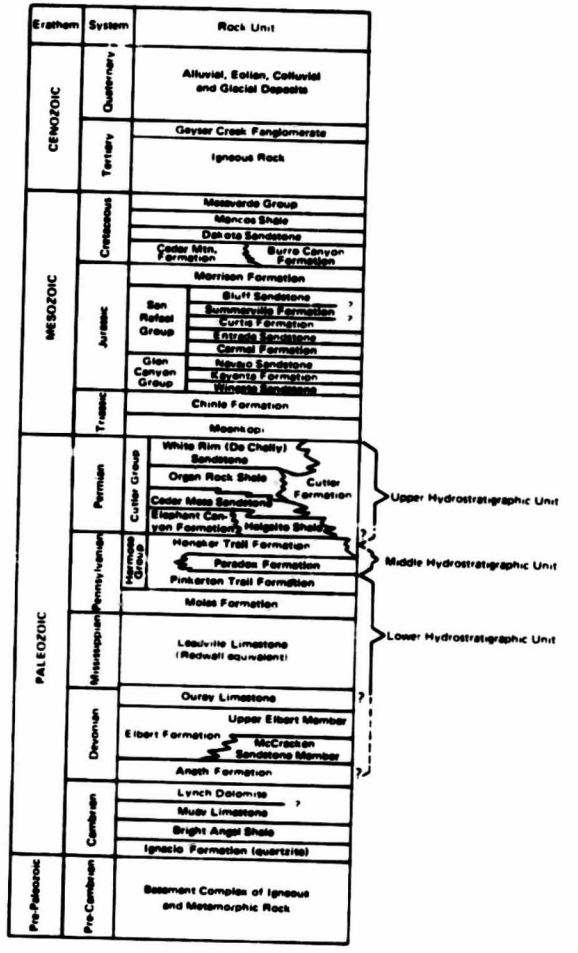
Land ownership in the Elk Ridge Study Area consists of approximately 89 percent federal, 10 percent state, and 1 percent private lands. Annual precipitation varies with elevation from 20 to 50 cm (8 to 20 inches).

The topography of the area ranges in elevation from 4,500 to 9,000 feet above MSL. To make the area accessible by rail would require 100 miles of rail line (Bechtel Group, Inc., 1981). Within the study area are one U.S. and two state highways. With the exception of scattered ranch dwellings, there are no industrial or institutional facilities within the area. Over 50 uranium and vanadium mines exist within or near the study area, although few are currently producing. The area contains a large uranium resource that has produced about half of the state's total uranium yield. Of the many oil wells drilled in the area, only one (drilled in 1962) recovered any petroleum. This well is not currently producing. Blanding, the nearest population center, is located about 20 miles east and has a population of about 2,380.

Vegetation in the study area is primarily part of the pinyon-juniper pines plant community with some ponderosa pine. Designated recreational areas in or adjacent to the Elk Ridge Study Area include Natural Bridges National Monument, a portion of the Manti-La Sal National Forest; Glen Canyon National Recreation Area, Grand Gulf Primitive Area, Dark Canyon Primitive area, seven proposed wilderness study areas, and numerous scenic, natural, and cultural landmarks. Archaeological sensitivity in the Elk Ridge Study Area is characterized as very high. It is one of the richest archaeological areas (in terms of quantity and quality of remains) in the United States.

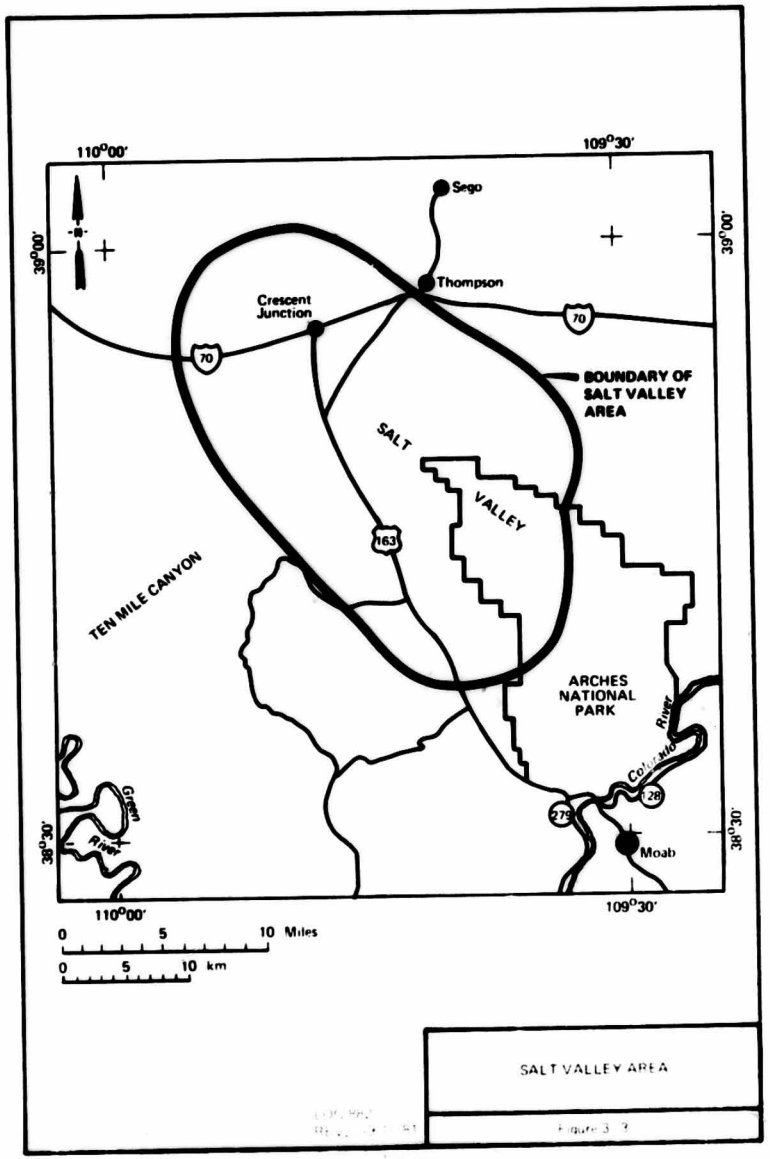
Rangeland productivity is at the level of 9 acres per animal unit month; less than 1 percent of the total Elk Ridge Study Area acreage is dry farmed. There are no major utility corridors or gas or oil pipelines in the study area. The only potentially interactive land uses are several small, private landing strips.





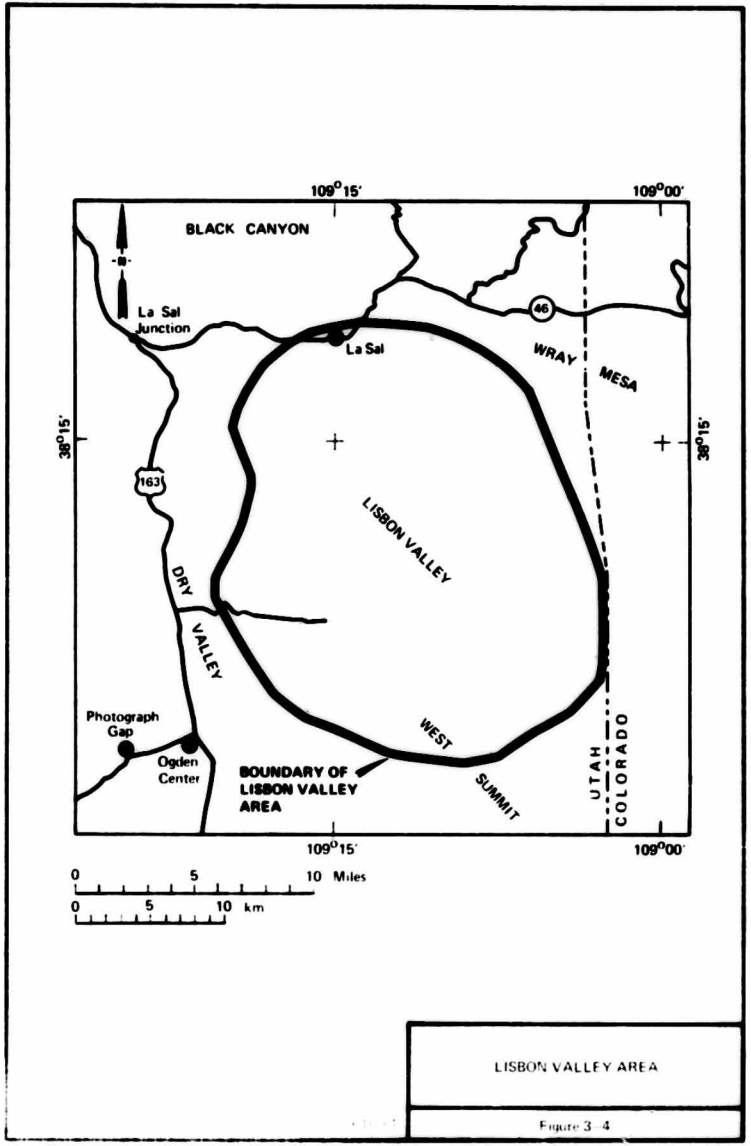
COMPOSITE STRATIGRAPHIC COLUMN
PARADOX BASIN

Figure 3-2



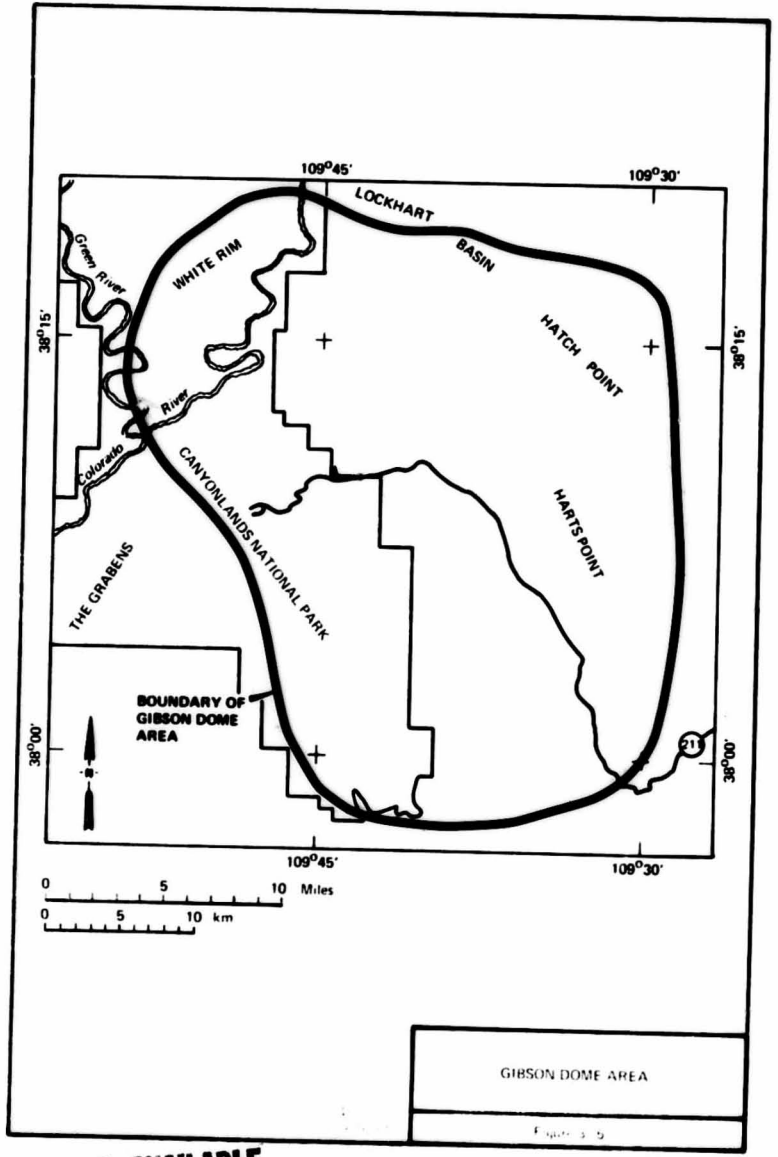
SALT VALLEY AREA

Figure 3-3



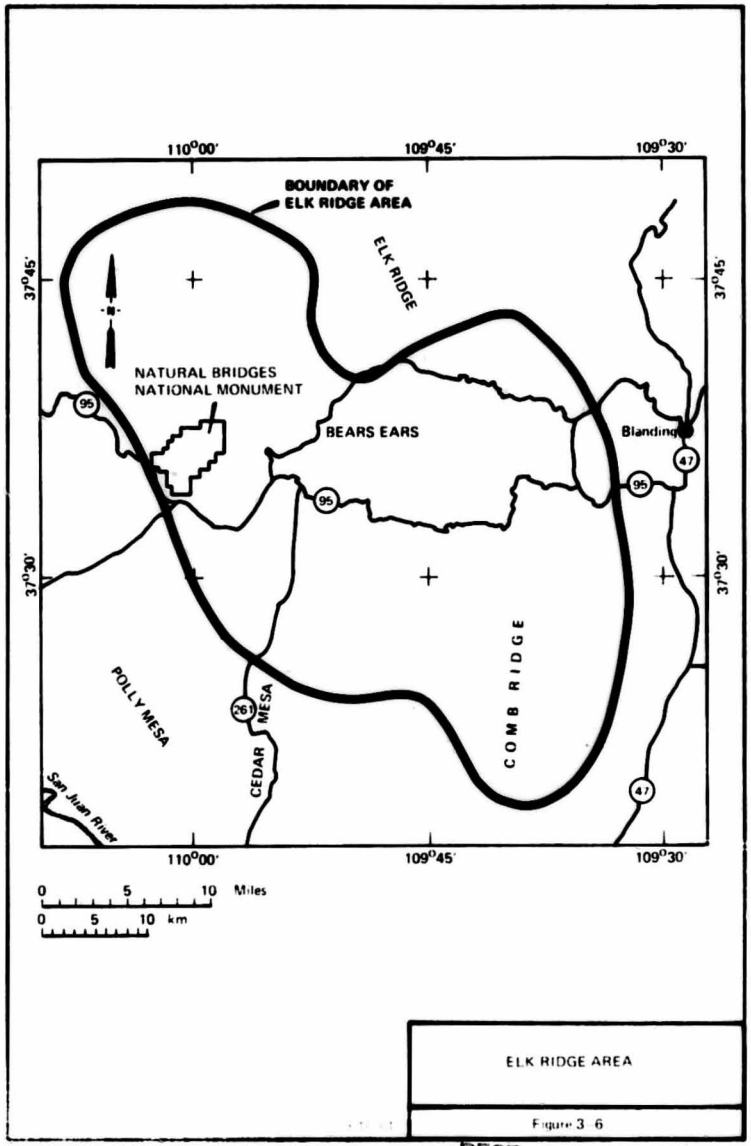
LISBON VALLEY AREA

Figure 3-4



GIBSON DOME AREA

Figure 3-5



ELK RIDGE AREA

Figure 3-6

Chapter 4

EVALUATION OF STUDY AREAS

This chapter describes how data gathered during the area characterization studies were used to evaluate the four study areas in order to define favored locations for further study. The essence of this evaluation was a five-step screening process.

4.1 SCREENING PROCESS

The objective of the screening process was to identify those parts of any study area that are potentially favored for repository siting. These potentially favored parts are called "locations."

This screening objective was achieved by application of a series of map overlays to the study areas. Each overlay depicts data for a single selected screening factor. (In this report, screening factors are defined as those factors potentially significant to health and safety aspects of repository development that are easily quantifiable and for which data are available.) The screening factors selected for this evaluation were depth to salt, thickness of salt, proximity to faults, proximity to boreholes, and boundaries of dedicated lands. These were judged to be the screening factors with the strongest potential for differentiating possible locations within the study areas. Screening factors have specified numerical limits (or specifications) that outline areas of relative siting favorability for that factor (i.e., minimum depth to salt is 1,000 feet). When combined, overlays depicting these factors identify locations within the study area that are suitable, based on these factors. This screening serves to focus further study on the favored locations.

The screening process is based on data plotted and evaluated on 1:62,500 scale maps. The process consists of the following tasks:

- Compilation of data, as feasible, on basic data map overlays within each study area showing the available data used for each factor
- Evaluation of the data on these maps in terms of density of control points, completeness, location accuracy, quality, and usefulness as an area-wide screening tool
- Selection of screening specifications (limits) and rationale for delineating more and less favorable areas
- Preparation of screening maps showing boundaries of potentially more favorable areas, based on the screening specifications selected in the previous task
- Assembly of map overlays to identify parts of the study areas having characteristics potentially more favorable for waste repository siting than other parts.

The figures presented in Section 4.2 of this report show the distribution of screening specifications for each factor. The data maps that formed the basis for these figures are from the area characterization reports prepared for ONWI by the RPM (Bechtel National, Inc., 1980) and the GPM (Woodward-Clyde Consultants, 1981a). Supplementary data were taken from Hite and Lohman, 1973. These basic data maps show the complete range of data needed to evaluate each factor. These maps and the derivative screening maps can be easily updated when new information becomes available. Each element of the screening process is designed to accommodate new data, changed or new criteria, advances in the state of the art, or other factors resulting in changes in the screening specifications.

4.2 SCREENING FACTORS AND SPECIFICATIONS

Table 4-1 lists screening factors and specifications developed from NWTS and NRC criteria to evaluate the study areas for potentially favorable locations. Individual screening factors and specifications and their

application to the study areas are described in this section. Nuclear Regulatory Commission (1981b) proposed regulation 10 CFR 60.123(b) requires that investigations be made of drill sites, faults, and other potential adverse conditions occurring within 2 kilometers of the repository location. To minimize further studies at this time, zones of at least a 2 kilometer radius surrounding boreholes and faults were identified as potentially unfavorable for siting and were set aside. Discussion of the factors in this section is presented in terms of significance, data acquisition methods, adequacy of data, and screening specifications.

4.2.1 DEPTH TO SALT

NWTS Site Performance Criterion I, Site Geometry, states that the site shall be located in a geologic environment that physically separates the radioactive wastes from the biosphere and that has geometry adequate for repository placement (U.S. Department of Energy, 1981a). Furthermore, the minimum depth of the repository waste emplacement area shall be such that credible human activities and natural processes acting at the surface will not unacceptably affect system performance (U.S. Department of Energy, 1981a). This subcriterion is the basis for addressing the depth-to-salt factor.

Significance. The repository must be at a depth that will separate it from human-induced events and natural surficial processes that may cause a breach of the geologic containment. Additionally, the repository must be deep enough to isolate it from the biosphere and atmosphere, but must not be located within a stress environment that could jeopardize its construction, operation, and physical integrity. Natural phenomena that could cause containment breach are erosion and denudation over the repository lifetime and meteorite impact at the site. Credible human activities include engineered explosions.

Data Acquisition Methods. In the Elk Ridge and Gibson Dome areas, depth-to-salt data were obtained through interpretation of geophysical well logs and consideration of surface topography. Distinctive geophysical log signatures were used to identify elevations of the tops of potential repository layers. Structure contours derived from these data were then used in conjunction with topographic maps to develop maps showing depth to potential repository layers.

In the Lisbon Valley area, geophysical log data were utilized to prepare depth maps to the top of saline facies and to selected potential repository layers within the saline facies. Because surface topographic relief within the area of potentially favorable depth was minimal relative to that in the Elk Ridge and Gibson Dome areas, surface topography was not factored into the Lisbon Valley depth maps.

In the Salt Valley study area, available structural data in Hite and Lohman (1973) were utilized to prepare a depth map to the top of saline facies.

Adequacy of Data. In the Elk Ridge, Gibson Dome, and Libson Valley areas, the density of available boreholes and the quality of available geophysical logs were judged adequate for this level of investigation to define: (1) top of saline facies and (2) top and bottom of potential repository layers within the saline facies. In the Salt Valley area, the top of salt could be identified readily (Hite and Lohman, 1973; Ackermann, 1979); but because of intense deformation within the Salt Valley diapiric anticline, individual cycles within the saline facies could not be identified, nor could site geometry be predicted (Hite, in preparation; Hite and Lohman, 1973).

Screening Specifications. Based on the average erosion rate in the continental United States, 300 meters (1,000 feet) was selected by Johnson and Gonzales (1978) as a minimum depth for the repository to isolate it from erosional processes that might expose it to the biosphere. During

the regional characterization phase of the Paradox Basin study, a preliminary analysis of average erosion rates on the Colorado Plateau (based on the available data) indicated a maximum depth of erosion of approximately 120 meters (400 feet) in 500,000 years (Woodward-Clyde Consultants, 1980). Further analysis during this area characterization phase indicates that an average erosion rate on the Colorado Plateau is less than 1 foot per 1,000 years (Woodward-Clyde Consultants, 1981a). Thus, a minimum depth of 300 meters (1,000 feet) will provide a significant cover for a potential repository, even after 100,000 years of erosion. It has also been judged that this minimum depth will provide isolation from events such as meteorite impact and engineered explosions (Brunton et al, 1978). The likelihood that a 25-meter meteorite will strike a particular repository site is assessed as 2×10^{-13} per year (U.S. Department of Energy, 1980b; Claiborne and Gera, 1974). This minimum depth specification is consistent with proposed USNRC regulations for repositories [10 CFR 60, Section 60.112(i)].

The repository rock should be shallow enough to maintain an opening without collapse caused by lithostatic pressure (Johnson and Gonzales, 1978; Gera, 1970; Brunton et al, 1978). For both regional and area characterization phases of this study, depths between 300 and 900 meters (1,000 and 3,000 feet) were judged to be favorable, and depths between 900 and 1,200 meters (3,000 and 4,000 feet) were judged to be potentially favorable. Based on borehole data obtained for the area study and on geotechnical tests performed in salt in a borehole in the Gibson Dome area, the maximum favorable siting depth in the Paradox Basin is estimated as 3,500 feet (Woodward-Clyde Consultants, 1981b). More definitive studies now in progress in Paradox salt indicate that repository depths greater than 3,500 feet may be feasible.

4.2.2 THICKNESS OF SALT

The thickness and lateral extent of the geologic system surrounding the waste emplacement area must be sufficient to accommodate the repository and a buffer zone, and to ensure that impacts induced by construction of

the repository and by waste emplacement will not unacceptably affect system performance (U.S. Department of Energy, 1981a). This subcriterion of NWTS Criterion I, Site Geometry, is the basis for addressing the thickness of salt.

Significance. Adequate thickness is important to: (1) minimize the possibility of breaching this containment during construction; (2) promote the healing of fractures should the repository be subjected to faulting; and (3) fully utilize the thermal transport properties of the salt.

In the Paradox Formation, individual salt beds are cyclically interbedded with shale, carbonate rock, and anhydrite. In the Elk Ridge, Gibson Dome, and Lisbon Valley areas, individual salt beds have been identified as potential repository layers. In the Salt Valley area, no individual potential repository layers that could be traced laterally were identified because of the extremely complex structural deformation.

Data Acquisition Methods. In the Elk Ridge, Gibson Dome, and Libson Valley areas, thicknesses of potential host rock layers were identified from geophysical logs. As in depth-to-host-rock investigations, distinctive geophysical log signatures were utilized to define top and bottom (and thus thickness) of layers. Isopach maps showing the areal distribution of thickness were prepared.

Adequacy of Data. In the Elk Ridge, Gibson Dome, and Lisbon Valley areas, the density of available boreholes and quality of available geophysical logs were judged adequate to define the range of thickness of potential repository layers for this level of investigation.

Screening Specifications. Current in-progress NWTS repository design studies have indicated that a minimum salt bed thickness of 70 feet is sufficient to accommodate the repository. Therefore, a screening specification for minimum salt layer thickness of 70 feet was established. For

determining thickness, a bed of 100 percent halide lithology having no argillaceous, sulfate, or carbonate strata was used. Thicknesses of 100 percent halide lithology greater than 70 feet are potentially favorable.

4.2.3 PROXIMITY TO FAULTS

Two subcriteria of NWTS Criterion V, Tectonic Environment, are the basis for assessing the proximity to faults:

- The site shall be located so that Quaternary faults can be identified and shown to have no unacceptable impact on system performance.
- The site shall be located so that the subsurface setting can be sufficiently characterized to permit identification and evaluation of conditions that are potentially adverse or favorable to waste containment, isolation, and retrieval.

Significance. This factor consists of two separate issues. The first issue is a concern for faults having Quaternary displacement, and therefore having a potential for future earthquake-related displacement during the period that the waste is potentially hazardous. Such displacement in the form of subsurface and surface rupture (vertical and/or horizontal deformation) could cause damage to and displacement of the repository horizon. Damage to surface structures would pose a safety issue for personnel within the facilities. In addition, nontectonic Quaternary faulting (associated with salt movement) could adversely affect facility construction and underground operations by causing higher engineering and construction costs, and by compromising the integrity of the repository.

The second issue is a concern for faults, regardless of age of last displacement, that provide a potential pathway for radionuclide migration across rock strata to the biosphere. Such features are potentially critical parts of the hydrogeologic flow regime.

These two issues were addressed in this study by separate structural geology considerations of: (1) faults having surface expression and thus

a potential for both a radionuclide migration pathway and Quaternary displacement; and (2) subsurface faults having no surface expression in pre-Cenozoic rocks and thus a potential only as a radionuclide migration pathway.

Data Acquisition Methods. Identification and characterization of surface structures were accomplished by several techniques, including remote sensing interpretation, a detailed literature search, structural and stratigraphic field mapping, and seismic reflection interpretation. Geomorphic features were searched for and documented, where present, using remote sensing interpretation and aerial and ground reconnaissance. Age and extent of Quaternary deposits were identified by literature review, remote sensing interpretation, geologic mapping, detailed sampling in excavated test pits in selected localities, and age dating of samples. Sites have been selected for future trenching across faults to assess age of last displacement.

Subsurface faults were identified and characterized using available literature, subsurface analysis of available oil well and geophysical log data, and interpretation of purchased seismic reflection data.

Adequacy of Data. Data for identification, mapping, and preliminary analysis of surface faults were judged adequate for this area characterization phase in the Lisbon Valley, Gibson Dome, and Elk Ridge areas. Geological characterization of the Salt Valley area is currently being done by the U.S. Geological Survey.

Coverage of seismic reflection data amenable to modern data processing and analysis is only partially adequate to assess subsurface faults in the Lisbon Valley and Gibson Dome areas, and is not currently available for the Elk Ridge area. Preliminary interpretations have been completed for available data in the Gibson Dome area. Such studies in the Lisbon Valley area have been deferred pending results of this area characterization phase of work.

Screening Specifications. For surface faults, preliminary evaluations indicate that at least one fault in each of the Lisbon Valley and Gibson Dome study areas may have Quaternary-age displacement (Woodward-Clyde Consultants, 1981a). In order to identify those areas having potentially unfavorable conditions related to Quaternary faulting, zones 8 kilometers around all mapped surface faults in all study areas were delineated. The selected 8-kilometer zone is based on existing regulations (5 miles) for nuclear power plants (U.S. Nuclear Regulatory Commission, 1981c). For subsurface faults having no surface expression in pre-Cenozoic rock strata, a zone of 2 kilometers surrounding the surface projection of such faults was designated as potentially unfavorable for siting. This 2-kilometer zone is based on a proposed U.S. Nuclear Regulatory Commission (1981b) regulation for repositories [10 CFR 60, Section 60.123(b)(7)]. Areas outside both the 2-kilometer zones and the 8-kilometer zones are potentially favorable for siting with regard to proximity to faults.

4.2.4 PROXIMITY TO BOREHOLES

The following subcriterion of NWTS Criterion VI, Human Intrusion, is the basis for addressing proximity to boreholes:

> "The site shall be located so that the exploration history or relevant past use of the site or adjacent areas can be determined and can be shown to have no unacceptable impact on system performance."

Significance. Subsurface penetrations may threaten the integrity of the repository by providing a possible pathway for radionuclide migration to the biosphere. They also represent evidence of some interest in a potentially exploitable resource, which could be repeated in the future. Conversely, lack of exploration in the vicinity of a repository suggests that these may be limited or no resource potential in the vicinity and the potential for future human intrusion may be minimal.

Data Acquisition Methods. Data regarding location of boreholes were obtained primarily from available literature and from petroleum information broker services. In addition, a recent report on the resource potential of the four study areas, prepared by Merrell and the Utah Geological and Mineral Survey (1979), was utilized. These sources were supplemented by discussions with mineral industry consultants and by limited field reconnaissance checks.

Adequacy of Data. These data were judged to be adequate for this area level of investigation. For later, more-detailed studies of smaller potentially favorable areas, additional inventories (such as the National Uranium Resources Evaluation files in Grand Junction, Colorado) should be utilized.

Screening Specifications. Proposed NRC regulations for repositories, (U.S. Nuclear Regulatory Commission, 1980) state that boreholes within 2 kilometers of a site must be investigated [10 CFR 60, Section 60.123(b)(2)]. For screening purposes, a zone of 2 kilometers around each borehole was designated as potentially unfavorable for repository siting.

4.2.5 LEGALLY DEDICATED LANDS

NWTS Criterion IX, Environmental Protection, recommends that a repository be located with consideration of environmental impacts, land use conflicts and ambient environmental conditions. The subcriterion dealing specifically with land use states: "The site shall be located to reduce the likelihood or consequence of air, water, and land use conflicts."

Significance. The presence of lands legally dedicated to uses that are incompatible with a repository will be avoided (unless appropriate changes or exceptions to the laws are enacted). These lands typically include wilderness areas and national parks and monuments that are readily shown on screening maps. In some cases, such as historical or archaeological sites, the legally dedicated lands are so small in extent that they are more appropriately considered in the location phase.

Data Acquisition Methods. Current land uses within the four study areas, including all areas legally dedicated to uses that are incompatible with a repository, were identified during area characterization in order to assist in location selection. A search of maps, photographs and literature, and contacts with state experts were used to determine potential land use conflicts.

Adequacy of Data. The data obtained from these sources were sufficient for determining present and planned land uses in the area characterization phase.

Screening Specifications. To facilitate location selection, all national parks, national monuments, Indian lands, wilderness areas, and proposed wilderness study areas were designated as potentially unfavorable. These dedicated lands are potentially incompatible with repository development, are easily quantifiable on screening maps, and allow discrimination among or within areas.

4.3 APPLICATION OF SCREENING FACTORS

In each study area, screening maps based on the specifications in Table 4-1 were prepared and combined. Results of this combination are described below.

4.3.1 SALT VALLEY STUDY AREA

In this area, no single salt cycle or layer could be identified because of the extremely complex deformation within the Salt Valley diapiric anticline (Hite, in preparation). Therefore, no assessment of potential site geometry based on depth or thickness of a single salt unit could be made. Depth to top of salt and dedicated lands are the most constraining screens for this area. A map showing depth to top of the deformed salt mass and boundaries of the dedicated lands is shown on Figure 4-1. The minimum depth to the top of the deformed salt mass is 560 feet (in DOE #3 borehole; Woodward-Clyde Consultants, 1979).

Results of further application of the surface fault screen are shown on Figure 4-2. The 5-mile potentially unfavorable zones from mapped surface faults overlap and extend across the entire area of salt less than 3,500 feet deep.

Further application of the borehole screen to the Salt Valley area is shown on Figure 4-3.

4.3.2 LISBON VALLEY STUDY AREA

In this area, potential repository host rock salt units were identified in salt cycles 6 and 9 (Woodward-Clyde Consultants, 1981a). Because screening results for each potential salt unit were similar, results of only salt subunit 6A are presented here. This subunit has the greatest area of potentially favorable depth plus thickness.

The depth-to-salt factor provided a more constraining screen than thickness of salt and was therefore applied first. The screens were combined in the following sequence: depth to salt, thickness of salt, proximity to surface faults, proximity to subsurface faults, and proximity to boreholes. These screens are shown on Figures 4-4, 4-5, 4-6, 4-7, and 4-8, respectively. No dedicated lands are present in this area. The potentially favorable area defined by depth and thickness screens is completely covered by potentially unfavorable areas related to proximity to surface faults and boreholes.

4.3.3 GIBSON DOME STUDY AREA

In this area a potential repository host rock salt unit was identified in salt cycle 6 (Woodward-Clyde Consultants, 1981a), although other salt beds below salt cycle 6 also may be suitable. The depth-to-salt factor provided a more constraining screen than thickness of salt, and was therefore applied first. The screens were combined as follows: depth to salt, thickness of salt, proximity to surface faults, proximity to subsurface faults, proximity to boreholes, and areas of dedicated lands. These

screens are shown on Figures 4-9, 4-10, 4-11, 4-12, 4-13, and 4-14, respectively. The potentially favorable areas defined by depth and thickness of salt that are also free from potentially unfavorable conditions related to faults and boreholes and dedicated lands are shown on Figure 4-14.

4.3.4 ELK RIDGE STUDY AREA

In this area potential repository host rocks salt units were identified in salt cycles 6 and 9 (Woodward-Clyde Consultants, 1981a). The thickness-of-salt factor provided a more constraining screen than depth to salt, and was therefore applied first.

For salt cycle 6, the screens were combined as follows: thickness of salt, depth to salt, proximity to surface faults, proximity to boreholes, and areas of dedicated lands. These screens are shown on Figures 4-15, 4-16, 4-17, 4-18, and 4-19, respectively. Available data regarding subsurface faults were not sufficient to prepare a screen showing proximity to subsurface faults. The potentially favorable areas of salt cycle 6 defined by thickness and depth of salt that are also free of potentially unfavorable conditions related to faults, boreholes, and dedicated lands are shown on Figure 4-19.

For salt cycle 9, the thickness and depth screens are shown on Figures 4-20 and 4-21, respectively. A combination of Figure 4-21 with the remaining screens applied also to salt cycle 6 is shown on Figure 4-22. Potentially favorable areas for salt cycle 9 partly overlap the similar area for salt cycle 6, as shown in Figure 4-23.

4.4 IDENTIFICATION OF LOCATIONS

By examining the screen maps on Figures 4-1 through 4-23, it is evident that no part of areas of potentially favorable salt depth and thickness in the Salt Valley and Lisbon Valley areas are also free from potentially unfavorable conditions related to faults, boreholes, and dedicated

lands. By contrast, the Gibson Dome and Elk Ridge areas do contain such parcels. Gibson Dome has one such area of 57 square miles (Figure 4-24); Elk Ridge has one large area and several smaller areas (Figure 4-23). The smaller areas are each less than 3 square miles and are not large enough to contain a repository. The larger area totals 6 square miles.

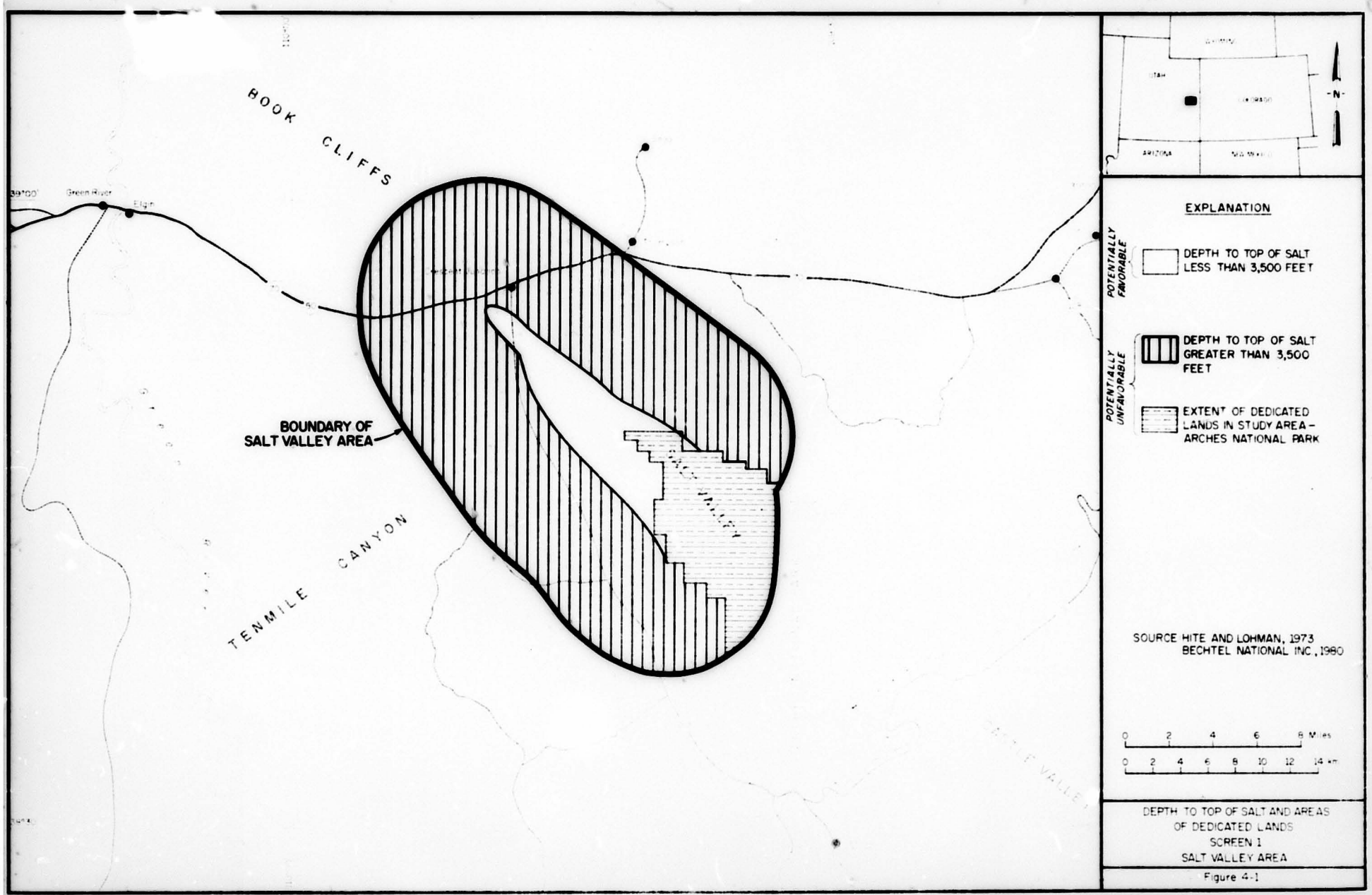
On the basis of the above described conditions, one location is designated at Gibson Dome, composed of the one 57-square-mile area resulting from screening. One location is also designated at Elk Ridge, composed of a 6-square-mile area resulting from screening. These designated locations are shown on topographic maps on Figures 4-24 and 4-25.

The remainder of the four study areas not designated as locations is held in reserve; further study of these areas is deferred. These areas may be reconsidered in light of newly acquired data or changes in the state of the art, screening specifications, repository design, or federal regulations.

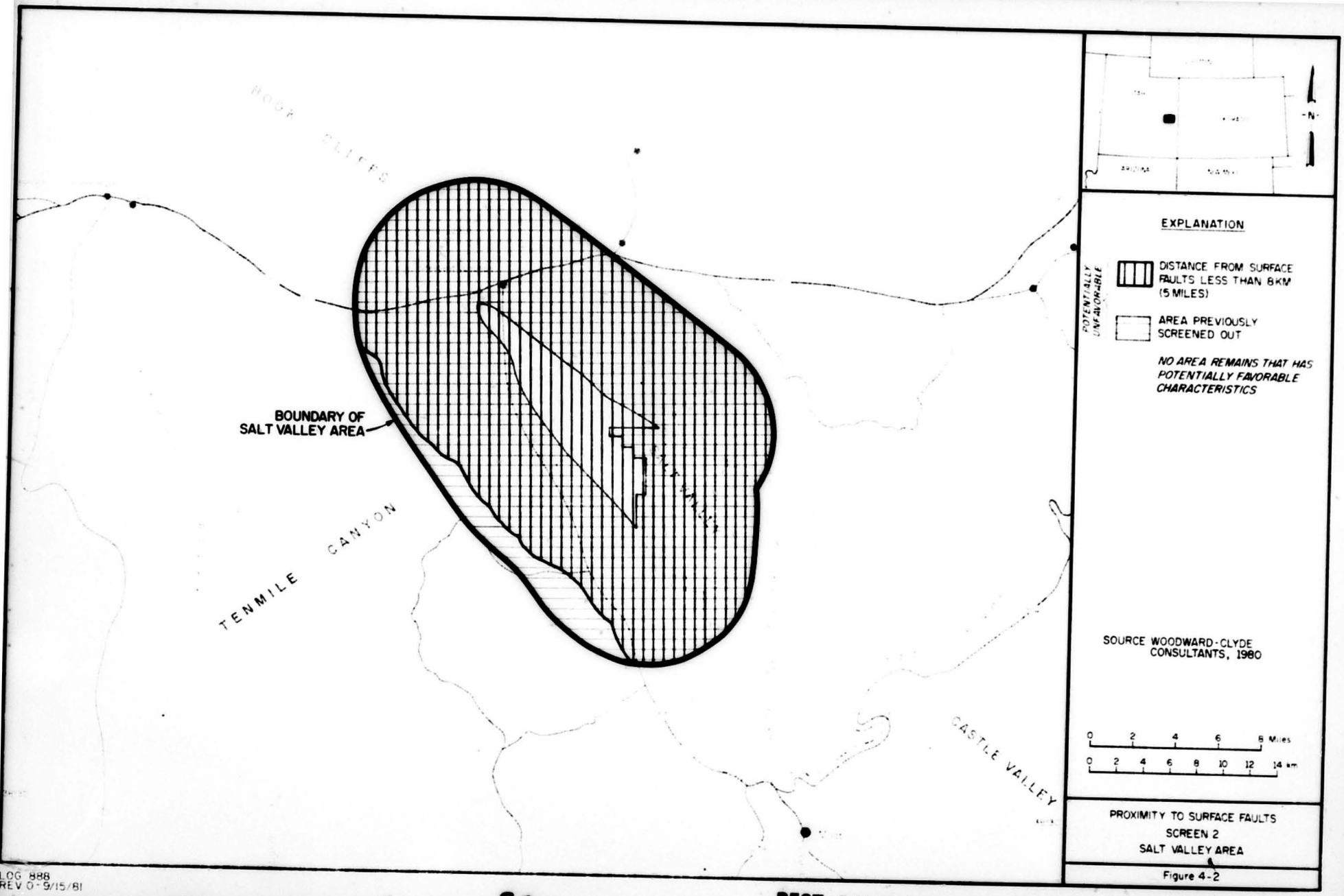
Table 4-1

SCREENING SPECIFICATIONS

Screening Factor	Applicable NWTS Criterion (see Table 2-1)	Specification
1. Depth to salt	I. Site Geometry	Minimum favorable depth to salt is 1,000 feet; all shallower beds were avoided. Maximum favorable depth to salt is 3,500 feet; all deeper beds were avoided.
2. Thickness of salt	I. Site Geometry	Thicknesses of 100 percent halide lithology greater than 70 geet thick are favorable; all other thicknesses were avoided.
3. Proximity to faults	V. Tectonic Environment	Lands within 8 kilometers of mapped surface faults were avoided; lands within 2 kilometers of surface projections of subsurface faults were avoided.
4. Proximity to boreholes	VI. Human Intrusion	Lands within 2 kilometers of boreholes were avoided.
5. Legally dedicated lands	IX. Environmental Protection	National parks, national monuments, wilderness study areas and Indian lands were avoided.



LOG 887
REVO-10/30/81



PROXIMITY TO SURFACE FAULTS
SCREEN 2
SALT VALLEY AREA

Figure 4-2

LOG 888
REV 0 - 9/15/81

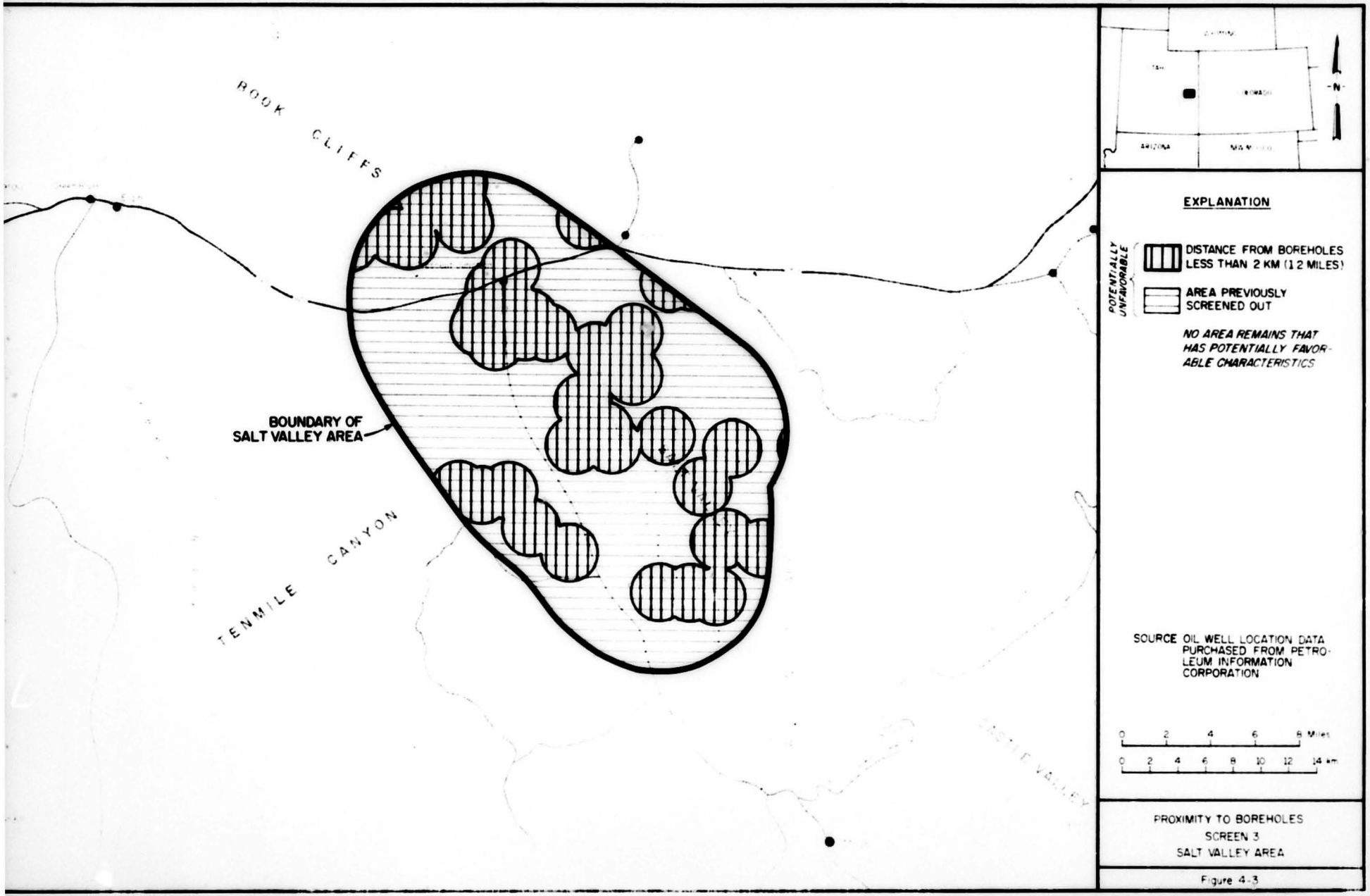


Figure 4-3

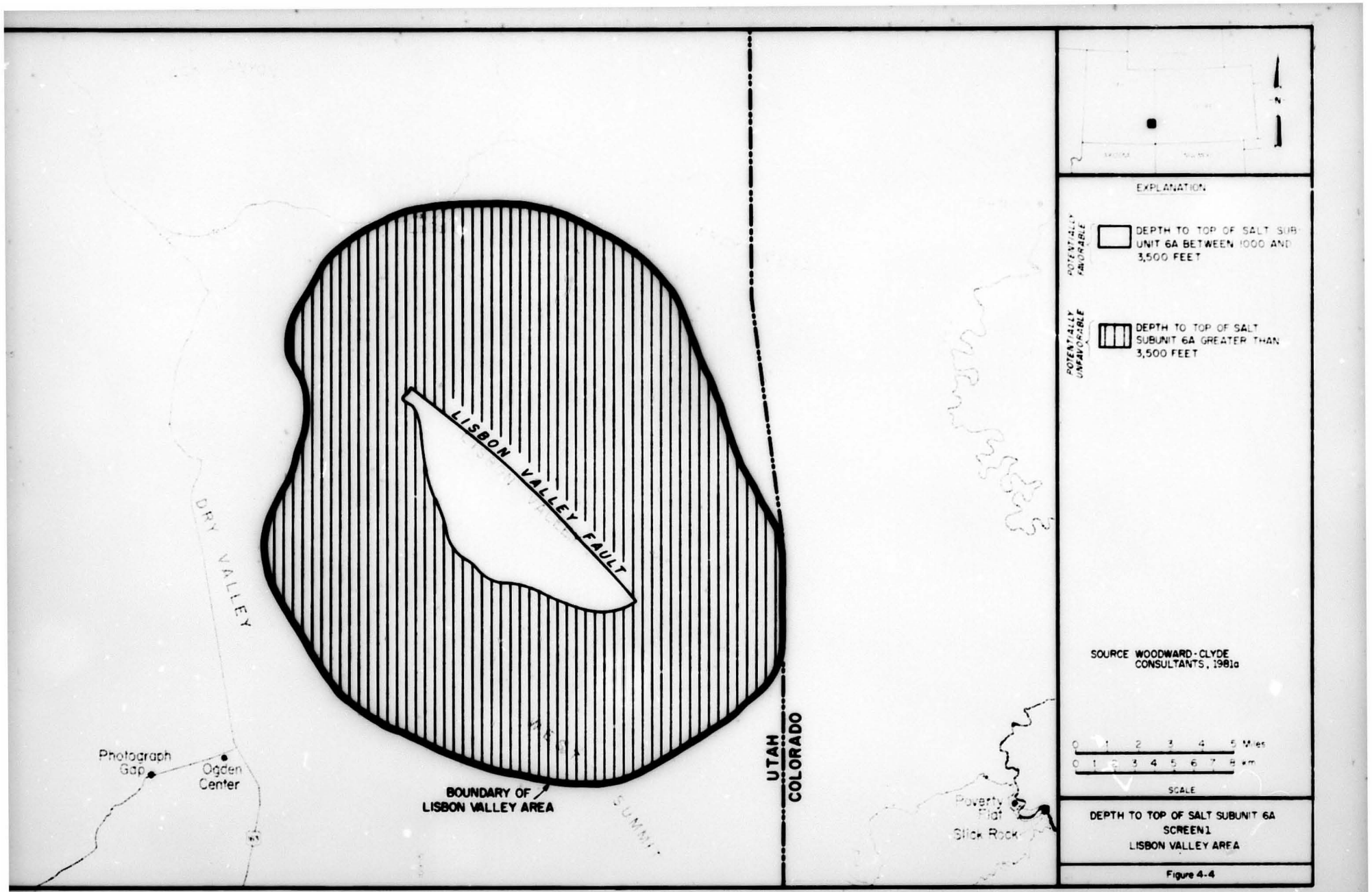


Figure 4-4

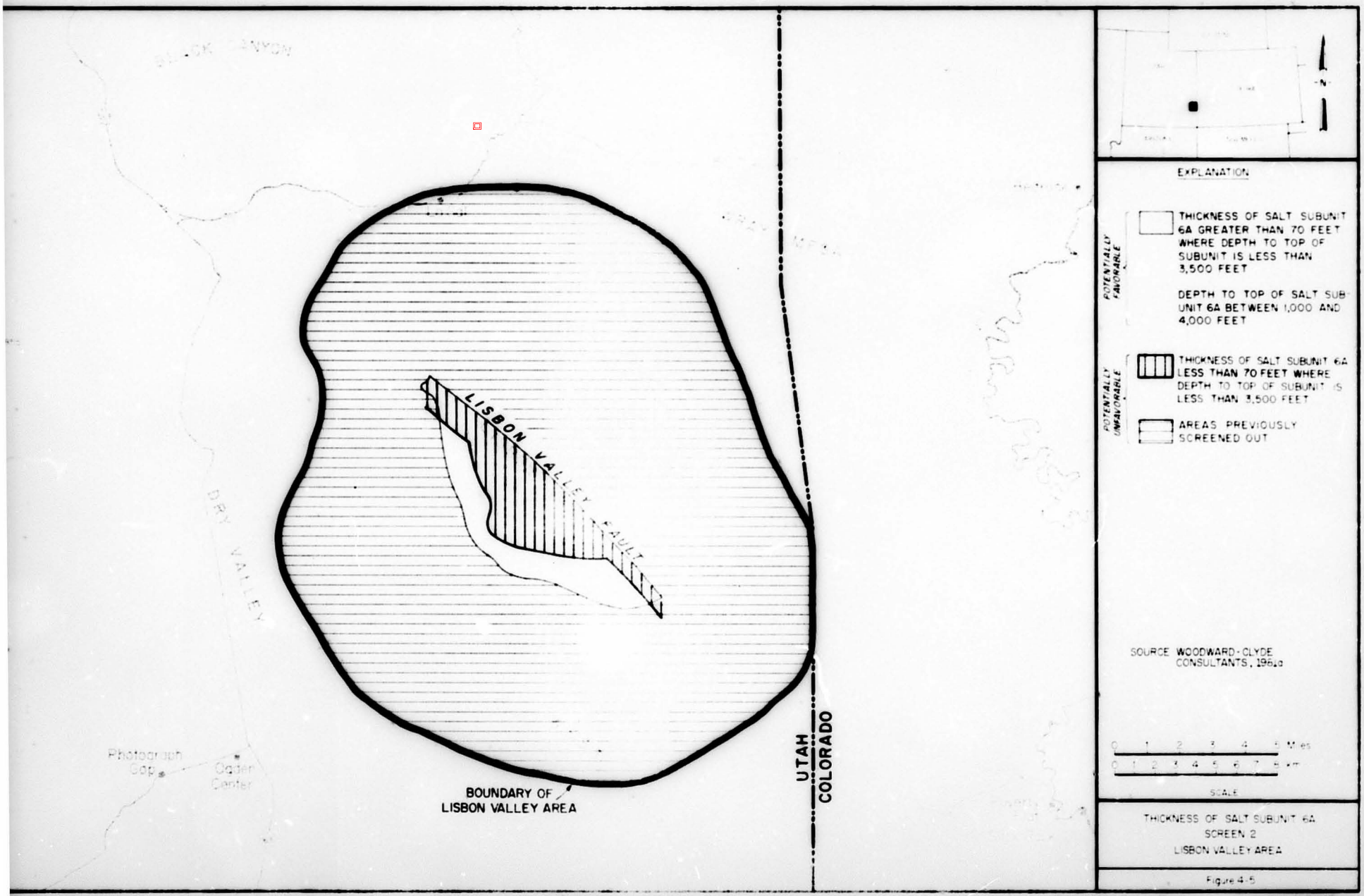
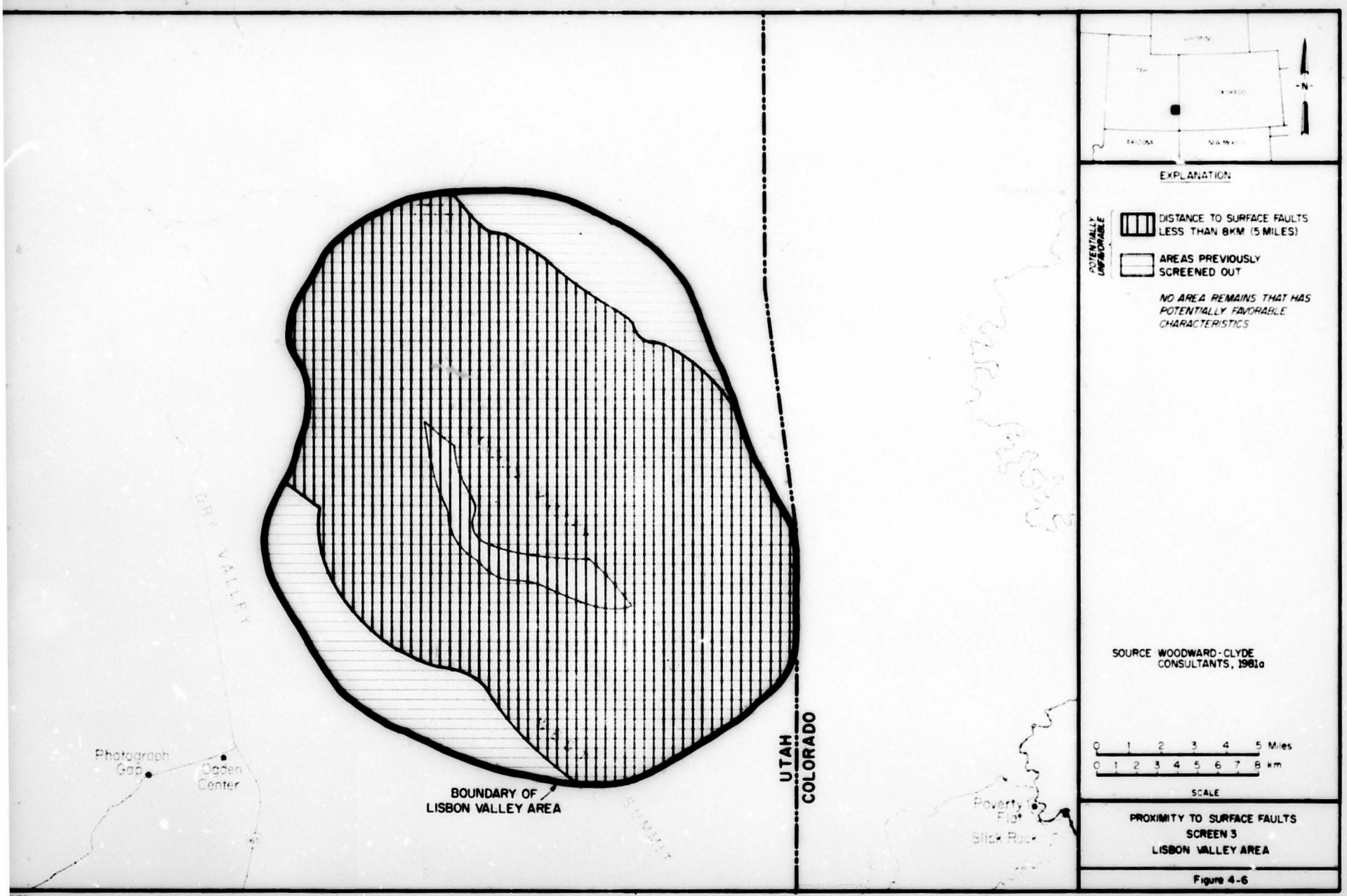


Figure 4-5



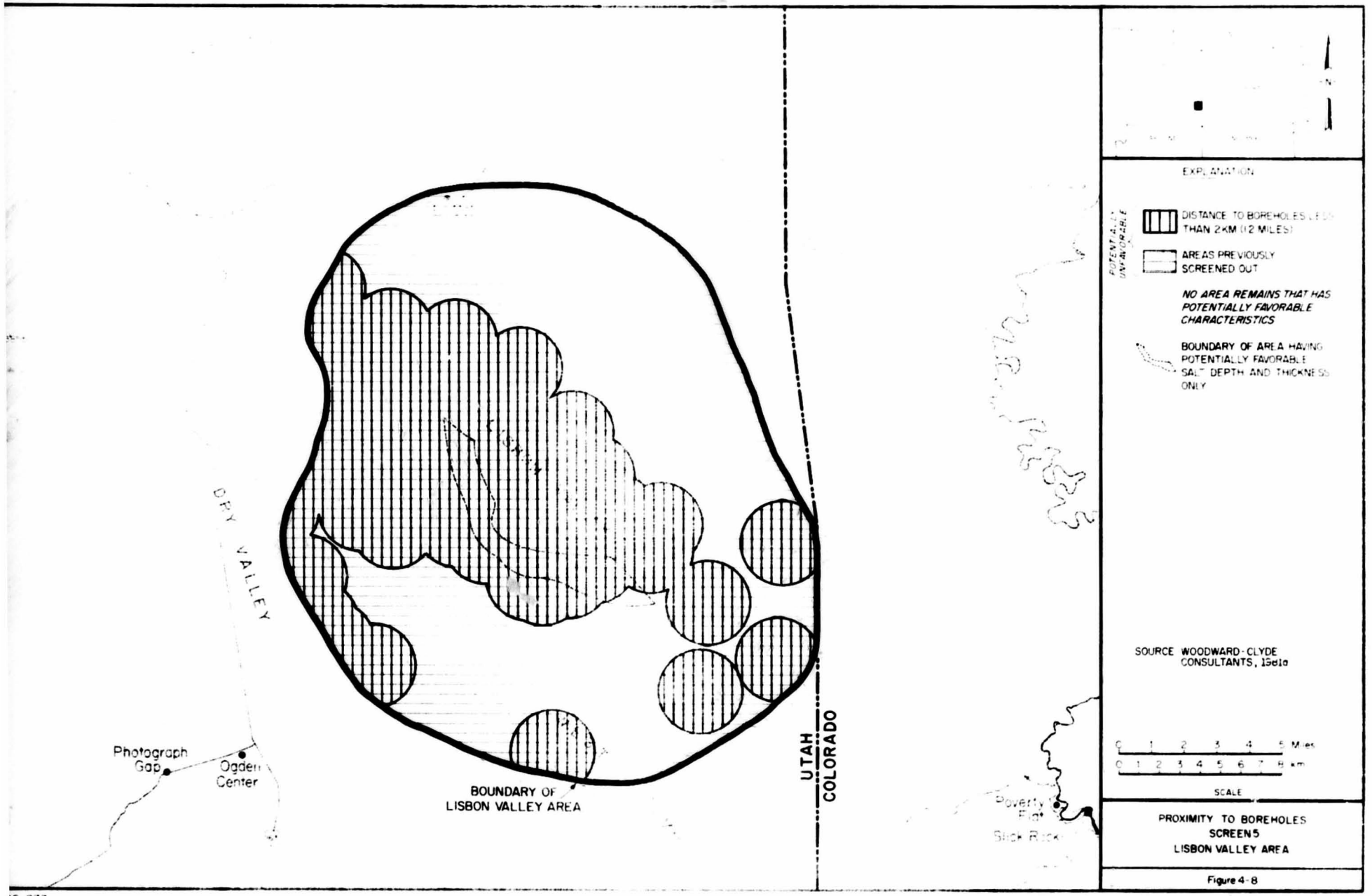
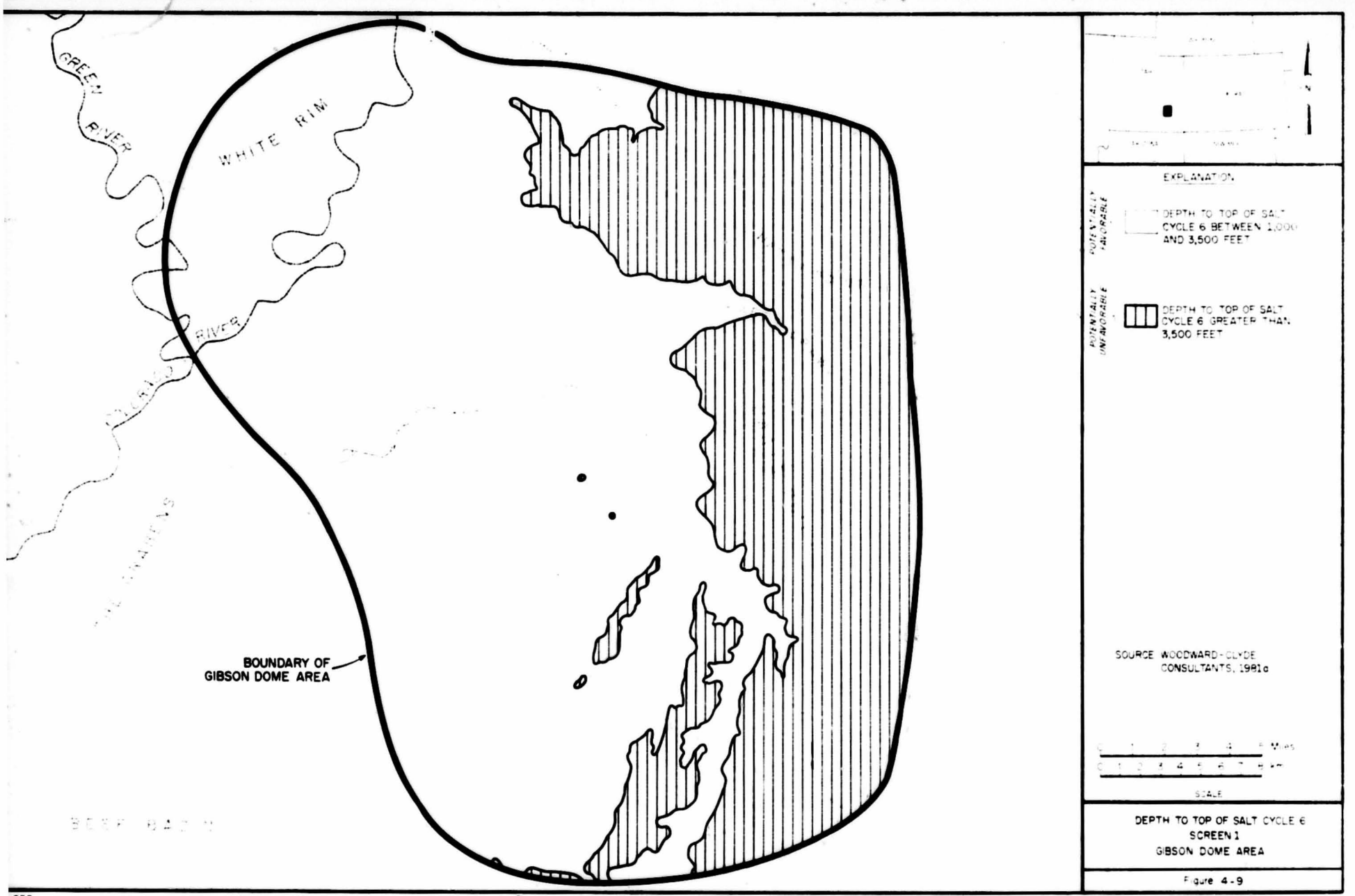
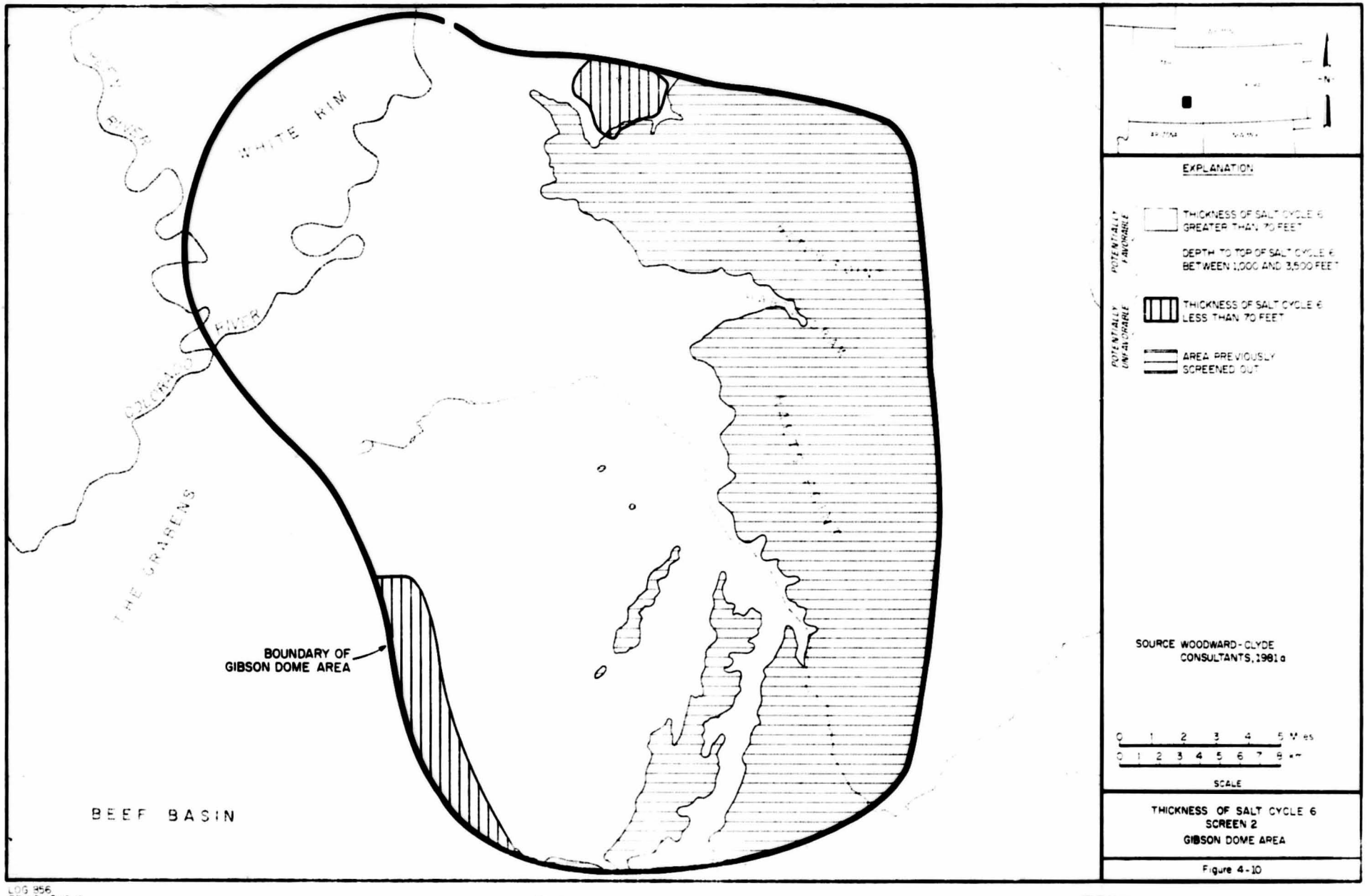
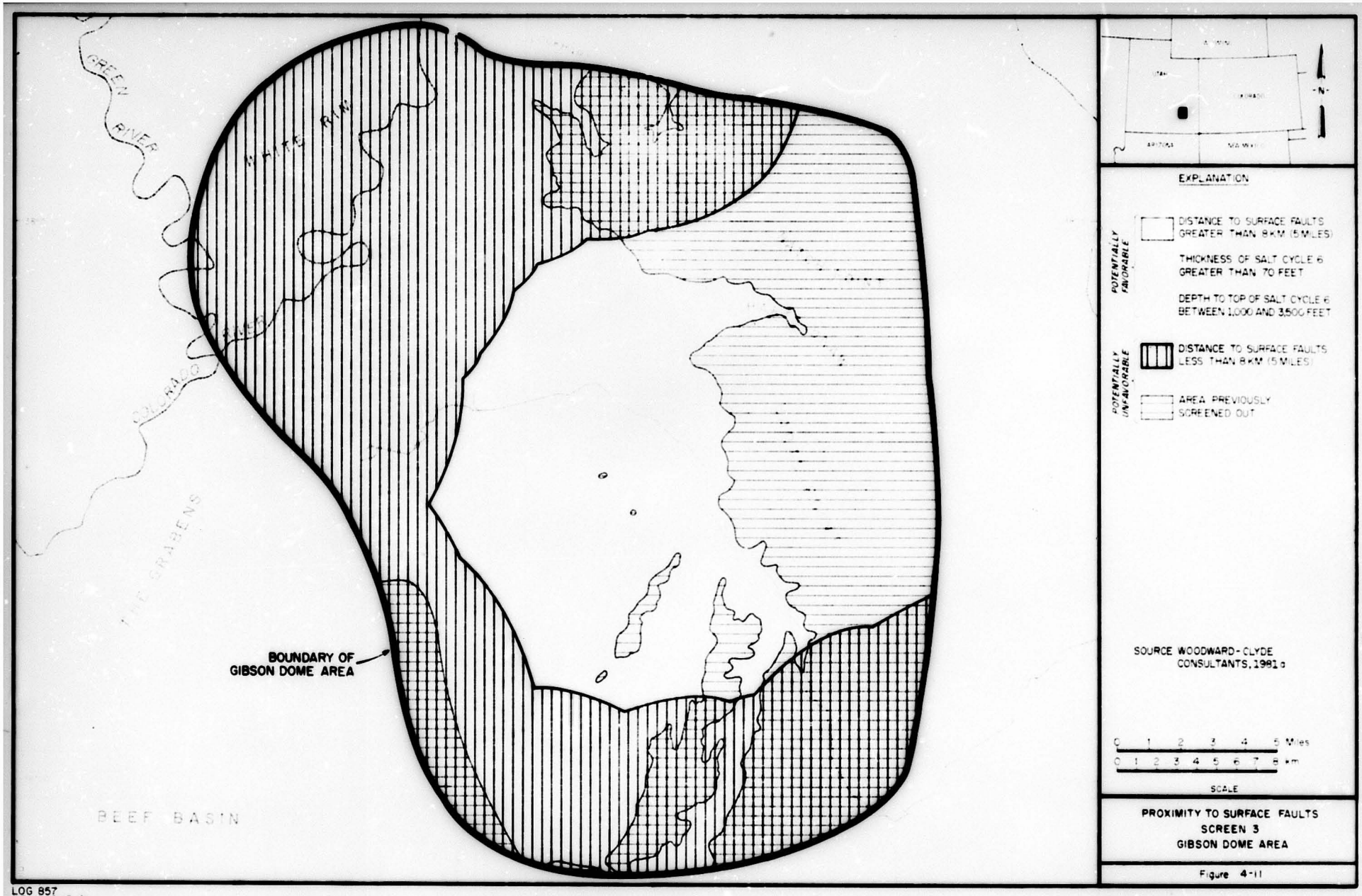


Figure 4-8





LOG 856
REV 0 - 9/15/81



LOG 857
REV 0-9/15/81

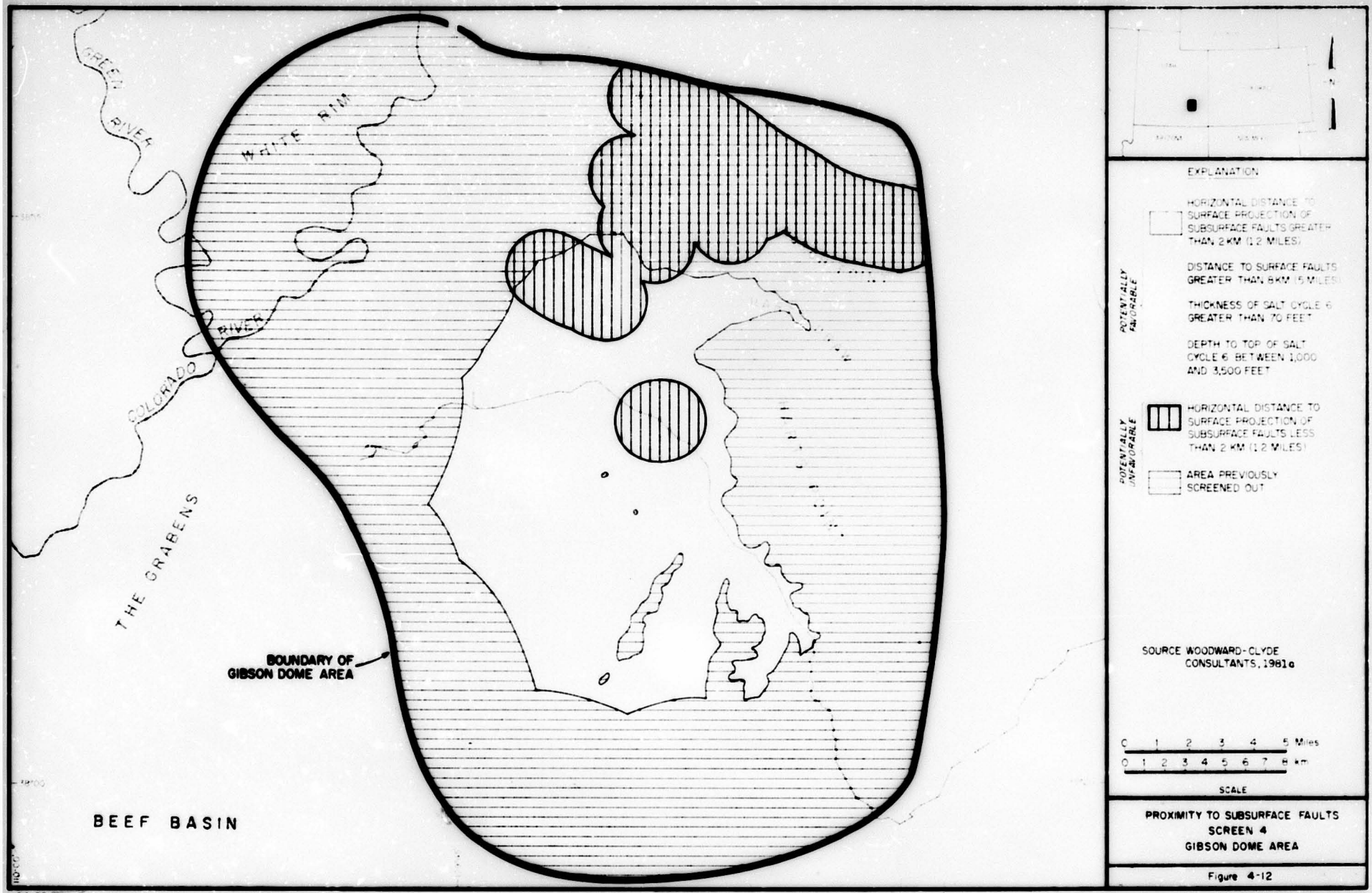
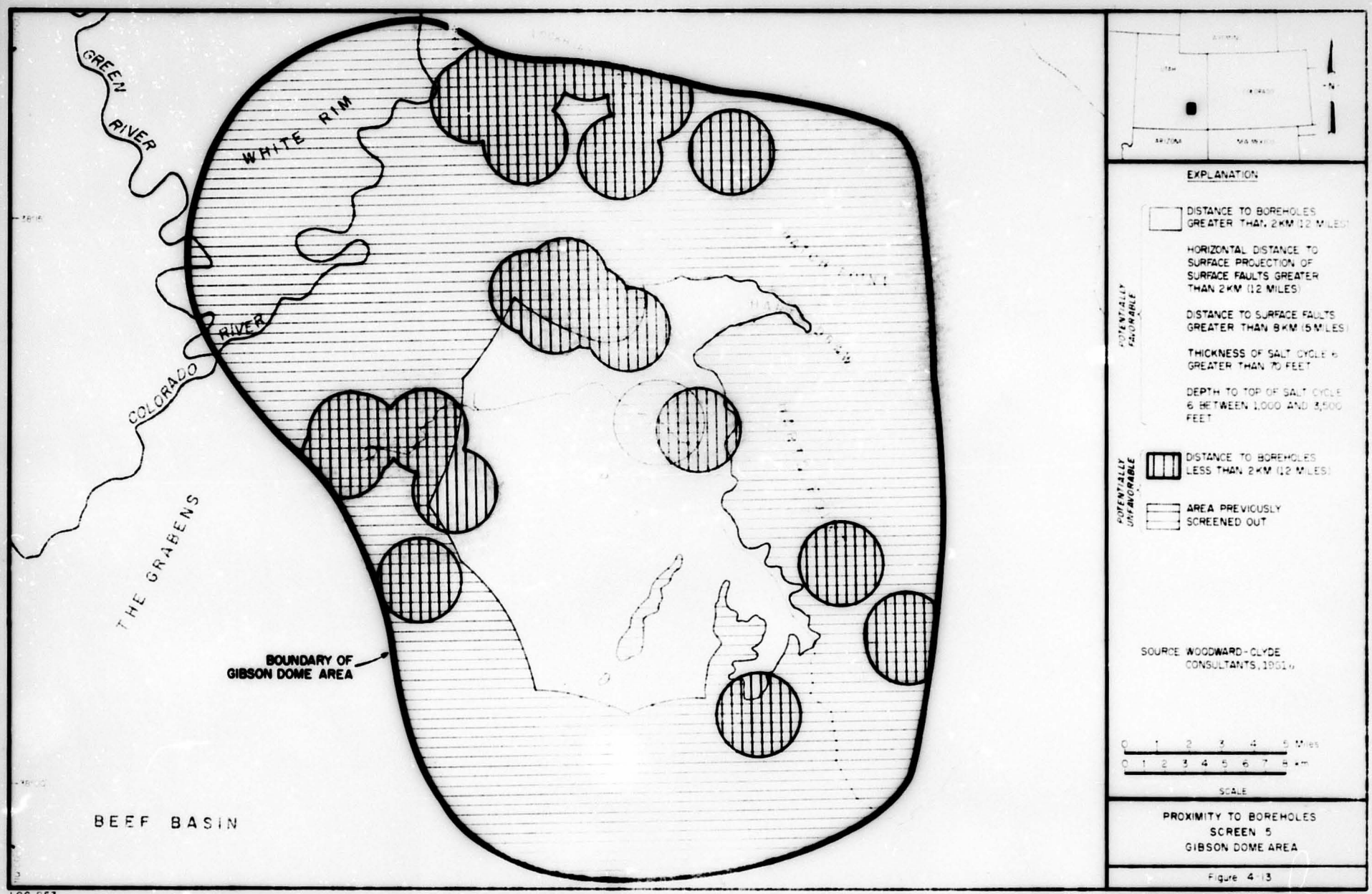
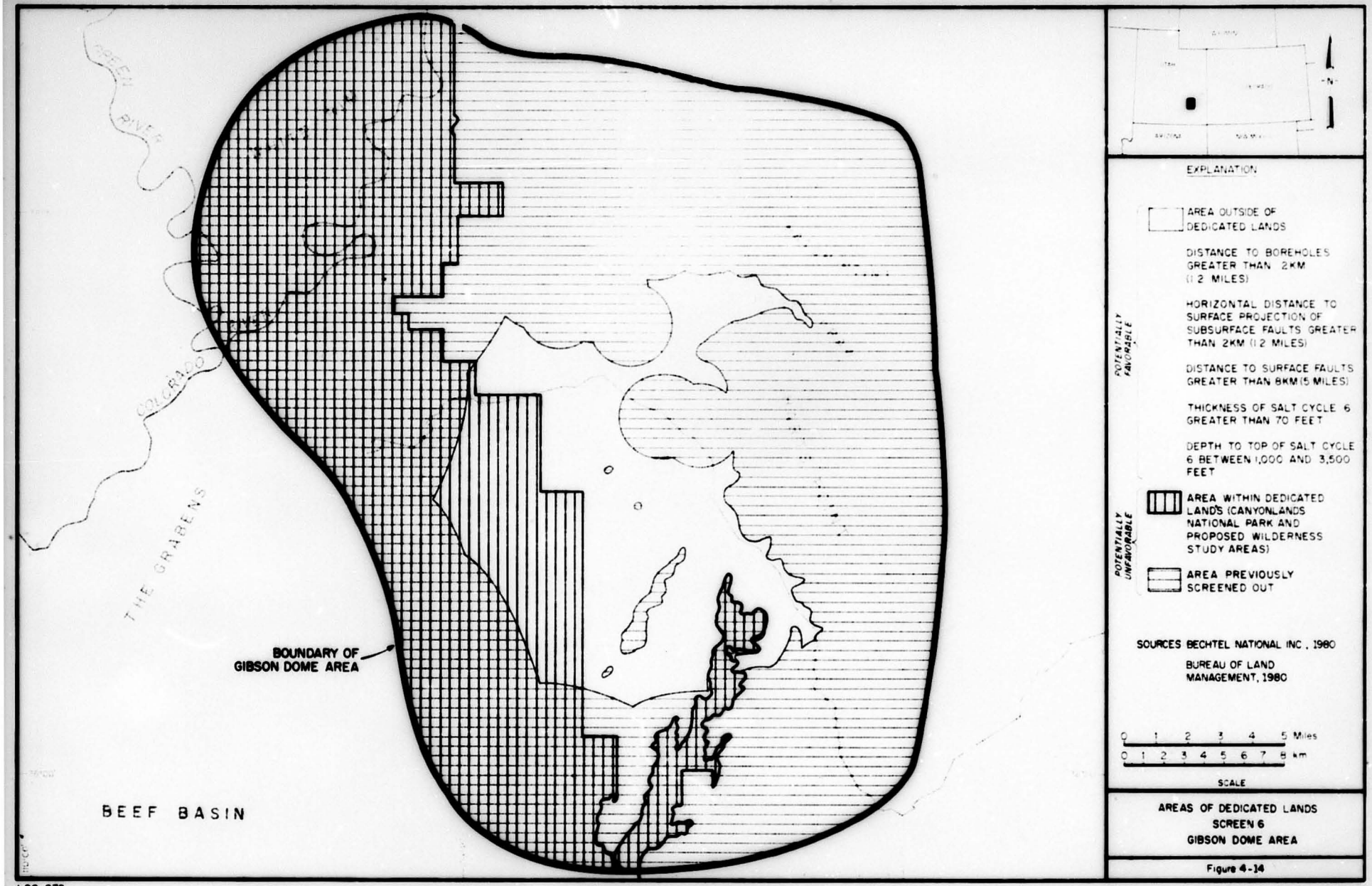


Figure 4-12

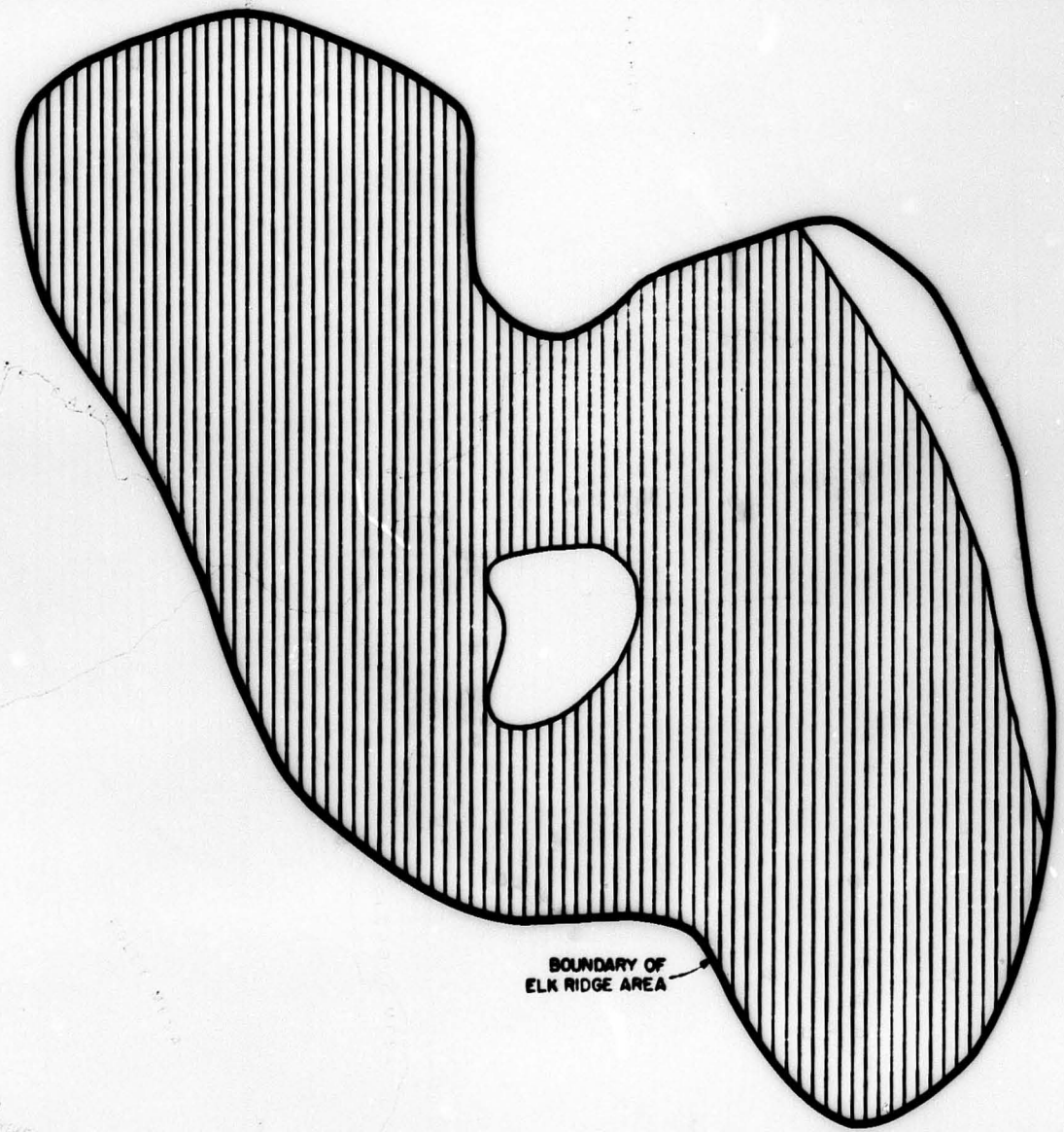
LOG 854
REV 0-9/15/81

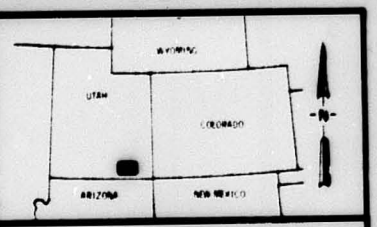


LOG 653
REV 0-9/15/81



LOG 872
REV 0 - 9/15/81





EXPLANATION

POTENTIALLY FAVORABLE

THICKNESS OF SALT CYCLE 6 GREATER THAN 70 FEET

POTENTIALLY UNFAVORABLE

THICKNESS OF SALT CYCLE 6 LESS THAN 70 FEET

SOURCE: WOODWARD-CLYDE CONSULTANTS, 1980

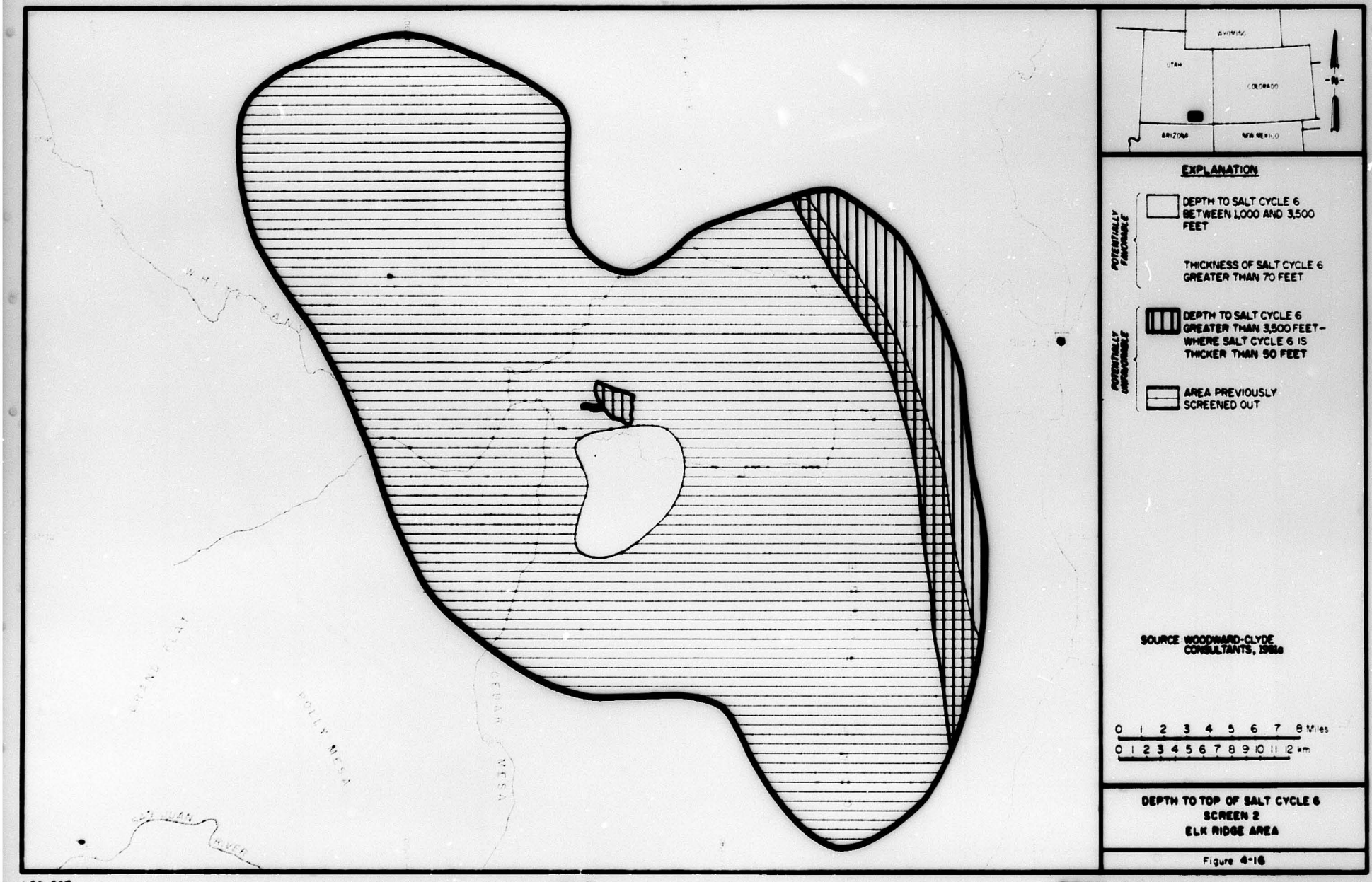
0 1 2 3 4 5 6 7 8 Miles

0 1 2 3 4 5 6 7 8 9 10 11 12 km

THICKNESS OF SALT CYCLE 6
SCREEN I
ELK RIDGE AREA

Figure 4-15

LOG 866
REV 0-9/15/81



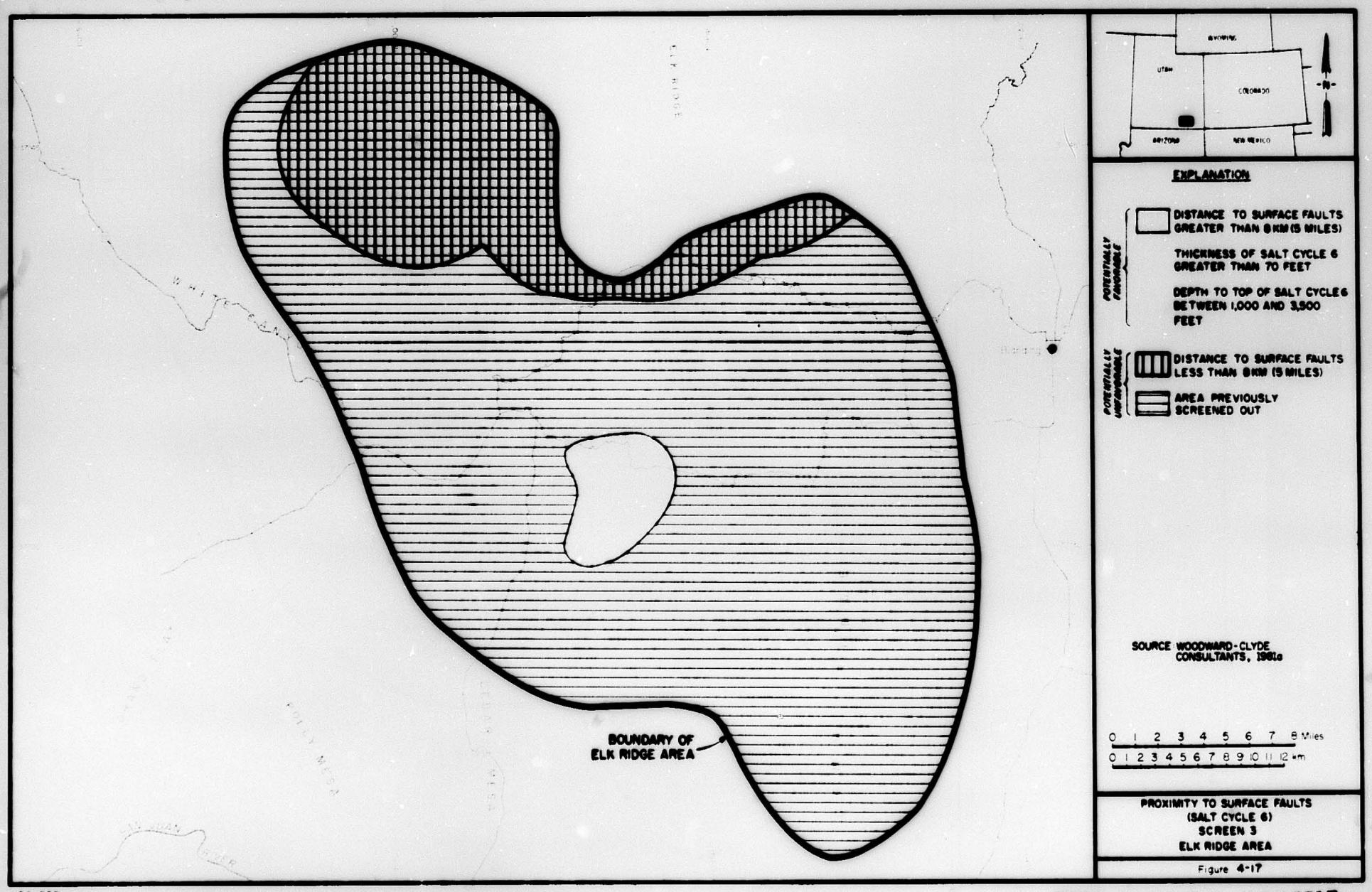
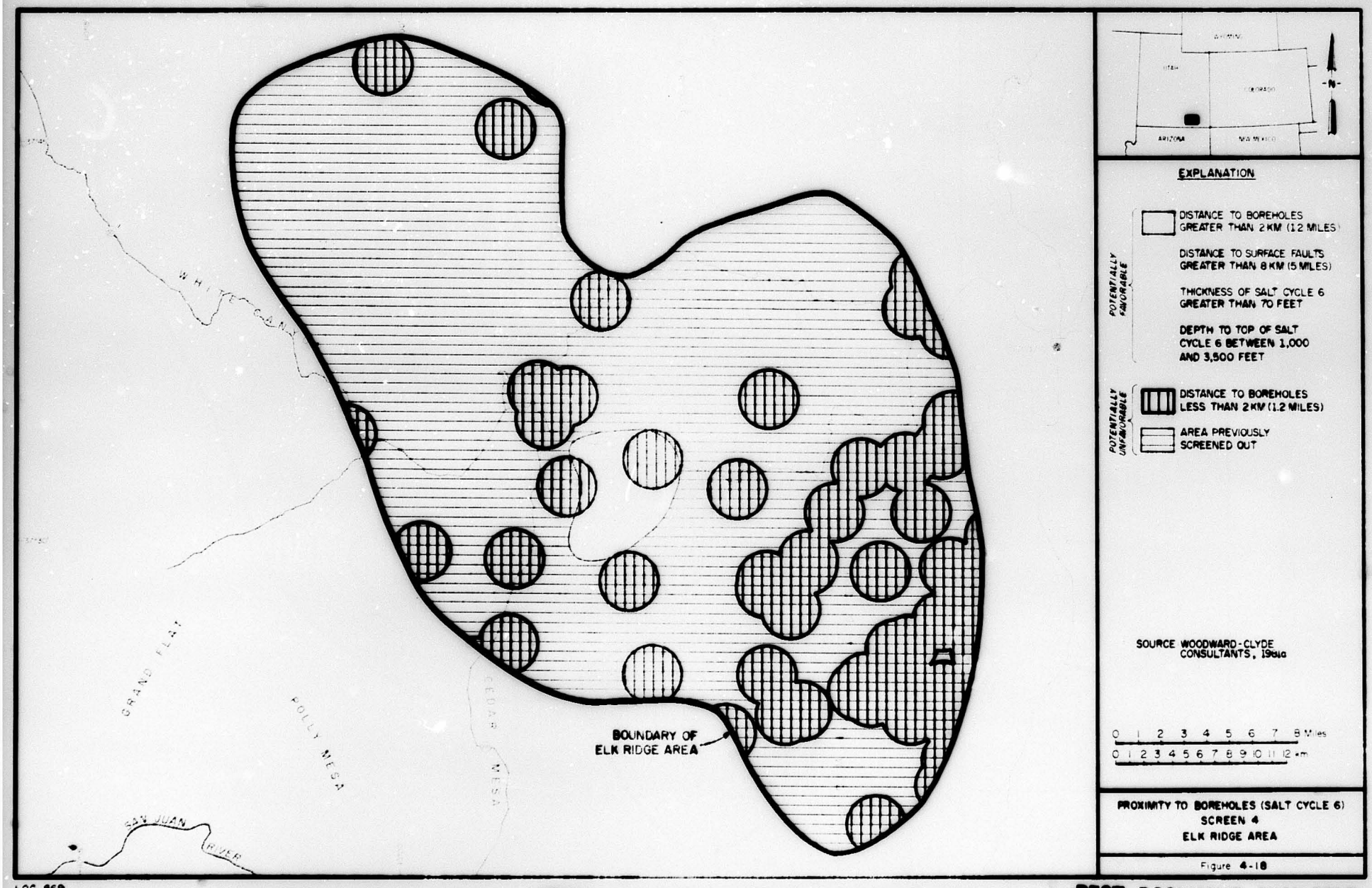


Figure 4-17

LOG 868
REV 0 - 9/15/81



PROXIMITY TO BOREHOLES (SALT CYCLE 6)
SCREEN 4
ELK RIDGE AREA

Figure 4-18

LOG 869
REV 0-9/15/81

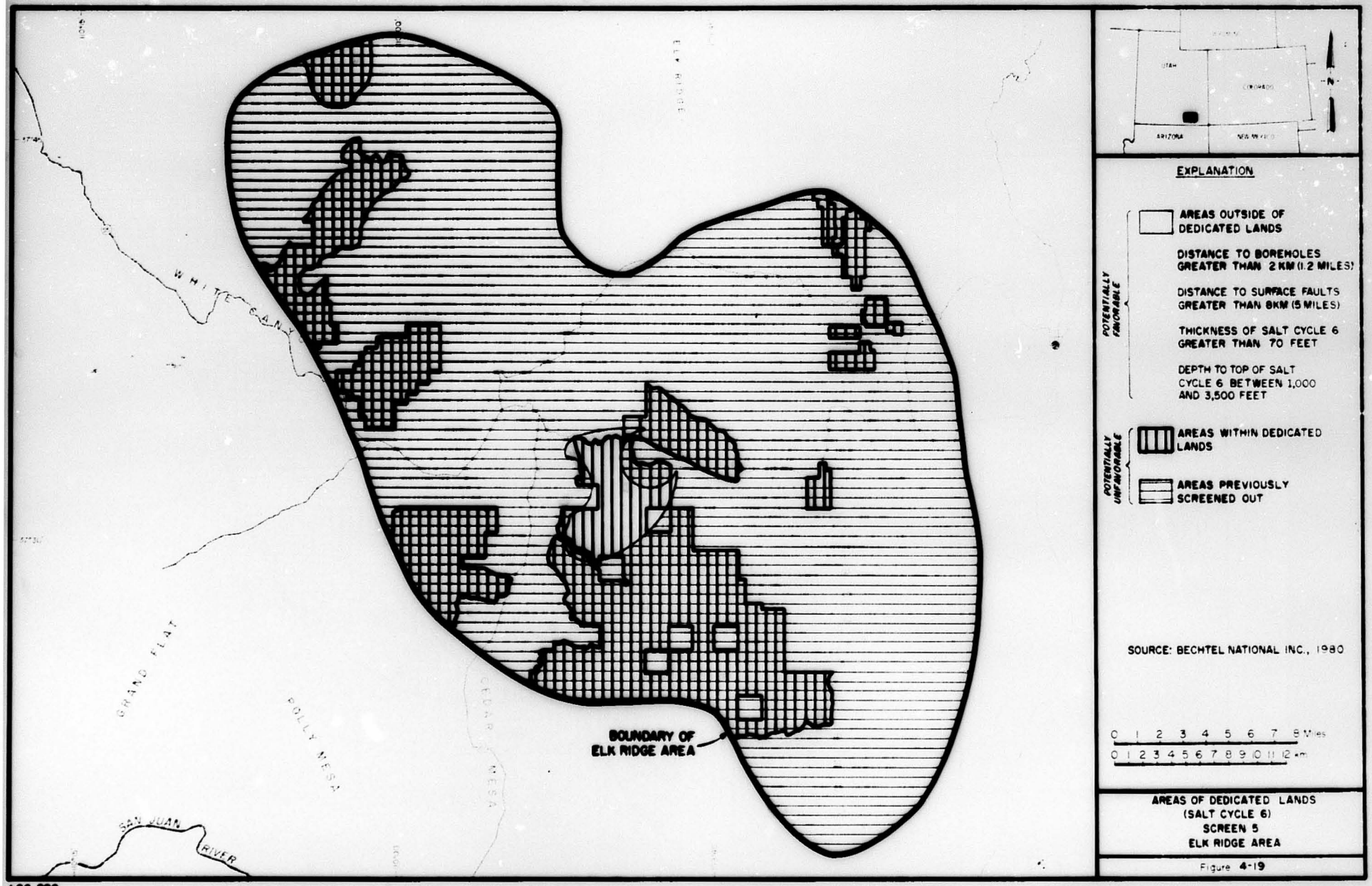
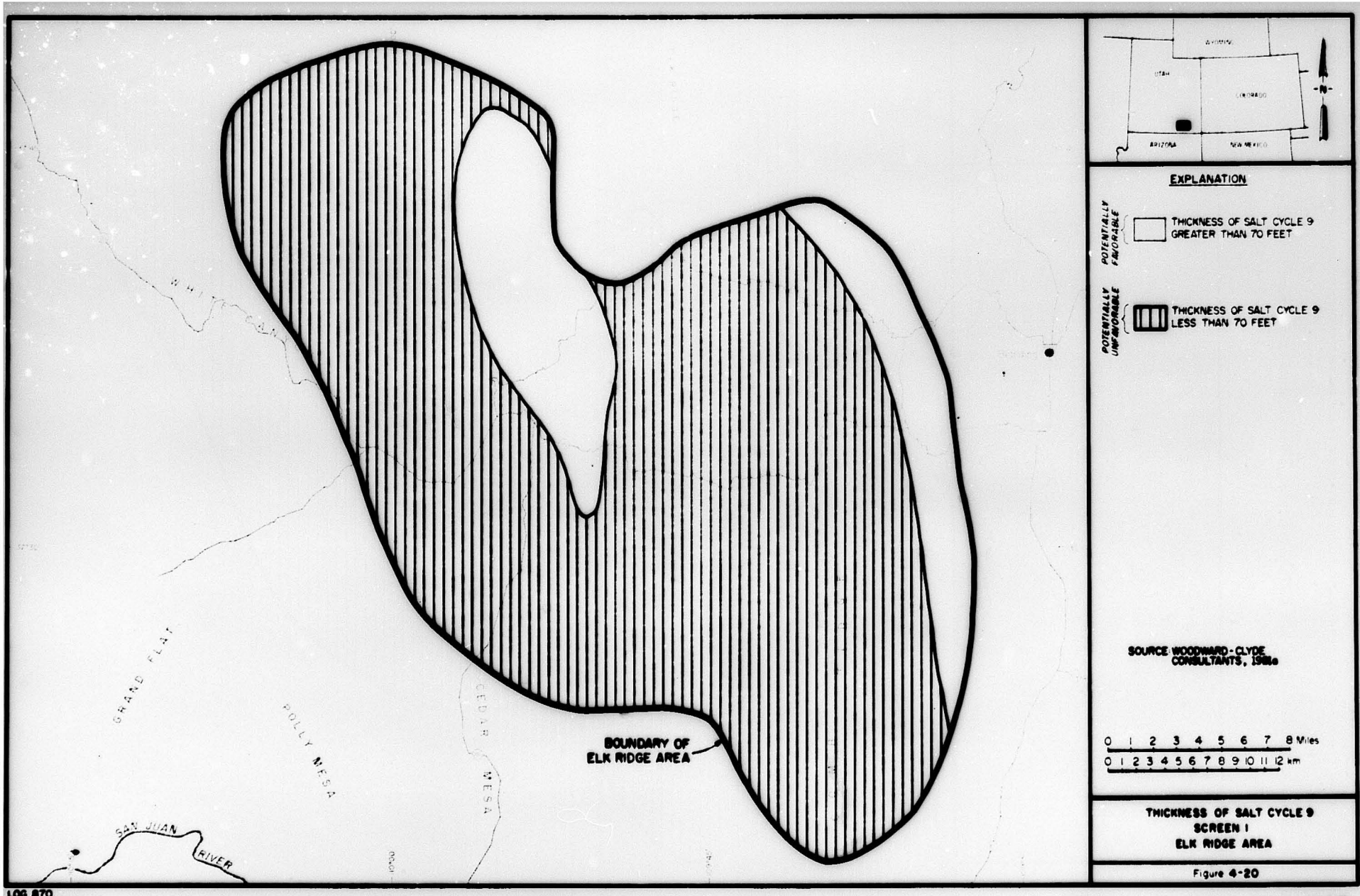


Figure 4-19

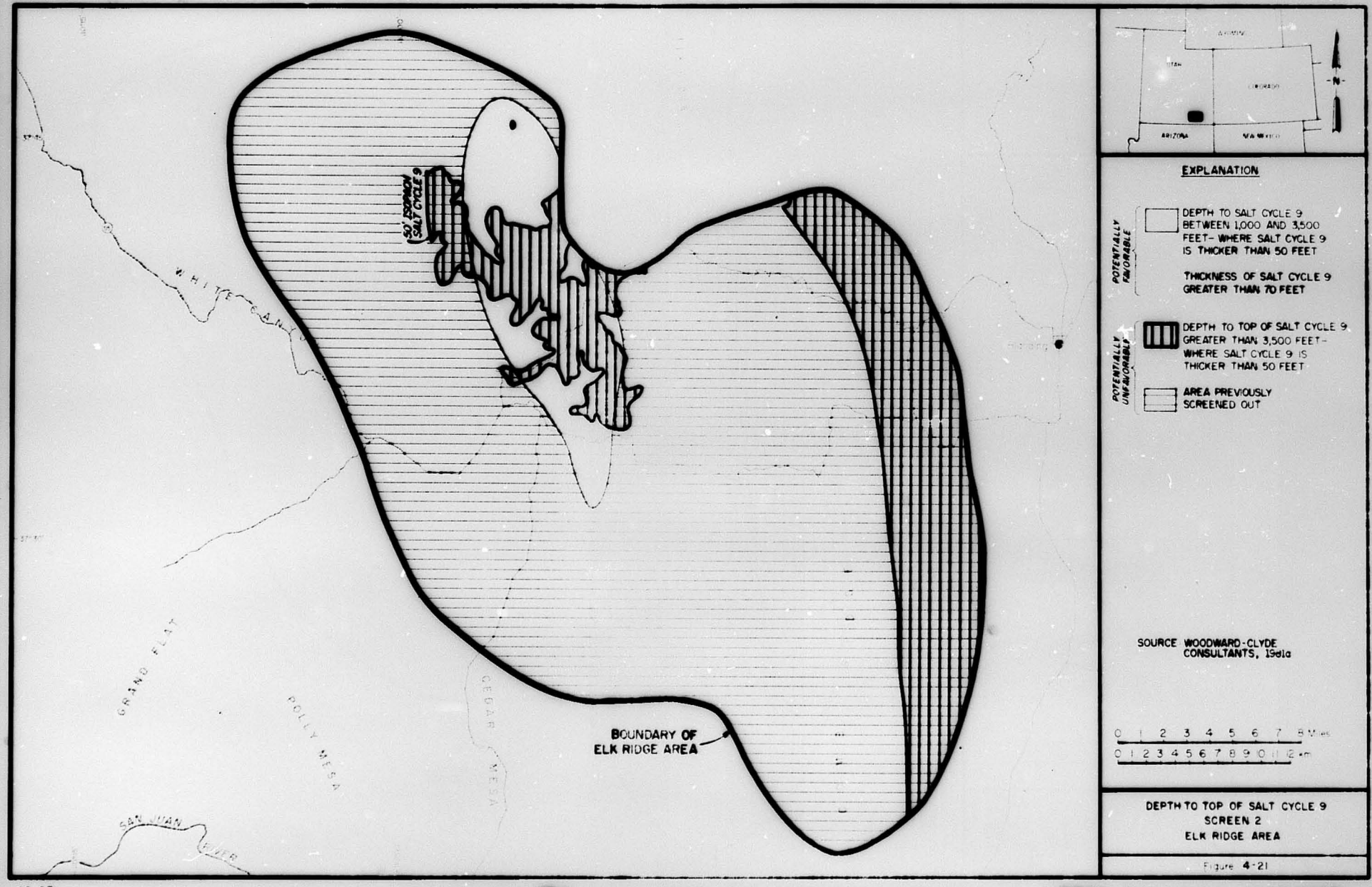
LOG 020
REV. 0 - 9/15/81



THICKNESS OF SALT CYCLE 9
SCREEN I
ELK RIDGE AREA

Figure 4-20

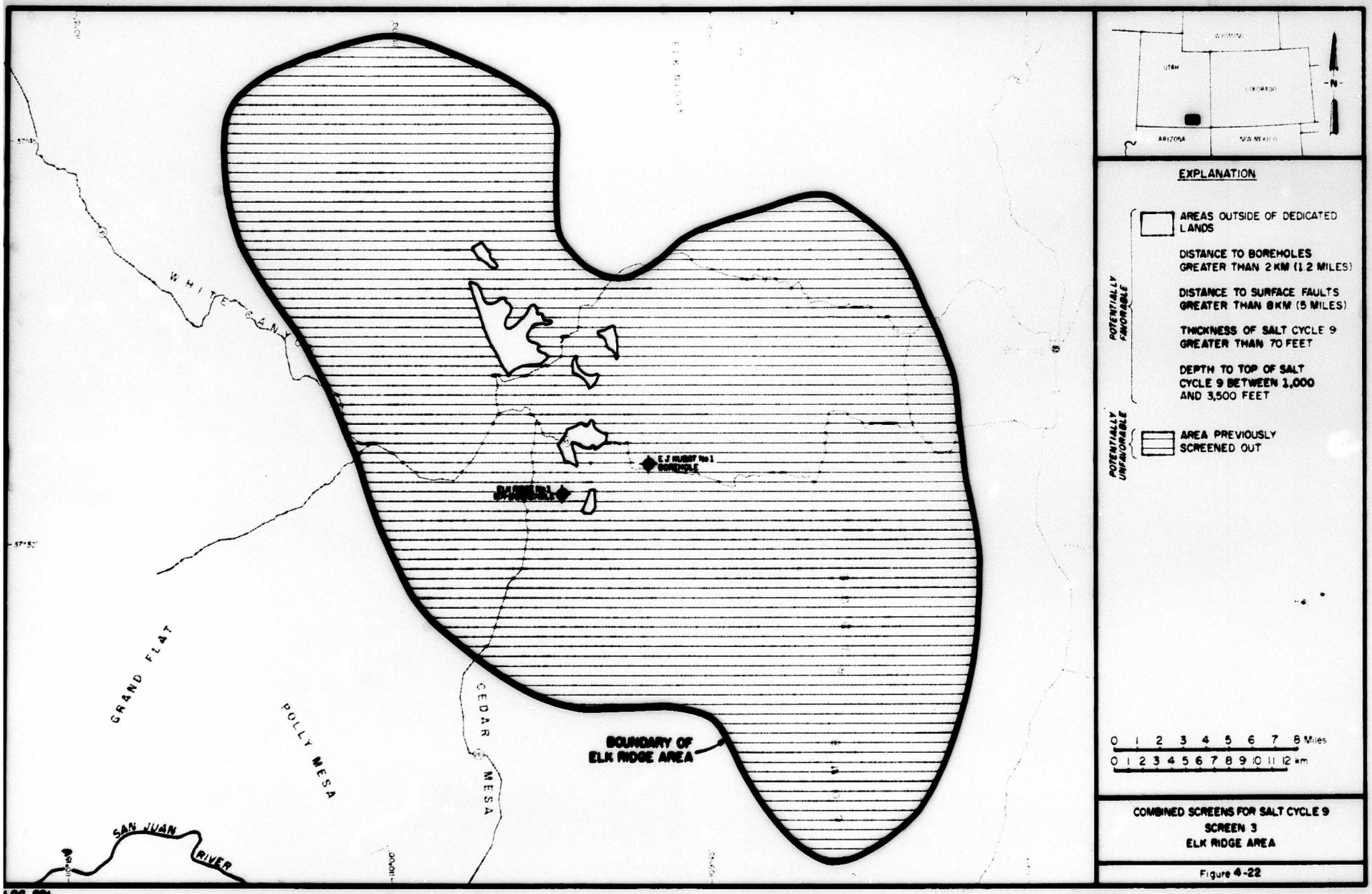
LOG 870
REV 0 - 9/17/81



DEPTH TO TOP OF SALT CYCLE 9
SCREEN 2
ELK RIDGE AREA

Figure 4-21

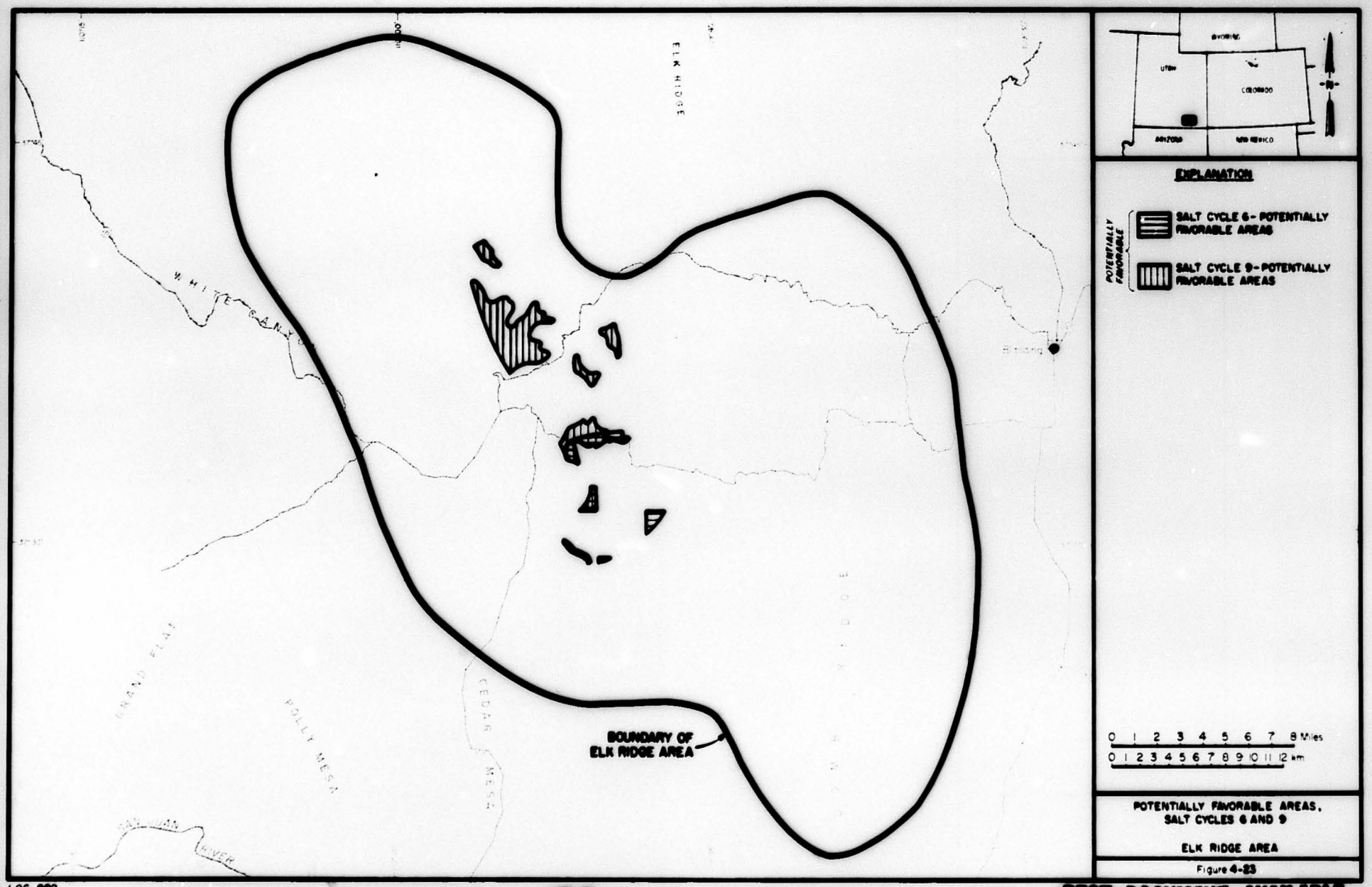
LOG 871
REV 0-9/15/81



COMBINED SCREENS FOR SALT CYCLE 9
SCREEN 3
ELK RIDGE AREA

Figure 4-22

LOS 251
REV 0-9/19/91

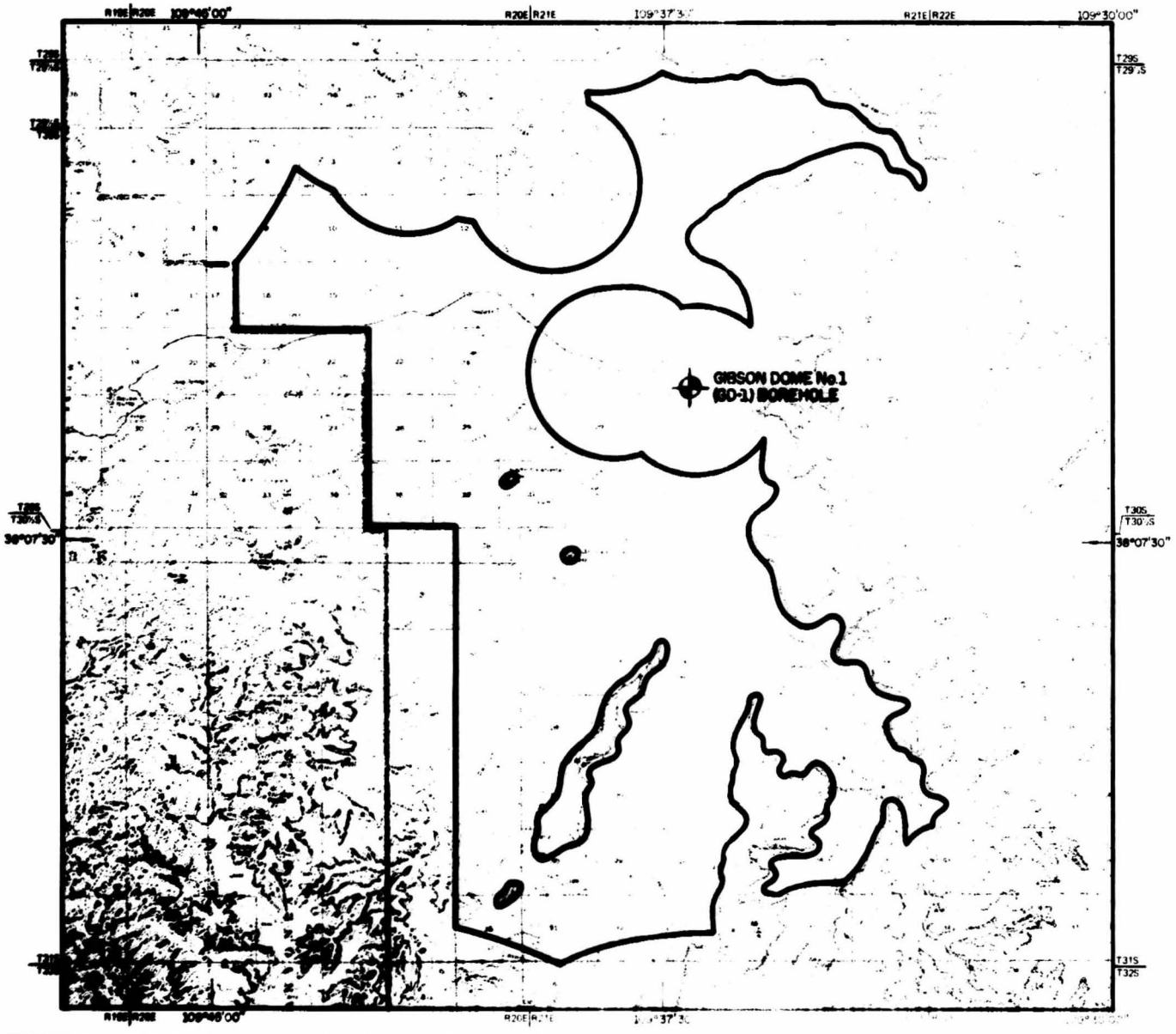


POTENTIALLY FAVORABLE AREAS, SALT CYCLES 6 AND 9

ELK RIDGE AREA

Figure 4-23

LOG 892
REV 0-9/15/81



EXPLANATION

BOUNDARY OF DESIGNATED LOCATION

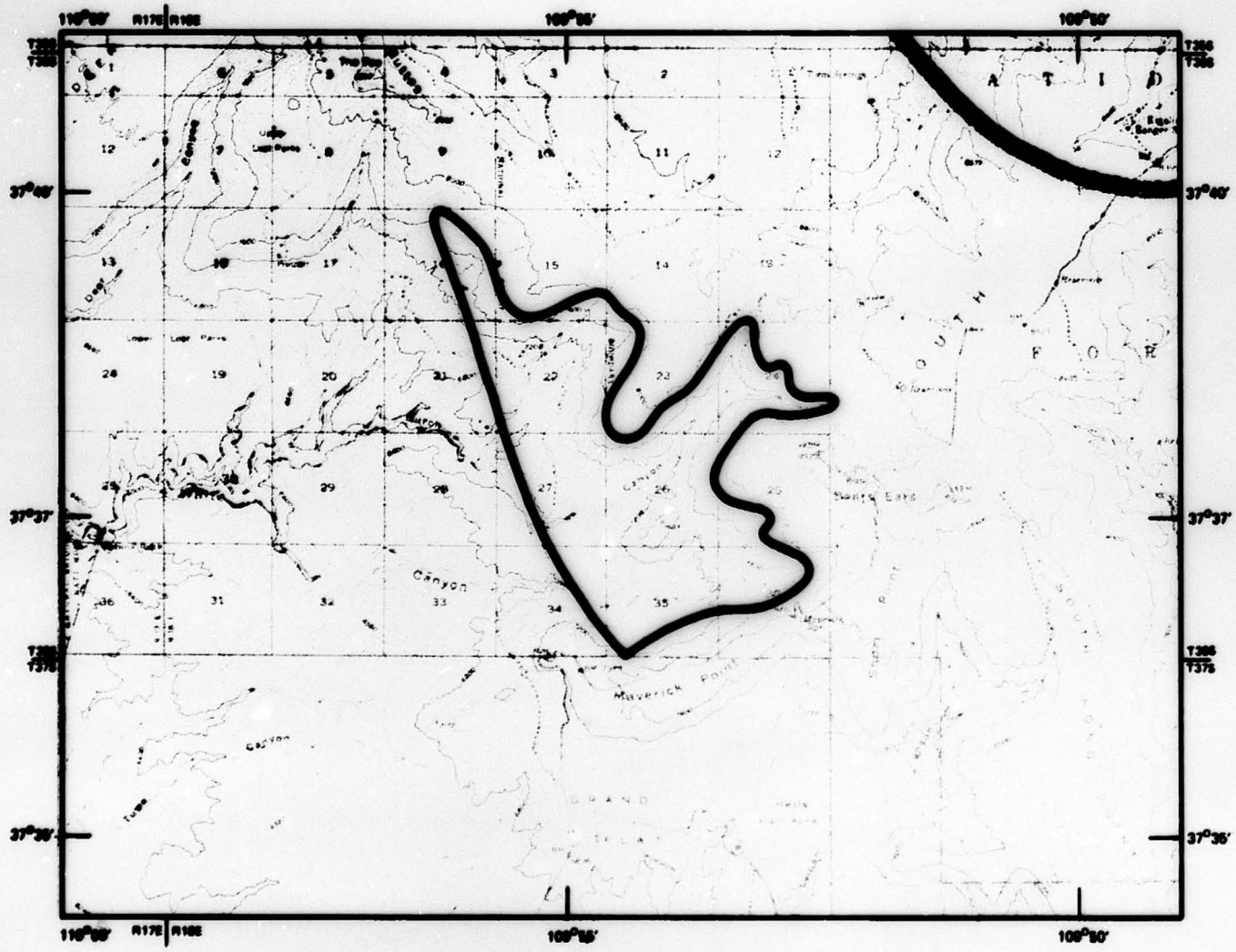
0 1 2 3 Miles

0 1 2 3 4 5 km

DESIGNATED GIBSON DOME LOCATION

Figure 4-24

LOG 888
REV. 0-20/30/91



EXPLANATION

BOUNDARY OF DESIGNATED LOCATION

0 1 2 Miles

0 1 2 3 km

DESIGNATED ELK RIDGE LOCATION

Figure 4-25

LOG 894
REV.0-10/30/81

Chapter 5

RECOMMENDATION OF PREFERRED LOCATION

The screening process by which the Gibson Dome and Elk Ridge location boundaries were delineated was described in Chapter 4. The two designated locations are shown in Figures 4-24 and 4-25. Chapter 5 compares and contrasts the characteristics of the two designated locations in order to recommend the location that appears to be most favorable for repository development.

5.1 EVALUATION PROCESS

The objective of this evaluation process is to identify a preferred location from among the two designated locations that has the greatest likelihood of proving suitable for repository siting and of meeting NRC licensing requirements. The preferred place will be recommended for more detailed study in the next phase of work.

This evaluation objective is achieved by (1) identifying comparison factors that address each NWTS subcriterion; (2) comparing the two designated locations in terms of these factors; (3) identifying which factors provide differentiation between locations; and (4) identifying a preferred location in terms of differentiating factors. Although each of the two designated locations appears to be acceptable for further study, this evaluation allows one location to be designated as "preferred." A data matrix, showing NWTS criteria and subcriteria, comparison factors addressing the subcriteria, and data comparison of the two locations, is presented in Table 5-1.

5.2 CRITERIA AND COMPARISON FACTORS

This section discusses the individual criteria, subcriteria and comparison factors, and their application to each designated location. Data in this section have been derived largely from Woodward-Clyde Consultants (1981a, 1981b) and Bechtel National, Inc. (1980).

5.2.1 SITE GEOMETRY

NWTS criteria and subcriteria that form the basis for addressing site geometry have been previously discussed in Chapter 4.

5.2.1.1 Minimum Depth

Factors that address the subcriterion of minimum depth include erosion rate and regional Quaternary uplift rate. These factors are identified in proposed U.S. Nuclear Regulatory Commission (1981b) regulations for repositories [10 CFR 60, Section 60.123(b) 4, 8] as topics requiring careful analysis.

5.2.1.1.1 Erosion Rate

Significance. Data on erosion rates contribute to the definition of the minimum depth below which waste should be placed in order to avoid a breach of the repository. Erosion rates are particularly important in the Paradox Basin because erosion has been the dominant geomorphic process in the Basin and the Colorado Plateau during Quaternary time. This process is evidenced by the numerous deep canyons in the region and by the scarcity of Quaternary deposits.

Data Acquisition Methods. Literature on the Colorado Plateau region was reviewed to derive erosion rates using reports of deposits of known age located adjacent to incised streams (Woodward-Clyde Consultants, 1981a). Analysis of aerial photographs, aerial reconnissance, and ground surveys identified additional useful deposits. Minimum ages of these deposits were assigned on the basis of soil profile development, paleomagnetic character, and radiometric dating methods. Geologic formations in the region were also ranked in classes by their relative erodibility. Rate of lateral cliff retreat is also influenced by bedrock erodibility. Long-term rates were calculated from data in the literature.

Adequacy of Data. The data are adequate to derive a long-term rate of bedrock incision during the last 1/2 to 1 million years. Short-term fluctuations in erosion rates cannot be defined without better age control on Quaternary deposits formed during the incision process. Rate of lateral cliff retreat is also a function of bedrock lithology, and was calculated from data in the literature. Knowledge of the surficial and subsurface stratigraphy is sufficient to assess effects of lithology or erosion rates in the near future.

Results/Comparison of Locations. The long term bedrock incision rate was calculated to be 0.8 foot per 1,000 years. Lateral cliff retreat was calculated to be 0.8 to 1.8 feet per 1,000 years. Near-future erosion rates are judged to be approximately equivalent to rates for the last 1/2 to 1 million years because strata overlying the Paradox Formation are of similar erodibility to those strata incised by the Colorado River during the last 1/2 to 1 million years. Based on the above values, a repository placed now at the 3,0[illegible] foot depth would still have a cover of 2,920 feet after 100,000 years of ero[illegible].

The present depth of incision is comparable in both the Gibson Dome and Elk Ridge locations. The primary difference between the areas is the apparent greater lateral erodibility of formations in the Gibson Dome location compared to those in the Elk Ridge location. This difference is evidenced by comparing the narrow incised canyons of Elk Ridge with the broad open expanse of the Indian Creek Valley at Gibson Dome. However, there is no evidence to indicate that erosion is proceeding any faster than the regional rate in either of the areas.

5.2.1.1.2 Regional Quaternary Uplift Rate

Significance. Regional uplift is of concern with regard to its potential to elevate the region and promote accelerated erosion that may lead to

breaching of the repository. Anticipated variations in uplift rate are also of concern in estimating the potential for breaching.

Data Acquisition Methods. A literature survey was made of studies addressing uplift on the Colorado Plateau. These studies include (1) total amount of uplift since Miocene time, when uplift started; (2) amount of incision during Quaternary time or Pliocene time; and (3) amount and rate of vertical displacement on normal faults bordering the western margin of the Plateau. Uplift rates are derived at particular points by determining present heights above stream level of uplifted deposits or surfaces of known age.

Adequacy of Data. In the Paradox Basin and on the whole Colorado Plateau, Quaternary and Tertiary deposits or surfaces have been preserved as only scattered remnants. At some locations, radiometric ages provide good age control. More typically, a minimum age has been assigned to a deposit in order to maximize the calculated rate of uplift. The data are adequate to assess and derive a general uplift rate for the region during the Quaternary epoch. However, they are not adequate to address the question of variable or differential uplift rates associated with specific geologic structures within the region. The data suggest that uplift has proceeded on the same order of magnitude through Quaternary and Pliocene time, but they are averaged over long time periods and do not indicate whether uplift occurred in pulses.

Results/Comparison of Locations. The Colorado Plateau has undergone regional uplift throughout much of Cenozoic time. In response, rivers within the plateau have incised deep, narrow canyons into the bedrock. It is therefore likely that this trend will continue during the lifetime of the repository.

Quaternary and Pliocene data indicate an uplift rate of approximately 1 foot per 1,000 years. This rate is comparable to the previously described bedrock incision rate of 0.8 foot per 1,000 years. In general, the Colorado Plateau has been uplifted approximately 5,000 feet in 5 to 7 million years (0.7 to 1.0 foot per 1,000 years).

Data are insufficient to differentiate individual uplift rates for the Elk Ridge or Gibson Dome locations. However, limited available data indicate that uplift of both locations is occurring at rates that are similar to the regional rate.

5.2.1.2 Maximum Depth

Factors that address this subcriterion include temperature, maximum feasible depth, loading by nearby cliffs, and in situ stress.

5.2.1.2.1 Temperature

Significance. The existing temperature at repository depths will be raised significantly by waste-generated heat during the repository lifetime. Therefore, a lower ambient (existing) temperature would result in a lower maximum operating temperature in the repository, or allow a greater concentration of waste within the repository. The location having the lower ambient temperature is therefore favored.

Data Acquisition Methods. Temperatures were obtained from temperature logs at repository depths in boreholes at Gibson Dome and Elk Ridge.

Adequacy of Data. Data from the temperature logs are judged adequate to indicate temperature at these points. As additional boreholes are drilled in future studies, more temperature data will be obtained to evaluate lateral temperature variations at repository depths.

Results/Comparison of Locations. Ambient temperature at 3,000 feet in the Gibson Dome No. 1 (GD-1) borehole was 86°F. In Elk Ridge at the E.J. Kubat borehole, temperature at 3,000 feet was 83°F. In the Elk Ridge No. 1 (ER-1) borehole, the temperature at 3,000 feet was 85°F (Woodward-Clyde Consultants, in preparation). The locations of the ER-1 and E.J. Kubat boreholes are shown in Figure 4-22; the location of the GD-1 borehole is shown in Figure 4-24.

5.2.1.2.2 Maximum Feasible Depth (Engineering Considerations)

Significance. It is important to estimate the maximum feasible siting depth of a repository in salt because the stability of underground openings becomes less certain with increasing depth. The primary stability factor is gradual closure of a deep opening over long periods of time (tens of years) arising from creep-type deformation of salt. The maximum depth is that depth at which stability of underground works can be maintained without extensive structural reinforcement.

Data Acquisition Methods. In situ stress-strain and creep data were measured in the GD-1 borehole at Gibson Dome. Measurements were made in salt strata using oilfield drill-stem test equipment to measure volume change of deep test zones as the pressure of the zone was reduced. Stress-strain data and short-term creep rates were calculated from pressure and volume measurements.

Adequacy of Data. The data obtained at GD-1 are adequate to make an estimate of maximum feasible siting depth. Laboratory triaxial strength and creep testing of salt core samples is in progress to complement in situ data.

Results/Comparison of Locations. Three successful in situ stress-strain/creep tests at depths of 3,240, 3,625, and 4,865 feet were completed at GD-1.

Short-term (1-day) creep rates for the 3,240 and 3,625 ft depths are 1.6×10^{-9} and 4.4×10^{-9} radial strain per second, respectively. Radial strain was defined as the change in borehole radius divided by the original borehole radius (typically 5-1/2 inches). For the 4,865 ft depth, short-term (1-day) creep rates are 42×10^{-9} radial strain per second. Because two shallow test creep rates are among the lowest values reported in the literature, a maximum feasible siting depth of 3,500 feet (approximately equal to the test depth of 3,625 feet) was estimated. This estimate, based only on area-specific data from one borehole, will be reevaluated based on further field and laboratory testing during succeeding phases of work.

Because no data are available for Elk Ridge, no direct comparison of maximum feasible depth can be made. However, based on the general geologic characteristics of each area, it is not expected that the maximum feasible depth would be much different for these two areas. Therefore, this is not a discriminating factor.

The actual depth to top of salt cycle 6 at the Gibson Dome location ranges from 2,400 to 3,400 feet; at the Elk Ridge location, actual depth to the top of salt cycle 9 ranges from 2,350 to 3,500 feet.

5.2.1.2.3 Loading by Nearby Cliffs

Significance. If repository workings are sited too close in plan view to a high cliff or within a narrow canyon, they may experience added stresses from the cliff mass in excess of those resulting from the lithostatic load calculated at the base of the cliff. Thus, the effective depth (base depth plus added stress from the cliff) is greater when near a cliff face than when located at the same base depth in flat terrain. If the effective depth is greater than the maximum feasible depth of 3,500 feet, the stability of underground workings could be compromised.

Data Acquisition Methods. Approximate stress distribution calculations were made for base depths of 2,500 and 3,000 feet near a 1,500-foot-high cliff. The calculations were based on an assumed infinitely long vertical cliff. If the base depth is 2,500 feet, the limits of the repository should be no closer than about 0.5 mile to the cliff face to give an effective depth of 3,500 feet; with a base depth of 3,000 feet the repository should be no closer than 1 mile to the cliff.

Adequacy of Data. The calculations are based on simplified geometries and conservative summation of cliff-induced stresses and lithostatic stress. These calculations are sufficient, however, for approximate delineation of set-back distance from cliff faces during the area to location screening process. If the selected site is located near substantial topographic relief, additional, more sophisticated stress calculations may be required.

Results/Comparison of Locations. Stress distribution analyses were applied to the abrupt high cliffs in the eastern and southern parts of the Gibson Dome location. Based on these analyses, the effective depths for the following areas were found to exceed 3,500 feet: all of Harts Draw, a 1-mile-wide zone along the front of Harts Point, and zones less than 1 mile wide around Bridger Jack Mesa and an unnamed mesa to the west. In the Elk Ridge location, the only similar area found was a zone less than 1 mile wide on the west side of South Long Point.

These set-back zones of identifed effective depth greater than 3,500 feet will be evaluated in more detail if a chosen site extends into the zones.

5.2.1.2.4 Magnitude of In Situ Stress

Significance. In situ state of stress data are important for design and layout of underground facilities as well as for evaluating the seimologic/tectonic regime in the areas. Knowledge of the direction of the maximum principal stress will aid in orienting underground chambers and passageways.

Data Acquisition Methods. In situ hydraulic fracture tests were performed in salt strata at five depths from 3,130 to 4,850 feet in the GD-1 borehole. The tests were made with a slower fluid injection rate than is used in conventional hydraulic fracture testing to better define the pressure-volume-time history of the tests. Downhole pressures and injection volume were carefully monitored. Impression packers were used to record the direction of any fracture formed during testing.

Adequacy of Data. The testing gives reasonable results for the vertical lithostatic stress gradient and minimum horizontal stress, but somewhat unexpected results for maximum horizontal stress. Conventional elastic interpretation methods used for these tests may not be applicable for salt (a plastic material). Additional testing will be done in hard rock strata overlying and beneath the salt formation near specific proposed repository sites.

Results/Comparison of Locations. The vertical lithostatic stress gradient was found to be 1.15 psi per foot of depth. Minimum horizontal stress is about equal to the vertical stress. The maximum horizontal stress was calculated to be 1.5 times lithostatic stress. No comparison can be made between the Gibson Dome and Elk Ridge locations because data are available only for the former. Stress magnitude and direction are not expected to vary significantly between the two areas; however, the more rugged topography at Gibson Dome may influence the stress pattern there.

5.2.1.3 Thickness of Host Rock

Factors that influence this subcriterion are thickness of salt interval and thickness of interbeds or impurities. These factors are important in achieving repository performance objectives as described in proposed U.S. Nuclear Regulatory Commission (1981b) regulations [10 CFR 60, Section 60.111(3)].

5.2.1.3.1 Thickness of Salt Interval

Significance, methods of data acquisition, and adequacy of data for this factor were discussed previously in Section 4.2.2. At Gibson Dome, salt cycle 6 is the target bed, while at Elk Ridge, salt cycle 9 is the target bed.

Results/Comparison of Locations. In the Gibson Dome location the thickness of salt cycle 6 ranges from 160 to 240 feet. The thickness of salt cycle 9 at Elk Ridge ranges from 70 to more than 90 feet.

5.2.1.3.2 Impurities

Significance. Any appreciable thickness of non-halite minerologies within the potential host rock layer may be potentially unfavorable in terms of diluting various halite properties such as thermal capacity and annealing ability. Depending on the nature of the non-halite component, additional potentially unfavorable conditions (such as gas and fluid content) may be introduced.

Data Acquisition Methods. Continuous cores of the potential host rock layer obtained from GD-1 and ER-1 boreholes were logged and described.

Adequacy of Data. The data from these boreholes are judged adequate to dilineate anhydrite. Other non-halite minerologies are under investigation. Similar data from additional boreholes during future work will provide a body of data to evaluate lateral variations in non-halite minerologies.

Results/Comparison of Locations. At Gibson Dome the only known non-halite minerologies within the potential host rock layers are carnallite and laminae of anhydrite. Anhydrite laminae occur as distinct bands approximately 1/8-inch thick, and are spaced one-half inch to one-half foot apart throughout the interval. They constitute a toal of less than 5 percent of the salt layer thickness. At Elk Ridge, anhydrite laminae occur

as diffuse bands of anhydrite sand (spaced approximately one-half foot apart) in a halite matrix. Anhydrite impurities make up approximately 2 percent of the host rock. At Gibson Dome, a minor amount of carnallite has been identified within the halite of salt cycle 6. The significance of molecular water in this mineral is being investigated. At Elk Ridge, no evidence of hydrous saline minerals has yet been found.

5.2.1.4 Lateral Extent of Host Rock

Factors that address this subcriterion are (1) the area meeting depth and thickness criterion; and (2) potential for encountering lateral variations in host rock layer. These factors are important in achieving repository performance objectives as described in proposed U.S. Nuclear Regulatory Commission (1981b) regulations [10 CFR 60, Section 60.111(3)].

5.2.1.4.1 Subsurface Area Having Potentially Favorable Characteristics

Significance. This subsurface area must be at least 3.1 square miles in order to accommodate the dimensions of the repository. Additional area is desirable to (1) allow shifting of the 3.1 square miles to avoid any unforeseen undesirable conditions that become known as a result of future investigations; and (2) provide a buffer zone.

Data Acquisition Methods. The screening maps presented in Chapter 4 delineate areas having potentially favorable characteristics for salt cycle 6 in Gibson Dome and for salt cycle 9 in Elk Ridge. The designated location maps (Figures 4-24 and 4-25) are summary maps showing such areas.

Adequacy of Data. Data on these figures are judged adequate for this stage of investigations. These maps will be updated as results of additional work become available.

Results/Comparison of Locations. At the Gibson Dome location, a potentially favorable subsurface area of 57 square miles is present. At the Elk Ridge location, a potentially favorable area of 6 square miles is present.

5.2.1.4.2 Potential for Lateral Variations

Significance. Lateral variations in lithology or other mass properties within the host rock may adversely affect repository performance by reducing thermal capacity or radionuclide isolation capabilities.

Data Acquisition Methods. Data regarding consistency of lithology within individual salt cycles were gathered from (1) Paradox Basin studies by Hite (1960) and Hite and Lohman (1973); (2) continuous core data from boreholes at Gibson Dome and Elk Ridge; and (3) evaluation of oil well geophysical logs.

Adequacy of Data. The data base described above is judged adequate to provide preliminary assessments of local variability in lithology. Data from additional boreholes during future studies will be needed to reach a final assessment of local variability.

Results/Comparison of Locations. Based on the data discussed above, it is judged that the likelihood for encountering significant local variability in lithology is somewhat higher at Elk Ridge than at Gibson Dome.

5.2.2 GEOHYDROLOGY

NWTS Site Performance Criteria (U.S. Department of Energy, 1981a) state that the geohydrologic regime in which the site is located shall have characteristics compatible with waste containment, isolation, and retrieval. Various aspects of geohydrologic conditions are specified for careful study in proposed U.S. Nuclear Regulatory Commission (1981b) regulations [10 CFR 60, Sections 60.112(b)(c); 60.122(c)(f); 60.123(a, 3)(b, 5, 7, 12, 16)].

5.2.2.1 Geohydrologic Regime/Flow

The following subcriterion from U.S. Department of Energy (1981a) is the basis for addressing geohydrologic regime/flow:

> "The site shall be located so that the present and probable future geohydrological regime will minimize contact between ground water and wastes, and will prevent radionuclide migration from the repository to the accessible environment in unacceptable amounts."

The factors that address the subcriterion of geohydrologic regime/flow include (1) ground-water travel time from site to discharge; (2) hydraulic communication between repository layer and surrounding units; and (3) vertical hydraulic gradient. Because these factors are closely related they were considered together.

Significance. Moving ground water provides the most significant mechanism by which radionuclides could be transported from the repository to the biosphere. Assessment of the ground-water flow system is critical to evaluating the potential for unacceptable amounts of radionuclides reaching the biosphere from any particular subsurface location. Major characteristics of the flow system critical for radionuclide migration are closely related to (1) variability in lithology of geologic formations in the region and near a potential site; (2) locations of regional and local recharge and discharge areas; and (3) geologic structure, including cross-cutting structures that may provide short-cut conduits for radionuclide migration.

Data Acquisition Methods. Regional flow-system data were obtained primarily from an understanding of regional stratigraphy and geologic structure, and from drill-stem tests in oil and gas exploration wells. Sampling of springs and existing wells was also conducted throughout the study areas and the adjacent recharge and discharge areas. A detailed literature search and review provided the remainder of the regional information.

Extensive hydrogeological testing was performed in the GD-1 borehole. Estimates of hydrological parameters have been obtained for all the formations within approximately 3,000 feet above and 3,500 feet below the target repository salt bed. Water samples were obtained for detailed chemical and isotopic analyses. A similar test borehole is presently underway in the Elk Ridge area.

Adequacy of Data. Based on presently available data, general ground-water movement rates and directions may be estimated within the Paradox Basin. However, there is a great deal of uncertainty with the majority of the existing data base because it is largely composed of drill-stem tests performed for purposes other than hydrologic testing.

At Elk Ridge, the data coverage is particularly sparse. Results of the in-process Elk Ridge borehole will add to the local and regional data base. At Gibson Dome, preliminary test results from the GD-1 borehole, when used in conjunction with the regional drill-stem test records, are sufficient for quantitative estimates of flow rate and direction. Data to assess the sorptive and dispersive characteristics of the strata are inadequate at this time in both of the locations.

Results/Comparison of Locations. The results and the level of hydrogeologic data available for the Gibson Dome location are sufficient to indicate that this location would meet the minimum requirements for radionuclide residence time specified in the NRC proposed technical criteria and the NWTS criteria (Woodward-Clyde Consultants, 1981a). The specified residence time from "permanent closure" of the repository to appearance of any radionuclide at the biosphere is 1,000 years (U.S. Nuclear Regulatory Commission, 1981b).

At Gibson Dome, the data gathered to date indicate that (1) there is little or no hydraulic communication between the repository layer and surrounding units; and (2) the vertical hydraulic gradient appears to be downward. Based on these conditions and on hydraulic conductivity data obtained in the GD-1 borehole, the following travel path was hypothesized to be most probable for migrating radionuclides in the Paradox Formation, should a release occur: (1) from repository in salt cycle 6 downward to the interbed between salt cycles 6 and 7; (2) within this interbed to the west and north toward the Colorado River; (3) to the intersection of this interbed with the diapiric salt structure along the Colorado River

nearest the Gibson Dome location (structure in "Y" canyon, 20 miles from the GD-1 borehole); and (4) upward within the salt diapir to the biosphere near the Colorado River.

The estimated ground-water travel time for this most probable travel path is 131,000 years should such a release occur. Several other similar flow paths were considered, including one through the interbed above Salt 6; all of these flow paths resulted in apparent flow times greater than 10,000 years. The worst-case hypothetical flow path, through the Elephant Canyon Formation, resulted in a calculated flow time to the biosphere of approximately 12,500 years. Because the factors of dispersion and sorption will retard migration of radionuclides contained in ground water, a radionuclide residence time before reaching the biosphere may be significantly longer.

The travel-path scenario described above is preliminary and is based on limited subsurface data. This scenario has been constructed to be consistent with the currently available information from the regional hydrogeologic studies and from GD-1 borehole data. As additional subsurface data become available from continuing hydrogeologic and structural geology studies, this scenario will be updated and may be significantly revised. Moreover, this scenario is specific to a hypothesized repository at the GD-1 borehole, assuming that conditions at this borehole are representative of conditions within and near that hypothesized repository. For a repository located elsewhere, a similar travel path scenario would have to be based on subsurface conditions revealed by boreholes at that locality.

In order to identify locations most favorable for further study at this early stage of detailed investigations, an approach such as designated above, based on conservative assumptions, was considered to be reasonable and useful.

In the Elk Ridge location, it is anticipated that hydrogeologic test data from the Elk Ridge borehole will be sufficient to make a similar hydrogeological analysis for this area with respect to residence times. The northern part of the Elk Ridge location is currently favored because of relatively long flow paths and low hydraulic gradients.

5.2.2.2 Hydrological Regime/Modeling

The following subcriterion from U.S. Department of Energy (1981a) is the basis for addressing the hydrological regime/modeling factor:

> "The site shall be located so that the hydrological regime can be sufficiently characterized to permit modeling to show that present and probable future conditions have no unacceptable impact on repository performance."

Factors that address the subcriterion of modeling include (1) complexity of the ground-water flow system; and (2) ability to produce a defensible ground-water flow model. Because these factors are closely related, they were considered together.

Significance. Modeling is necessary to describe the hydrogeologic system in sufficient detail to facilitate evaluation of repository performance. The ability to model the ground-water flow system is crucial to demonstate conclusively the effects of present and probable future conditions, and to evaluate effects of those conditions on repository performance. Because simple conditions can be modeled more quickly and with a much higher degree of confidence than complex systems, areas having simpler systems are more desirable for model construction and use.

Data Acquisition Methods. Methods were the same as those stated in Section 5.2.2.1.

Adequacy of Data. For the Gibson Dome location, data are sufficient to prepare a conceptual ground-water flow model. Preliminary numerical modeling has been initiated for the study region based on available knowledge of the regional ground-water flow system and on detailed data from hydrogeologic testing at the GD-1 borehole. Modeling will be facilitated because of the relative simplicity of hydrogeologic conditions on the western part of the Paradox Basin containing the Gibson Dome and Elk Ridge locations. Forthcoming

data from the Elk Ridge No. 1 borehole will add to the hydrogeologic data base for numerical modeling.

Comparison of Locations. Because regional hydrogeologic conditions are similar between these areas, no preference regarding this factor can be made at this time.

5.2.2.3 Geohydrological Regime/Shaft Construction

The following subcriterion from U.S. Department of Energy (1981a) is the basis for addressing the geohydrological regime/shaft construction factor:

> "The site shall be located so that the geohydrological regime allows construction of repository shafts and maintenance of shaft liners and seals."

Significance. The geohydrologic regime impacts on: (1) the cost and feasibility of shaft construction; and (2) the integrity of the mined opening during the period of construction and operation. Abundant flowing ground water can make shaft construction difficult, expensive, and impractical. Even after shaft construction is complete, an imperfect seal could allow the passage of water downward along the shaft, increasing the potential for flooding the mine chamber.

Data Acquisition Methods. Information needed for evaluation of this factor includes permeability, porosity, static water levels (potentiometric levels), saturated thickness and mechanical properties of the rock. A preliminary estimate of these characteristics was obtained in the Gibson Dome location from the hydrogeological testing, geophysical logging, and coring operations at the GD-1 borehole. The Elk Ridge No. 1 borehole should provide similar data.

Adequacy of Data. Data from the boreholes at Gibson Dome and Elk Ridge will be sufficient to provide preliminary estimates of pertinent factors, particularly ground-water inflow into a shaft.

Results/Comparison of Locations. At the GD-1 borehole, the total flow estimated to occur into a 12-foot-diameter shaft from ground surface to repository depth is approximately 57 gallons per minute. The majority of the flow would be produced from strata at a depth of approximately 1,000 feet. Porosities and permeabilities were generally low. Permeabilities within the strata above and below the Paradox Formation ranged from 36 millidarcies to 2×10^{-7} millidarcies. Within the Paradox Formation, permeabilities ranged from 7.0×10^{-6} to 2×10^{-7} millidarcies (Woodward-Clyde Consultants, 1981a). Similar data should be available from the Elk Ridge No. 1 borehole. Comparisons between locations cannot be made until these data are available.

5.2.2.4 Dissolution

The following subcriterion from U.S. Department of Energy (1981a) is the basis for addressing the dissolution factor:

> "The site shall be located so that subsurface rock dissolution that may be occurring, or is likely to occur, can be shown to have no unacceptable impact on system performance."

Factors that address this subcriterion include distance to and activity of dissolution features. The factors will be considered together.

Significance. Dissolution of salt represents a possible method of breaching the host rock or of reducing the buffer zone around or within the host rock. This breach could lead to a loss of repository isolation. Moreover, existing dissolution surfaces could shorten the radionuclide migration pathway and lead to an unacceptable loss of repository containment. For safety considerations, dissolution rates that would violate the integrity of the host rock over a period of thousands or possibly tens of thousands of years should be avoided.

Evidence of current dissolution, or of conditions that could give rise to dissolution in the immediate future, are also items of concern.

The boundary of acceptability depends on both the rate of dissolution that might be occurring or anticipated, and the thickness of buffer zones that would be susceptible to dissolution before the dissolution front contacted the radioactive material. The current absolute requirement (U.S. Nuclear Regulatory Commission, 1981a) is that radioactive material not be allowed to reach the biosphere for 1,000 years.

Data Acquisition Methods. Available information in the literature was examined for any mention of salt dissolution or dissolution-related structures. Pertinent data were then gathered during surface stratigraphic and structural mapping, including degree of stratigraphic continuity, attitude of bedding, and geometric characteristics of faults and folds. In addition, borehole logs throughout the study areas were interpreted to locate and define the apparent boundaries of salt dissolution. Some seismic reflection data were interpreted to detect any anomalies in salt thickness or any other evidence of potential salt flowage or dissolution.

Spring sampling along the Colorado River was performed to detect any salinity differences that might suggest salt dissolution. Geophysical and water chemistry data from water wells and water-producing oil wells were also analyzed, as were hydrogeologic tests of the GD-1 borehole for evidence of dissolutioning.

Adequacy of Data. For the Elk Ridge and Gibson Dome locations, literature, borehole data, and seismic reflection data pertaining to possible dissolution phenomena are sparse. Information from stratigraphic and structural mapping is relatively complete, but provides information only on surface manifestations of salt dissolution and collapse. Current hydrogeologic data are adequate to make regional correlations between potentiometric interpretations and dissolution processes; however, data are insufficient at present to make confident prediction of the likelihood of dissolution for a particular part of a location.

Near the Gibson Dome location, one collapse structure was identified (Lockhart Basin). This feature is believed to have been formed as a result of dissolution of 1,100 feet of salt (Huntoon and Richter, 1979). This area was further investigated during stratigraphic and structural mapping investigations for this study (Woodward-Clyde Consultants, 1981a). Further investigations of this feature and any other detected dissolution features are needed to further define dissolution rates and the extent and impact of these features on any part of the Elk Ridge or Gibson Dome locations that is selected for further study.

Comparison of Locations. Dissolution features closest to the Gibson Dome and Elk Ridge locations are shown in Figure 5-1. Because no dissolution features have been identified within the Elk Ridge location, it is preferred over Gibson Dome with respect to the presence of such features. Rates of dissolution at Lockhart Basin, or the presence of dissolution phenomena within the Gibson Dome location, have not yet been fully evaluated. Such evaluation is planned for the next phase of work if the Gibson Dome location is selected for further study.

5.2.3 GEOCHEMISTRY

NWTS Site Performance Criteria (U.S. Department of Energy, 1981a) state that the site shall have geochemical characteristics compatible with waste containment, isolation, and retrieval. Geochemical conditions are specified for careful study in proposed U.S. Nuclear Regulatory Commission (1981b) regulations [10 CFR 60, Sections 60.122(d)(g); 60.123(b, 13, 14, 15)].

5.2.3.1 Ground-Water Chemistry

The following subcriterion from U.S. Department of Energy (1981a) is the basis for addressing the chemical interaction factor:

> "The site shall be located so that the chemical interactions between radionuclides, rock, ground water, or engineered components will not unacceptably affect system performance."

Factors that address this subcriterion include geochemical environment and host-rock water content. These factors were considered together.

Significance. Ground-water chemistry must be compatible with waste containment, isolation, and retrieval in order not to unacceptably affect system performance. Assessment of this compatibility includes the following:

- Definition of hydrochemical facies
- Correlation of these hydrochemical facies with ground-water flow patterns deduced from potentiometric and permeability data
- Hydrochemical evidence regarding salt dissolution
- Assessment of in situ redox conditions
- Water-rock equilibrium assessments.

Data Acquisition Methods. Geochemical data used in the area characterization phase include both chemical data collected prior to this investigation, and data collected for this study (Woodward-Clyde Consultants, 1981a). These chemical data are from springs, water wells, water produced from oil wells, and one exploratory boring constructed in the Gibson Dome area for this program. Host-rock water-content data have been obtained from analysis of cores at the GD-1 borehole. Similar data will be obtained from the Elk Ridge borehole.

Adequacy of Data. Current data are adequate to assess regional hydrochemical trends, to make regional correlations with potentio-metric interpretations and dissolution processes, and to estimate redox conditions. The data are therefore suitable for the level of interpretation being made in the area characterization phase. There are significant gaps in the data on a local scale, however, that should be filled in during the next phase of work. Additionally, water-rock equilibria evaluations have not been completed.

Results/Comparison of Locations. As stated in Section 5.2.2.1, available hydrochemical data generally confirm the ground-water flow patterns observed in the regional potentiometric interpretation. Redox conditions of ground water in the lower hydrostratigraphic unit (below the Hermosa Group) and in the lower part of the upper hydrostratigraphic unit (lower Permian strata) appear to be moderately reducing. This indicates that conditions above and below the target repository bed are favorable for the immobilization or retardation of various radionuclides. These reducing conditions and associated brines must be considered when designing the corrosion control aspects of repository construction.

Preliminary results of host-rock water content analyses from GD-1 core show 0.01 to 0.2 weight percent of intergranular and fluid inclusion water. This does not include water of hydration.

Based on the current geochemical knowledge, neither the Gibson Dome nor the Elk Ridge locations can be identified as preferable. When more complete geochemical data become available, they can be used as a comparison tool in conjunction with hydraulic interpretations of the flow system. The distribution of hydrochemical facies and associated assessments of ground-water evolution and flow directions should mesh with the ground-water flow pattern deduced from potentiometric interpretations. These interpretations can be used in the comparison process to identify localities that are hydrogeologically more favorable for siting.

5.2.3.2 Retardation Potential

Factors that address this subcriterion include radionuclide adsorption properties in the migration pathway and thickness of highly adsorptive rocks above and below the potential host rock layer. These factors were considered together.

Significance. Radionuclide adsorptive properties of rocks in the migration pathway away from a repository can result in retardation of the radionuclide travel time and thus longer residence time before reaching the biosphere.

Additionally, a greater cumulative thickness of highly adsorptive rocks above and below the repository provide a larger potential retardation factor, and thus constitute a potentially favorable siting factor.

Data Acquisition Methods. Continuous cores taken in the GD-1 borehole provided samples for future measurement of radionuclide adsorptive properties. Total thickness of shale and other fine-grained deposits (which may have highly adsorptive properties) was also obtained from the continuously cored boreholes. These data were combined with analysis of geophysical logs from other previously drilled boreholes at Gibson Dome and Elk Ridge.

Adequacy of Data. Interpretation of shale from geophysical logs has two potential limitations. The first is the relative uncertainty in accurately picking a shale lithology from a downhole sequence given only geophysical log data with no accompanying core or cuttings information. Comparison of geophysical log shale picks with known core lithology at the GD-1 borehole, however, shows a relative accuracy in this ability. Therefore, the level of confidence in accurately picking shale lithology is conservatively judged to be near 75 percent. Second, shale mineralogy cannot be determined directly from geophysical logs. The shale's radionuclide retardation properties are dependent on the presence of clays capable of trapping or adsorbing radionuclides. It is not yet known if these clays exist in the shales picked from geophysical logs. Given these uncertainties in the existing data, a 50 percent level of confidence is associated with this radionuclide retardation assessment.

Comparison of Locations. The Gibson Dome location has 155 to 265 feet of shale in the geologic section above the repository horizon and 230 to 480 feet in the section below it. The Elk Ridge location has 125 to 142 feet of shale in the section above the repository horizon and 125 to 150 feet in the section below it.

5.2.4 GEOLOGIC CHARACTERISTICS

NWTS Site Performance Criteria (U.S. Department of Energy, 1981a) state that the site shall have geologic characteristics compatible with waste containment, isolation, and retrieval.

5.2.4.1 Geologic Characterization

The following subcriterion from U.S. Department of Energy (1981a) is the basis for addressing the geologic characterization factor:

> "The site shall be located so that the subsurface setting can be sufficiently characterized to permit identification and evaluation of conditions that are potentially adverse or favorable to waste containment, isolation, and retrieval."

Factors that address this subcriterion include: (1) simplicity and definition of surface and subsurface geologic conditions; (2) extent and age of Quaternary deposits; and (3) magnitude of potential changes in climate. These factors address conditions specified for careful study in proposed U.S. Nuclear Regulatory Commission (1981b) repository regulations [10 CFR 60, Sections 60.112(b); 60.122(e); 60.123(a,8)(b, 4, 16)].

5.2.4.1.1 Simplicity and Definition of Geologic Conditions

Significance. Geologic conditions, particularly stratigraphy, must be evaluated in the vicinity of the repository in order to determine their adequacy with regard to repository performance. Stratigraphy, for example, may provide one or more of the key barriers to radionuclide migration in the event of breach of the containment provided by the host rock. Detailed knowledge of the stratigraphy is also the key to understanding the geologic structure and geologic history. Stratigraphic information, in addition, permits evaluation of resource potential, ground-water potential, and tectonic stability. Stratigraphy should be sufficiently simple and continuous to permit confident identification of discontinuities. Simple stratigraphy is preferred to complex stratigraphy because it reduces uncertainties in the knowledge of geologic history and greatly facilitates modeling.

Data Acquisition Methods. For the Elk Ridge and Gibson Dome locations, nearly every square mile was field-checked with respect to stratigraphic continuity and structural setting. Geophysical logs from most borings in the areas were interpreted to investigate the stratigraphic continuity between the ground surface and the Mississippian Leadville Limestone. Surface seismic lines were and are being interpreted, in part, to locate continuous reflectors in the subsurface.

Adequacy of Data. Data and resulting interpretations of surface traceable stratigraphic and geologic conditions at Elk Ridge and Gibson Dome have been completed with a high level of confidence. Excellent stratigraphic exposures occur in both areas. Varied rock lithologies have been accurately traced throughout the areas both above and below the ground surface. In the subsurface, each geologic formation carries distinctive geophysical signatures that can and have been identified with accuracy, in many cases down to specific beds within the unit. Wells are widely spaced at Elk Ridge and Gibson Dome, but available diagnostic geophysical log signatures can be correlated between virtually all wells, regardless of spacing.

Seismic reflection data coverage is partial at Gibson Dome, but is entirely absent at Elk Ridge. Subsurface faults have been detected at Gibson Dome by interpretations of these data (Figure 4-12). Subsurface faults were detected in two boreholes at Elk Ridge (Edward J. Kubat Govt. #1 and William B. Kidd Federal #1). However, the extent or orientation of these faults could not be estimated because of the lack of seismic reflection data.

Comparison of Locations. Surface and subsurface stratigraphy are simple and traceable at both locations. Subsurface structure is better defined at Gibson Dome because of the availability of seismic reflection data.

5.2.4.1.2 Extent of Age of Quaternary Deposits

Significance. An understanding of events and processes during Quaternary geologic history can be derived from the characteristics of Quaternary deposits and soils. These deposits and soils can be used to assess regional uplift and erosion rates and potential future climate changes. These phenomena are of interest in evaluating the minimum depth of waste burial, and in assessing the significance of future hydrologic or geomorphic processes at the site and in the subsurface. In addition, Quaternary deposits and soils are also useful in assessing Quaternary displacement on faults or rates of dissolution where such structures could adversely affect repository performance. This type of evaluation is most informative where deposits spanning the whole Quaternary epoch are preserved above the geologic feature of interest.

Data Acquisition Methods. A literature search of federal, state, local, and academic data was made to identify the extent and character of Quaternary deposits in the Paradox Basin. Analysis of aerial photographs, aerial reconnaissance and field mapping augmented these data for the Gibson Dome and Elk Ridge locations. Correlations of Quaternary deposits was based on topographic position, soil profile development, relative weathering characteristics, character of deposits, and stratigraphic position. Deposits were examined at natural exposures and at soil test pits excavated with a backhoe.

Adequacy of Data. Available data augmented by field investigation have identified most of the sparse Quaternary cover in the Paradox Basin region and in the Gibson Dome and Elk Ridge locations. Locally, data are inadequate to assess whether older Quaternary deposits underlie the Holocene veneer. Sequences of strata spanning all or a large percentage of Quaternary time are rare.

Results/Comparison of Locations. Quaternary deposits are preserved (1) as pediment gravel flanking the Abajo and La Sal Mountains; (2) as isolated remnants on the pre-incision Plateau surface; (3) as gravel-covered strath

terraces on resistant sandstone units in lithologic units of variable resistance; and (4) as a veneer of fine-grained eolian and alluvial deposits on upland surfaces and modern valley bottoms, respectively.

Mapping of Quaternary deposits at Elk Ridge and Gibson Dome indicates that more extensive deposits encompassing more of the Quaternary epoch exist at Elk Ridge than at Gibson Dome. Elk Ridge has more remnants of deposits that predate canyon incision, and also has a mantle of multiple sheets of loess on upland surfaces. These eolian deposits could record paleo-climatic conditions and provide adequate stratigraphy for evaluating history of deformation of any underlying geologic structure. Such deposits at Elk Ridge are not present over existing structures that require an evaluation of the age of the last displacement.

5.2.4.1.3 Magnitude of Potential Climate Change

Significance. Rates of geomorphic processes presently operating in the areas reflect present climatic conditions. Modeling studies of hydrogeologic and erosional conditions are based on historical data. The effects of future climatic changes on these models and on the future integrity of the repository need to be considered. Climatic change may affect the magnitude and recurrence of floods, rate of bedrock incision, and the rate of ground-water recharge.

Data Acquisition Methods. Predictions of future climatic fluctuations can be made by evaluating the range of conditions that have existed during Quaternary time. Indications of paleoclimates in the Paradox Basin have been obtained from (1) the character of Quaternary deposits and soils developed on the deposits; (2) a literature review of paleoclimatic data and the archaeological record available for other areas in the southwest; (3) discussions with scientists involved in these studies; and (4) a comparison of the above data with global climatic data. Site specific studies planned for the future include examination of pollen and vegetation preserved in Quaternary sediments and animal middens.

Adequacy of Data. Available paleoclimatic data are not specific to the Elk Ridge and Gibson Dome locations. Regional and global data can provide an indication of long-term trends and climatic extremes. Age control on Quaternary deposits is generally not sufficient to define short-term fluctuations prior to approximately 1,500 years ago.

No studies of climate-sensitive vegetation or fauna have yet been conducted at Elk Ridge or Gibson Dome. These studies are planned for the next phase of work and may provide more specific climatic data for at least the last 10,000 years.

Results/Comparison of Locations. Available global and regional climatic data are equally applicable to both the Elk Ridge and Gibson Dome locations. Any future pollen studies conducted at Elk Ridge may potentially encompass a longer time span than any conducted at Gibson Dome because of the presence of older deposits and a more complete stratigraphic section in the Elk Ridge area. This more complete record would also permit a better evaluation of past climates based on relative soil development.

Future periods of major global cooling and glacial advances, similar to Pleistocene climatic conditions could occur in the future. The effects of increased effective moisture on erosion rates and on the hydrogeologic system in both locations need to be considered. Further analysis of effects of potential climatic changes will be performed in the next phase of work.

5.2.4.2 Host Rock Characteristics

The following two subcriteria from U.S. Department of Energy (1981a) are the basis for addressing host rock characteristics:

> "The site shall provide a geologic system which can be shown to accommodate anticipated geomechanical, chemical, thermal, and radiological stresses caused by rock/waste interactions."

> "The site shall be located so that development, operation, and closure of underground areas can be accomplished without undue hazard to repository personnel."

Host rock characteristics are specified for careful study in proposed U.S. Nuclear Regulatory Commission (1981b) regulations [10 CFR 60, Sections 60.122(f)(h); 60.123(b, 16, 17)].

Significance. Host rock characteristics of importance in salt are: (1) inherent strength and long-term deformation characteristics (creep) sufficient to permit an engineered structure to be excavated and maintained; (2) thermal properties that will allow adequate dissipation of heat; (3) minimum fracture density, gas content, permeability/porosity; (4) low moisture content; and (5) chemical properties compatible with, or that will enhance, repository performance. Salt with inadequate inherent strength or high creep rates could prevent construction of the repository or make it unacceptably hazardous. Poor thermal properties could lead to heat buildup that might result in fracturing or increased creep deformation of the underground chambers. Fractures, entrapped gas, and unfavorable permeability/porosity could contribute to possible loss of repository isolation. The presence of certain chemical species could result in long-term changes in host rock characteristics that could be detrimental to repository performance.

Data Acquisition Methods. At this level of study, it is sufficient to assess the range of variability in the host rock's physical properties among the various areas under study. There is an extensive body of literature describing the mechanical, thermal, and chemical characteristics of rock salt. Because of the relative uniformity of literature data, only confirmatory data are required at representative locations at this time. Water content is being assessed by analysis of cores as described in Section 5.2.3.

In situ and laboratory tests have been and are being performed to confirm the general properties of the Paradox salt. A wide variety of geophysical logs were made at the GD-1 borehole. In situ geomechanical tests were also conducted to measure stress-strain and short-term creep properties in the GD-1 borehole. Drill cores have been described in detail to delineate

fractures and other mass properties, and have been and are being tested in the laboratory for thermal, chemical, and mechanical properties. These area-specific data can be compared with data on the mechanical properties of salt from the literature and with design, construction, and performance data from salt mines.

Adequacy of Data. The core sample descriptions and laboratory tests, geophysical log data, and in situ test data from the GD-1 borehole are adequate to characterize Gibson Dome host rock properties for this level of study.

Results. Preliminary host rock strength values measured under unconfined compression conditions were 4,300 to 5,100 psi. Core descriptions identified few to no fractures; those fractures that were observed were closed. Gas was observed emerging from the core in a few of the black shale interbeds. Core samples for hydrocarbon analysis were taken; analysis is underway.

Laboratory tests for permeability and porosity have been performed on cores above the Paradox Formation (592 to 2,559 feet) and below the Paradox Formation (5,579 to 6,218 feet). Paradox Formation cores are being tested. Permeability and porosity test results are as follows:

- Above Paradox Formation

  Permeability – 90 to $<1 \times 10^{-4}$ millidarcies
  Effective porosity – 1.3% to 19.8%

- Below Paradox Formation

  Permeability – 2 to $<1 \times 10^{-4}$ millidarcies
  Effective porosity – 2.4% to 15.0%

Thermal property measurements were made on 12 samples, 9 of which were within 200 feet of the potential repository strata, salt cycle 6. Thermal conductivity values were measured at various temperatures between 75°C and 512°C. Selected results are as follows:

- At 80°C ± 5°C – 0.0169 to 0.0435 w $cm^{-1}C^{-1}$
- At 505°C ± 7°C – 0.0087 to 0.0195 w $cm^{-1}C^{-1}$

Thermal expansion of core samples, as their temperature was raised from room temperature to 400°C, ranged from 0.5 to 1.9 percent of their initial length. The specific heat of the test samples ranged from 0.220 to 0.245 cal $g^{-1}C^{-1}$. Bulk density of these samples ranged from 2.17 to 2.81 g/cc.

5.2.4.3 Non-Tectonic Deformation

Non-tectonic deformation features in the Paradox Basin that are pertinent to repository siting are several faults and grabens probably related to salt flowage located 6 miles west of the Gibson Dome location. These structures are collectively named the Needles fault zone. Such features are an important part of the structural framework specified for careful study by proposed U.S. Nuclear Regulatory Commission (1981b) regulations [10 CFR 60, Sections 60.112(a); 60.122(a); 60.123(a, 7)].

Significance. The Needles fault zone has been interpreted to be caused by gravity sliding resulting from down-dip (to the west) sliding of the sedimentary sections overlying the Paradox Formation (Stromquist, 1976). Cumulative canyon incision during the late Cenozoic is believed to have formed a free face toward which this sediment column is moving. Toward the river an additional mechanism of down-dip salt flowage induced by unloading is also believed to be operating (Stromquist, 1976).

The fault zone has been found to have widened progressively eastward and southeastward toward the Gibson Dome location. If these phenomena encroach upon the location during the lifetime of the repository, its performance may be significantly compromised.

Data Acquisition Methods. The nature and characteristics of this fault zone were assessed by review of pertinent literature, remote sensing evaluations, and limited field investigations.

Adequacy of Data. The data collected from literature are adequate to describe the fault zone and to identify a plausible mechanism for occurrence and migration in time.

Results/Comparison of Locations. The Needles fault zone is located entirely on the western flank of the Monument Upwarp. The Gibson Dome location is situated on the east flank of this upwarp (Figure 5-1). The condition of westerly dip toward the Colorado River canyon (which is necessary for continued southeastward migration of the Needles fault zone) ends at the crest of the upwarp. Therefore it is judged that gravity sliding conditions associated with the Needles fault zone will not migrate eastward or southeastward past the Monument Upwarp crest, which is located west of the Gibson Dome location.

No evidence of similar gravity sliding structures was found in or near the Elk Ridge location.

5.2.5 TECTONIC ENVIRONMENT

NWTS Site Performance Criteria (U.S. Department of Energy, 1981a) state that the site shall be located such that credible tectonic phenomena will not degrade system performance below acceptable limits. Tectonic conditions are specified for careful study in proposed U.S. Nuclear Regulatory Commission (1981b) regulations [10 CFR 60, Sections 60.112(a); 60.122(a)(6); 60.123 (a, 4, 5) (b, 6, 7, 8, 9, 10, 11)].

5.2.5.1 Tectonic Element Identification

The following subcriterion from U.S. Department of Energy (1981a) is the basis for addressing tectonic element identification:

> **"The site shall be located so that its tectonic environment can be evaluated with a high degree of confidence to identify tectonic elements and their impact on system performance."**

Factors addressing this subcriterion include (1) ability to detect faults and other tectonic elements; (2) presence of anomalous thermal gradients or magmatic features (intrusive and extrusive igneous rock); and (3) general geologic stability of the region. These factors were considered together.

Significance. **Tectonic elements must be identifed and evaluated with a high level of confidence in order to adequately judge the long-term geologic stability of the repository site. Tectonic elements are most easily detected and evaluated in areas containing (1) an extensive area of rock outcrop and minimal vegetation cover; (2) a rock outcrop sequence of sedimentary strata having well-defined bedding and extensive lateral continuity; and (3) the occurrence of datable late Cenozoic deposits of sufficient lateral extent to evaluate the age and development of any significant tectonic features present.**

Data Acquisition Methods. Identification of tectonic elements began in the regional phase and continued through the area characterization phase of

work. Methods for collecting and analyzing data included literature review, interpretation of remote sensing data, stratigraphic and structural mapping, subsurface analysis, evaluation of borehole data, and seismic reflection interpretation.

Adequacy of Data. **Study of literature for information on magmatic features and geothermal gradients, and field observations during geologic mapping, are adequate for identifying the proximity of these features to the designated locations. Magmatic features described in the literature were identified during the regional investigation phase, and the present study areas were located outside 5-mile buffer zones around the features.**

Identification and evaluation of tectonic elements were approached through a combination of surface and subsurface methods. Surface methods provided an adequate data base for information for this phase of work. These methods included remote sensing interpretation, stratigraphic and structural mapping, and Quaternary studies. Subsurface data are provided in the form of borehole logs and seismic reflection data. Borehole logs are available for both locations, but seismic reflection data are presently available only at Gibson Dome, and these in a limited amount. These data are sufficient for general subsurface structural interpretations in the Gibson Dome location. Continued interpretation of seismic reflection data in the next phase of work will more adequately define those tectonic elements (primarily faults) that may be potentially unfavorable for siting.

Results/Comparison of Locations. No evidence of volcanoes, volcanic deposits, intrusive igneous rock, or abnormal thermal gradients were identified within or near the Gibson Dome or Elk Ridge locations during mapping or literature studies for this area characterization investigation.

Faults identified at Gibson Dome and Elk Ridge have been identified and were discussed in Section 4.2.3. Designated locations within both Gibson Dome and Elk Ridge study areas were delineated to be outside a 5-mile buffer

zone around any surface fault and a 2-km buffer zone around the surface projection of the extent of known subsurface faults. In the Elk Ridge location, there are two subsurface faults (one observed in each of two boreholes) for which lateral extent or orientation is unknown at this time.

The ability to detect surface faults in both the Gibson Dome and Elk Ridge locations is excellent because of the extensive exposures and well-defined stratigraphy. Discussions of simplicity of geologic conditions and of the extent and age of Quaternary deposits is presented in Section 5.2.4.1.

5.2.5.2 Quaternary Tectonic Faults

Quaternary tectonic faults were discussed in Section 4.2.3. Both the Gibson Dome and Elk Ridge locations were delineated to be more than 5 miles from any surface fault.

For the Gibson Dome location, the nearest suspected Quaternary tectonic fault is Shay graben. Quaternary deposits overlying faults within this graben are adequate to evaluate Quaternary displacement. For the Elk Ridge location, the closest fault is Hammond graben; the closest suspected Quaternary tectonic fault is Verdure graben. Quaternary deposits near the Hammond graben are probably not sufficient to evaluate the potential for Quaternary displacement; at the Verdure graben, Quaternary deposits are similar to those at Shay graben.

If an additional fault is discovered that requires evaluation of possible Quaternary-age displacement, the extent and nature of Quaternary soils and deposits could become a critical comparison factor between the two locations (Section 5.2.4.1.2).

5.2.5.3 Quaternary Igneous Activity

The following subcriterion from U.S. Department of Energy (1981a) is the basis for addressing the Quaternary igneous activity factor:

"The site shall be located so that the centers of Quaternary igneous activity can be identifed and shown to have no unacceptable impact on system performance."

Significance. Newly formed or migrated magma could suddenly breach the repository and displace the contents. Magma could also cover the surface overlying the repository with flows of volcanic material. Nearby igneous activity would be accompanied by increased heat flow that could degrade the performance of the repository.

Data Acquisition Methods. Quaternary igneous activity was identified through regional literature searches of federal, state, and academic publications, geophysical surveys, and review of remote sensing imagery. Geologic mapping supplemented the above sources.

Adequacy of Data. The data collected in the regional literature search for Quaternary igneous activity are adequate (when supplemented by field mapping) to delineate Quaternary and earlier Cenozoic igneous activity of concern to the designated locations. Quaternary igneous activity was addressed in the regional characterization phase of study (Woodward-Clyde Consultants, 1980). Areas of prime interest within the present study areas were defined by the regional phase of work to avoid areas within 5 miles of any such igneous activity.

Results/Comparison of Locations. During this area characterization phase of the study, no evidence was found for any additional Quaternary igneous activity within or near the locations. Distances to the nearest center of Quaternary igneous activity are 170 miles for Gibson Dome (igneous center near Glenwood Springs, Colorado); and 135 miles for Elk Ridge (igneous center near Cameron, Arizona).

5.2.5.4 Long-Term Uplift and Subsidence

Long-term uplift and subsidence were discussed in Section 5.2.1.1. Both the Gibson Dome and Elk Ridge locations are subject to probable future uplift rates of up to 1 foot per 1,000 years. It is judged that no unacceptable impact on repository system performance will be produced by this uplift rate.

5.2.5.5 Ground Motion from Maximum Credible Earthquakes

The following subcriterion from U.S. Department of Energy (1981a) is the basis for addressing the ground motion factor:

> "The site shall be located so that ground motion associated with the maximum credible earthquake will not have unacceptable impact on system performance."

Factors addressing this subcriterion include characteristics of local seismicity within the Paradox Basin, regional seismicity, the local and regional tectonic stress field, the maximum historical earthquake, the potential for mining-induced seismicity, and the character of subsurface ground motion.

Significance. Ground shaking related to earthquake-generated ground motion will impact principally as a potential hazard to personnel and equipment. Ground motion evaluations will thus be utilized primarily in the design of surface and subsurface facilities.

Based on a limited number of observations, it has been suggested that the magnitude of ground motions will be smaller in the subsurface than at the surface (Woodward-Clyde Consultants, 1981a). However, site-specific data are needed to fully assess topics such as behavior of subsurface salt in response to seismic ground motions and the effects of seismic surface waves from a postulated maximum credible earthquake. An increasing amount of evidence also indicates that high-frequency, high-peak accelerations generated by close-in earthquakes (even of small magnitude) may be of concern in a

subsurface facility. It is thus important to clearly define the characteristics of the local seismicity and address the potential for mining-induced seismicity. The local seismicity should be compared with regional seismicity to identify possible sources for the maximum credible earthquake producing design ground motions at a site.

The characterization of the local and/or regional tectonic stress field is also important as input to identification of seismic sources. This will aid in assessing the potential of currently seismically inactive but potentially seismogenic structures such as Shay graben and the Lisbon Valley fault zone.

Data Acquisition Methods. Data on the historical seismicity of the region were collected from published and unpublished sources. Data on contemporary seismicity and the regional tectonic stress field were derived from an extensive program of microearthquake monitoring and from monitoring by other networks, most notably the University of Utah (Woodward-Clyde Consultants, 1981a). These data are summarized on Figure 5-2. Preliminary analysis of the potential for mining-induced seismicity was derived from published and unpublished sources, personal communication, and in situ stress measurements.

Adequacy of Data. The data are adequate to allow a comparison of locations based primarily on the character of the local seismicity. The Paradox Basin region (part of the Colorado Plateau) appears to be a region of low-level contemporary seismicity consistent with both the historical seismicity record and geologic evidence, which suggests relative stability in Cenozoic time.

Results/Comparison of Locations. The evaluation of the contemporary and historical seismicity based on the data available at this time indicates that ground motion levels from the maximum credible and/or design earthquake can be accommodated by practical design measures. No seismic issues appear

to exist that would prohibit the siting of a repository in the Paradox Basin. However, questions regarding mining-induced seismicity, the character of subsurface ground motions, and possible seismogenic structures such as Shay graben and the Lisbon Valley fault zone still remain to be resolved.

Contemporary microearthquake data are shown on Figure 5-2. These data suggest that the sources of microseismicity observed within the Paradox Basin are probably not capable of generating large-magnitude earthquakes. Thus, the ground motions from the design earthquake will probably have their source outside the Paradox Basin, where large magnitude earthquakes have historically occurred. Regarding regional tectonic stress, analysis of fault plane solutions from selected microearthquakes and results of hydrofracture tests in the GD-1 borehole indicate that east-west compression is the maximum principle stress in the Paradox Basin.

The primary factors used to compare the Gibson Dome and Elk Ridge locations are their proximity to concentrations of local seismicity and to possible seismogenic features (Figure 5-2). Other factors such as proximity to regional sources of seismicity, mining-induced seismicity, and subsurface ground motion are issues that do not appear to show differences between the locations at this time. The Elk Ridge location is judged to be more favorable than the Gibson Dome location, principally because of its (1) very low level of local seismicity; (2) greater distance from the active source of microseismicity along a segment of the Colorado River northeast of the confluence with the Green River; and (3) greater distance from the nearest possible source of larger magnitude earthquakes – Shay graben.

5.2.6 HUMAN INTRUSION

NWTS Site Performance Criteria (U.S. Department of Energy, 1981a) state that the site shall be located to reduce the likelihood that past or future human activities would cause unacceptable impacts on system performance.

5.2.6.1 Mineral Resources

The following subcriterion from U.S. Department of Energy (1981a) is the basis for addressing the resources factor:

> "The level of evaluation necessary to assess the likelihood of human intrusion will increase with the value of and the proximity of the site to exploitable features or resources such as water, thermal energy, petroleum, or minerals."

Resources are specified for careful study in proposed U.S. Nuclear Regulatory Commission (1981b) regulations [10 CFR 60, Section 60.123 (b, 1, 3)].

Significance. Resource potential is significant for two reasons: (1) known resources could be a target for future exploration, which might lead to a breach of the repository; and (2) resources in the vicinity of a repository site might have to be indefinitely withdrawn from use. Because resource exploration will continue for the foreseeable future, the problem is one of evaluating the potential for future penetration and of estimating the value and amounts of resources. The future-penetration problem could be mitigated by locating sites to avoid areas containing large amounts of valuable resources.

Data Acquisition Methods. Data regarding location of boreholes were obtained primarily from available literature and from petroleum information broker services. In addition, a recent report on the resource potential of the four study areas was utilized (Merrell and Utah Geological and Mineral Survey, 1979). These sources were supplemented by discussions with mineral industry consultants and by limited field reconnaissance checks.

Adequacy of Data. These data were judged to be adequate for this area level of investigations. For later, more detailed studies of smaller potentially favorable areas, additional inventories (such as the National Uranium Resources Evaluation files in Grand Junction, Colorado) should be utilized.

Results/Comparison of Locations. Evaluation and comparison of resource potential in or near the two locations focused on uranium, oil and gas, potash, brines, carbon dioxide, coal, geothermal energy, and potable water. These commodities are listed above in general order of decreasing current economic importance and future potential.

There is no current commercial production of mineral resources in either location. The uranium occurrences in these locations are restricted to the Chinle and Cutler formations, situated far above the potential repository layer. Any additional uranium exploration would not significantly impact on the repository.

The Elk Ridge location is judged to have a relatively low potential for discovery of the above listed resources. Some potential exists for small oil and gas accumulations in reef traps, but no such discoveries have been made in or near the location.

The Gibson Dome location is judged to have a slightly higher potential for potash, oil, and gas resources. Oil has been recently discovered in the Paradox Formation 14 miles northeast of the location boundary, but no production has occurred within the location or study area. Minor potash mineralization within the Paradox Formation (absent at Elk Ridge) is present 2 kilometers north of the Gibson Dome location. However, the thinness, low grade, and great depth of these deposits currently precludes development.

5.2.6.2 Exploration History

The topic of exploration history was addressed during screening in Section 4.2.4 in terms of distance from boreholes extending below the surface-accessible environment. Most of these boreholes have penetrated the upper contact of the Paradox Formation, and many extend into the Mississippian Leadville Limestone. The Gibson Dome and Elk Ridge locations were delineated more than

2 kilometers from any known borehole. Therefore, these locations are equally favorable with respect to distance from boreholes. The density of boreholes in the vicinity of both locations is sparse.

Additional features of exploration history in and near these locations are mining excavations, consisting of surficial test pits; shafts less than 100 feet deep; and horizontal adits extending, at most, a few hundred feet. All of these excavations are surficial with respect to the potential repository depths of 1,000 to 3,500 feet.

5.2.6.3 Land Ownership/Access

The following subcriterion from U.S. Department of Energy (1981a) is the basis for addressing the land ownership/access factor:

> "The site shall be located on land for which the federal government can obtain ownership, control access, and obtain all surface and subsurface rights necessary to ensure that surface and subsurface activities at the site will not cause unacceptable impact on system performance."

Significance. Land ownership and access must be identified in order to judge adequately the availability of the repository site. The site should be located on land that the federal government can obtain easily and maintain permanently. Dedicated lands difficult to acquire typically include wilderness areas and national parks and monuments. Acquisition of land is a major differentiating factor. The federal government must be able to control and monitor all activities on the site to properly protect the facility.

Data Acquisition Methods. Data regarding land ownership in the Gibson Dome and Elk Ridge locations were obtained primarily from available literature. Information was also acquired from federal, state, and county agencies. A search of maps, photographs and literature, and contacts with state experts were used to determine potential land rights conflicts.

Adequacy of Data. These data were judged to be adequate for this level of investigation. As smaller, potentially favorable, areas are identified, more detailed studies of specific land ownership and rights should be conducted.

Results/Comparison of Locations. During this area characterizaion phase of study, little evidence was found that acquisition of land would be difficult at Gibson Dome or Elk Ridge. A large percentage of these lands is federally or state owned, which indicates that much of it is available. Land ownership/access is not a differentiating factor in this case because both locations have the same potential availability.

Although the Gibson Dome location is situated in a BLM designated Multiple-Use area it is utilized primarily for recreational and agricultural purposes, so there are few developed land uses. Visitors to Canyonlands National Park, however, have access to the park via jeep trails through the location. In addition, only a small percentage of the land is privately owned.

Much of the Elk Ridge location is federally owned public land used for unimproved grazing. The Manti-La Sal National Forest covers part of the location. However, available national forestland is used primarily for recreation, and may be difficult to acquire for repository development. Information indicates that land is available in the Elk Ridge location.

5.2.7 SURFACE CHARACTERISTICS

NWTS Site Performance Criteria (U.S. Department of Energy, 1981a) state:

"The site and its surrounding area shall be such that surface characteristics or conditions can be accommodated by engineering measures and can be shown to have no unacceptable impacts on repository operation and system performance."

5.2.7.1 Surficial Hydrologic System

The following subcriterion from U.S. Department of Energy (1981a) is the basis for addressing the surficial hydrologic system:

"The site shall be located so that the surficial hydrological system, both during anticipated climatic cycles and during extreme natural phenomena, will not cause unacceptable impacts on repository operations or system performance."

Factors that address this subcriterion include the fluvial cycle and the floodplain disposition. The factors will be considered together.

Significance. An understanding of the surficial hydrologic system is necessary to evaluate the potential for flooding of surface facilities. Flooding could critically impede surface construction and operation of the facility. Also, the potential for surface-water contamination – either directly from aboveground facilities or indirectly through ground-water cross-contamination – must be assessed.

Methods of Data Acquisition. Pertinent data were obtained from aerial topographic maps and stream and gauging station information.

Adequacy of Data. Flood data for the small drainage basins found within the locations are scarce. This is partly because of the lack of gauging stations located on these intermittent streams and the low interest in collecting such data in such unpopulated and undeveloped land. Because of the low probability of one of these scattered gauges being in the path of a typically localized cloudbust storm, precise records of the resultant cloudburst floods are scarce. Hydrologic system information was acquired from gauging stations and available literature.

Results/Comparison of Locations. No major streams, lakes, or reservoirs occur within the Gibson Dome or Elk Ridge locations, but a number of small

springs and reservoirs do flow around and in the locations. The effects of the fluvial cycle are similar for both locations, so no preference is indicated.

A 500-year flood is defined as a flood of the magnitude that occurs on the average of once every 500 years. A flood of this size can destroy or damage all materials in its path. Proper engineering design and evacuation procedures are mandatory in flooding areas in order to be properly prepared. The repository facility would require mitigating measures during both construction and operation.

The Gibson Dome location has a significant percentage of land area inundated by a 500-year flood (Figure 5-3), whereas the Elk Ridge location does not contain a significant floodplain area (Figure 5-4). Therefore, this is a major differentiating factor. Elk Ridge is the preferred location based on the flooding factor.

5.2.7.2 Surface Features and Conditions

The following subcriterion for U.S. Department of Energy (1981a) is the basis for addressing the surface features and conditions factor:

> "The site shall be located so that the surficial hydrological system, both during anticipated climatic cycles and during extreme natural phenomena, will not cause unacceptable impacts on repository operations or system performance."

Significance. Nearby surface-water bodies, impoundments, embayments, streams, floodplains, runoff, and drainage must be evaluated for their effects on the repository. Specific areas that will be affected are surface and subsurface facilities and onsite access corridors during both the operational phase of the repository and the long-term isolation phase of the disposal system.

Data Acquisition Methods. Information on the surface features of the two locations was obtained by examination of available literature.

Adequacy of Data. These data were judged to be adequate for this level of investigations. More detailed surface conditions data, mainly concerning flooding, will be useful for more precise studies of environmental impact prediction.

Results/Comparison of Locations. Because the surface features and conditions encountered in the Gibson Dome and Elk Ridge locations are similar, with the exception of flooding, the impact on repository construction and operation is essentially the same. Information on flooding was provided in Section 5.2.7.1; on that factor, Elk Ridge is preferred to Gibson Dome.

5.2.7.3 Surface Topographic Features

The following subcriterion from U.S. Department of Energy (1981a) is the basis for addressing surface topographic features:

> "The site shall be located in an area where surface topographic features do not unacceptably affect repository operation."

Factors that address this criterion include accessibility, surface slope, and slope stability. These factors will be considered together.

Significance. Sites in which road and rail access routes encounter steep grades, sharp switchbacks, slope instability, or other potential sources of hazard to incoming waste shipment should be avoided.

Data Acquisition Methods. Data were acquired from the draft topical report Southeastern Utah Nuclear Waste Transportation Study (Bechtel Group, Inc., 1981) and regional topographic maps.

Adequacy of Data. Data obtained are adequate for this study.

Results/Comparison of Locations. The proposed railroad routes to the Gibson Dome and Elk Ridge locations vary greatly. The Gibson Dome route is 32 miles and covers smoother terrain; the Elk Ridge route is 99 miles and covers rough terrain. Because of these factors the Gibson Dome railroad route makes Gibson Dome the preferred location.

Surface slopes and slope stabilities at both locations are variable. From available maps, it is difficult to determine the exact terrain configurations at specific places within the two locations, although Elk Ridge appears to have slightly rougher terrain. Both locations contain land slopes greater than 10 percent in many places that could cause stability and/or access problems (see Figures 5-5 and 5-6). Both locations, however, also contain areas of relatively level terrain. Because topographic factors are not distinguishing between the locations, they are not considered principal differentiating factors.

5.2.7.4 Meteorological Conditions

The following subcriterion from U.S. Department of Energy (1981a) is the basis for addressing meteorological conditions:

> "The site shall be located where meteorological phenomena can be accommodated by engineering measures and can be shown to have no unacceptable effect on repository operation."

Factors addressing this subcriterion include flash floods, avalanche, high wind, tornadoes, and hurricanes.

Significance. Meteorological conditions information is important for assessing the potential danger of structural damage to the facility. Data

on the frequency and intensity of severe weather are pertinent in establishing design criteria for aboveground facilities and vents and access ways to subsurface facilities.

Data Acquisition Methods. Information on meteorological conditions was found through regional literature searches of federal, state, and academic publications, meteorological surveys, and gauging stations.

Adequacy of Data. At this level of study the data collected in the literature search are fairly adequate. These data, however, are not detailed enough to differentiate between the two locations.

Results/Comparison of Locations. The data base of the meteorological conditions available at this time indicates that severe weather can be accommodated by practical design measures. No meteorologic conditions appear to exist that would prohibit the siting of the repository at either Gibson Dome or Elk Ridge. This subcriterion is not a principal differentiating factor. Both locations experience similar meteorological conditions and require the same engineering considerations and design.

5.2.7.5 Nearby Hazards

The following subcriterion for U.S. Department of Energy (1981a) is the basis for addressing the nearby hazards factor:

> "The site shall be located where present and projected effects from nearby industrial, transportation, and military installations and operations can be accommodated by engineering measures and can be shown to have no unacceptable impacts on repository operations."

Factors that address this subcriterion include proximity to transportation routes, industrial/military installations, and gas/petroleum pipelines or storage areas.

Significance. Nearby hazards represent a potential danger to surface facilities. Catastrophes involving industrial, transportation, or military operations could reach the repository and adversely affect or damage surface construction and operation. Interactive land use increases the potential for accidents or incidents that would retard or stop repository work.

Date Acquisition Methods. Data regarding nearby hazards were acquired principally from available literature such as state and county maps and surveys. A search of maps, photographs and literature, and contact with state experts were used to determine nearby hazards.

Adequacy of Data. The data obtained from these sources were sufficient for determining nearby hazards in the location characterization phase.

Results/Comparison of Locations. Evaluation and comparison of nearby hazards in or near the two locations focused on transportation routes, mining activities, and gas/petroleum pipelines or storage areas. Both locations have state highways and uranium exploration in the vicinity; neither have pipelines or storage areas. The Gibson Dome location also has two minor landing strips.

Both areas have the potential for further uranium exploration. However, the small-scale uranium activity is presently restricted to the Chinle and Cutler formations, stratigraphically far from the potential repository layer.

Because a paved public thoroughfare (the extension of Highway 211 constructed and maintained by the National Park Service to provide access to Canyonlands National Park from Dugout Ranch to Canyonlands National Park) crosses the Gibson Dome location and U-95 is near the Elk Ridge location, precautions and engineering measures may be necessary to protect the repository. When a specific site is chosen, the impact of the highway can be better assessed.

The minor landing strips on the Gibson Dome location have a low hazard potential. No landing strips are located near Elk Ridge.

5.2.8 DEMOGRAPHY

NWTS Site Performance Criteria (U.S. Department of Energy, 1981a) state that "the site shall be located to minimize the potential risk to and potential conflict with the population."

5.2.8.1 Human Proximity

The following subcriterion from U.S. Department of Energy (1981a) is the basis for addressing the human proximity factor:

> "The site shall be located in an area of low population density and at a distance away from population concentrations and urban areas."

Significance. The proximity of human populations and activities is significant for the following reasons: (1) potential risk to human health from the inadvertent release of radioactivity from waste materials; and (2) maintenance of security of the repository facilities. The risk of vandalism or sabotage in a remote area will be decreased as unauthorized human activity in and around the repository will be more obvious. As the storage of nuclear wastes may be a highly political and emotional subject for some time, sites should be selected to avoid areas that have a high potential for large population growth or expanded human activity. Transient tourist populations will be addressed as described in Section 13.7.2.9 of ONWI-301.

All factors will be considered together.

Data Acquisition Methods. Data regarding population densities and centers were obtained from published sources — primarily the U.S. Bureau of the Census and the Utah State Planning Coordinator's Office.

Adequacy of Data. The collected data are adequate to characterize current population levels and to reasonably project future levels.

Results/Comparison of Locations. The only urban center in the Gibson Dome area is Moab with a 1980 population of 5,300. This represents an 11.3 percent increase over 10 years and an actual increase of 540 persons. Moab is located 20 miles from the proposed site.

The city of Blanding, 20 miles from the Elk Ridge location, had a 1980 population of 3,100 and has experienced a growth rate of 38.6 percent over the preceding 10 years, which is an actual increase of 870 people.

Both cities are located far enough away from the respective proposed repository locations that the health and safety of their residents will be ensured in the event of the release of radioactivity at the repository. The populations of both cities are small, thereby posing a minimum security hazard to the repository.

There is not a significant difference in the population densities of the two locations; both are estimated to be about 1.2 persons per square mile.

With current growth patterns neither city is expected to become a large urban area by the year 2000. There is no indication that the population density of either area will increase significantly.

Both cities and the areas surrounding the repository site would experience a population increase, estimated at 4,800 people for 30 years, because of the operation of the repository.

5.2.8.2 Transportation Risk

The following subcriterion from U.S. Department of Energy (1981a) is the basis for addressing the transportation risk:

"The site shall be located such that risk to the population from transportation of radioactive wastes and from repository operation can be reduced below acceptable levels to the extent reasonably achievable."

Significance. The transportation of spent fuel through populated areas or along public highways may pose a radioactivity exposure risk to the populace, particularly in the case of a collision, derailment or other accident. If an accident were to occur near a water drainage, radioactive wastes could enter the watershed of nearby residents. Collapse of a tunnel or bridge while in use by a spent fuel carrier could result in exposing people to a radioactive hazard.

All factors will be considered together.

Data Acquisition Methods. The data have been extracted from the draft report Southeastern Utah Nuclear Waste Transportation Study (Bechtel Group, Inc., 1981). The report data were acquired by literature studies, topographic and archaeological evaluations, and field studies.

Adequacy of Data. The data are adequate for this level of study. Several routes have been studied for the two sites. Selection of a route for each site will enable a more accurate evaluation for this subcriterion.

Results/Comparisons of Locations. The four points of consideration of the transportation risk are: (1) proximity of route to a population center, (2) proximity of route to a public highway, (3) proximity of route to a water concourse, and (4) number of bridges and/or tunnels along the route.

The Gibson Dome routes pass through less rugged country and require few major bridges and tunnels. These routes cross water courses as do the Elk Ridge routes, but are much shorter and thus require fewer minor bridges and viaducts and pose less risk to the watershed in the case of an accident.

The Gibson Dome location offers safer access routes considering the points of bridges/tunnels, water courses and highways. The Canyon route to the Gibson Dome also avoids urban centers, the main advantage of the Elk Ridge southern routes.

5.2.9 ENVIRONMENTAL PROTECTION

NWTS Site Performance Criteria (U.S. Department of Energy, 1981a) state that "the site shall be located with due consideration to: potential environmental impacts; air, water, and land use; and ambient environmental conditions."

5.2.9.1 Environmental Impacts

The following subcriterion from U.S. Department of Energy (1981a) is the basis for addressing the environmental impact factors: "The site shall be located with due consideration to potential environmental impacts."

Factors that address this subcriterion include: (1) flora and fauna; (2) ecosystem characteristics; (3) spoil disposal; (4) threatened and endangered species; (5) natural resources; (6) noise and odor; (7) air and water quality; and (8) wetlands. These factors are considered separately.

5.2.9.1.1 Flora and Fauna

Significance. The construction and operation of the repository will have some potential adverse environmental effects with regard to flora and fauna. The destruction of plants and animals during construction and the removal of available habitat during construction and operation of the repository is an impact that cannot be mitigated. Potential secondary effects include the disruption of nearby habitats by noise and dust pollution, the impact of construction and use of railroad and road corridors; the potential disruption caused by the presence of up to 1,600 persons during construction and 1,250 during repository operation; and the increased environmental burden caused by any general population growth resulting from the increased area employment. A breach of the repository

integrity resulting in radionuclide migration to the biosphere could have significant and long lasting adverse effects on nearby flora and fauna.

Data Acquisition Methods. Information on the numbers and variety of flora and fauna was obtained by examination of the available literature.

Adequacy of Data. These data were judged to be adequate for this level of investigations. More detailed flora and fauna population counts may be useful for more precise studies of environmental impact prediction.

Results/Comparison of Locations. Although the types of flora and fauna encountered in the Gibson Dome and Elk Ridge locations are different, the magnitude of the impact of repository construction and operation is essentially the same for each location. Rail construction and operation impacts may be more significant for the Elk Ridge location because of its greater distance from existing major rail lines. Overall, no preference of one location over the other is indicated by flora and fauna considerations.

5.2.9.1.2 Ecosystem Characteristics

Significance. Certain ecosystems are more fragile and less likely to reestablish themselves after disruption by construction and operation activities and associated environmental stresses. The site should be chosen which has the least fragile, most reclaimable ecosystem.

Data Acquisition Methods. Information on area ecosystems was determined by examination of available literature with special attention to publications of the Utah Department of Natural Resources and the U.S. Forest Service.

Adequacy of Data. These data were judged to be adequate for the current level of investigation.

Results/Comparison of Locations. The Gibson Dome location is predominantly a desert shrub ecosystem, and the Elk Ridge location is a pinyon pine-juniper

community. Each of these ecosystems if fairly resilient, although the pinyon pine-juniper ecosystem has a longer recovery time. A slight preference for the Gibson Dome location is indicated on the basis of ecosystem characterization.

5.2.9.1.3 Spoil Disposal

Significance. The environmental significance of spoil disposal is demonstrated by the concern for adverse environmental effects evident in the wording of the Resource Conservation and Recovery Act. The 8 million tons of unreturned spoil will have to be disposed of in accordance with regulations associated with the act. Geological differences in the two sites could produce a difference in the quality of the spoil to be disposed of.

Data Acquisition Methods. Data were obtained by examination of the available literature.

Adequacy of Data. These data were judged to be of sufficient detail and scope for the current level of investigation.

Results/Comparison of Locations. For purposes of solid waste disposal, the characteristics of the spoil removed from each location would be identical. Disposal location and design would not be influenced by location choice. Spoil transportation environmental impacts would be approximately the same regardless of repository location. No location preference is indicated on the basis of the spoil disposal factor.

5.2.9.1.4 Threatened and Endangered Species

Significance. The United States and the State of Utah are committed to affording special protection to species of flora and fauna that are threatened with extinction. Actions that further endanger these species or reduce their habitat are not acceptable.

Data Acquisition Methods. Data on the presence of endangered species were obtained by examination of the available literature.

Adequacy of Data. Based on current knowledge of the habitat requirements of the species in question, the data were judged to be adequate for this level of investigation. More detailed studies may be required for more site-specific suitability studies.

Results/Comparison of Locations. Two endangered fish species, the humpback chub and the Colorado squawfish, and two fish species proposed for addition to the endangered species list, the humpback sucker and the bonytail chub, inhabit the Colorado and Green rivers, both of which receive runoff from both of the locations. Improperly mitigated construction activity could result in a heavy sediment load to these rivers, damaging the endangered species habitat. Since runoff from the Gibson Dome location would flow more directly into these waters than runoff from the Elk Ridge location, the impact on the receiving waters would be more substantial from improperly mitigated construction at the Gibson Dome location.

Two bird species, the bald eagle and the peregrine falcon, are residents of the general area. Construction at the Gibson Dome location would result in no loss of habitat for either species. Construction at the Elk Ridge location may involve some loss of habitat for the bald eagle. Associated environmental pressures, including increased population and traffic, may have an adverse effect on the two species regardless of location.

A single mammal species, the black-footed ferret, may be present in either location. No difference between environmental impact on this species between the Gibson Dome and the Elk Ridge locations can be determined at this time.

A total of 23 proposed threatened or endangered plant species are found in San Juan County, Utah. Specific environmental impact on these species by construction and operation of the repository would probably be fairly limited at either location. Quantitative comparison of impacts on these species requires further study.

On the whole, endangered species considerations do not indicate preference of one location over the other.

5.2.9.1.5 Natural Resources

Significance. The existence of mineral resources in the repository area is of great significance in choosing a location. The repository would remove these resources from availability for exploitation. In addition the presence of valuable mineral resources near the repository increases the chance of violation of the repository integrity.

Data Acquisition Methods. Information on natural resources in the study locations was obtained through literature examination.

Adequacy of Data. These data are deemed adequate for the purposes of this study. The data are being continually updated.

Results/Comparison of Locations. Several vanadium and uranium mines, mostly inactive, are located in the Elk Ridge area. A smaller number are present in the Gibson Dome location. There is no current commercial production of mineral resources in either location. The small-scale uranium occurences in these locations are restricted to the Chinle and Cutler formations, stratigraphically far above the potential repository layer. Any additional uranium exploration would not significantly impact on the repository.

The Elk Ridge location is judged to have a relatively low potential for discovery of significant mineral resources. Some potential exists for small oil and gas accumulations in reef traps, but no such discoveries have been made in or near the location. This does not preclude future discoveries or exploration, however, since the need for oil and gas is unlikely to decrease.

The Gibson Dome location is judged to have a slightly higher potential for potash, oil, and gas resources. Oil has been recently discovered in the Paradox Formation 14 miles northeast of the location boundary, but no production has occurred within the location. Minor potash mineralization within the Paradox Formation (absent at Elk Ridge) is present 2 kilometers north of the Gibson Dome location. However, the low grade and great depth of these deposits presently precludes development.

5.2.9.1.6 Noise and Odor

Significance. Noise and odor impacts from construction activities and from increased population and traffic lower the aesthetic value of the environment and reduce the recreation and wildlife habitat use potential of the affected area.

Data Acquisition Methods. Data were obtained through review of the available literature.

Adequacy of Data. Data were judged to be adequate for the current depth of investigation.

Results/Comparison of Locations. Noise and odor pollution is primarily a function of construction and operation process rather than location. No location preference is indicated on the basis of noise and odor environmental impact.

5.2.9.1.7 Air and Water Quality

Significance. Construction and operation of the repository may have an adverse effect on air and water quality due to dust production and increased sediment loads in runoff. Increased traffic and local population will also lower area air and water quality.

Data Acquisition Methods. Information on air and water quality impacts and mitigating measures was obtained by examination of the available data.

Adequacy of Data. These data are deemed adequate for the purposes of this study. For a more quantitative assessment of potential air and water quality degradation more detailed data are required.

Results/Comparison of Locations. Dust emissions from the repository area are expected to be the same regardless of location. These emissions can be reduced by proper dust control measures, including wetdowns and reduction of time of exposure of cleared ground and earth storage piles.

Canyonlands National Park, adjacent to the Gibson Dome location, is a Class I Air Quality area. The Natural Bridges National Monument, near the Elk Ridge location, is a Class II Air Quality area, as are the wilderness study areas near each location. Some degradation of the air quality of these areas may occur. Based on existing information, these data are insufficient to differentiate between the two locations.

Water quality considerations are not significantly different at the two locations because of the intermittent nature of the streams and because any potential water quality impacts from construction and operation will be mitigated at either site.

Secondary impacts resulting from increased traffic and population would be substantially the same for both locations.

5.1.8 Wetlands

Significance. Wetlands are specially protected by state and federal agencies because of (1) the extreme fragility of wetlands ecosystems, (2) their extreme importance in providing breeding and nesting habitats and food sources for a wide range of wildlife, and (3) the large number of wetland areas that have been destroyed by human action.

Data Acquisition Methods. Data acquisition was by review of the available literature.

Adequacy of Data. The data were deemed adequate for the purposes of this study.

Results/Comparison of Locations. Neither the Gibson Dome location nor the Elk Ridge location contains any wetlands.

5.2.9.2 Land Use Conflicts

The following subcriterion from U.S. Department of Energy (1981a) is the basis for addressing the land use conflict factor: "The site shall be located to reduce the likelihood or consequence of air, water, and land use conflicts." Environmental legislation (statutes and regulations) addressing this subcriterion covers the following topics: (1) parks and recreation; (2) industry and agriculture; (3) wilderness; (4) archaeology; (5) forests; (6) endangered species; (7) wild and scenic rivers; (8) wildlife preserves; (9) national parks; (10) historic sites; and (11) military reservations. These factors are considered separately in the following subsections.

5.2.9.2.1 Parks and Recreation

Significance. Visual, air pollution, noise, and odor impacts from the construction and operation of the repository may interfere with recreational land use. Visual impact is of special importance because one of

the most significant aesthetic recreational values in the area is that of the magnificent vistas that are available in a number of locations.

Data Acquisition Methods. Information on recreational land use was obtained by examination of the available literature, including publications of the U.S. Bureau of Land Management (BLM) and the U.S. Forest Service.

Adequacy of Data. The data were judged to be adequate for the limited scope of this investigation. More detailed study of recreational land use conflicts will require more quantitative data.

Results/Comparison of Locations. Important recreational land use near the Elk Ridge location include the vistas of the geologic formations of the Natural Bridges National Monument and the Bears Ears campsite of the Manti-La Sal National Forest. Both of these recreation land use areas are less than 5 miles from the area under consideration. Construction and operation of the repository could have a negative aesthetic impact on this land use, if visible from the dedicated land.

The Gibson Dome location is adjacent to Canyonlands National Park. A number of picnic areas, natural landmarks, and campgrounds are also located near the Gibson Dome location, as is a scenic automobile route. Repository location in the Gibson Dome location could have a negative effect on recreational land use by altering the vistas.

The Elk Ridge location has very little topographic relief, so an NWTS facility built at Elk Ridge could not be shielded by topographic features. At Gibson Dome, there are opportunities for concealing the facility from view in one of the canyons.

5.2.9.2.2 Industry and Agriculture

Significance. Construction and operation of the repository could reduce the agricultural use potential of a small portion of land, reduce the amount of prime farmland, and reduce the mining and petroleum industry use potential of a larger portion of land.

Data Acquisition Methods. Information on agricultural and industrial land use was obtained by examination of the available literature, including publications of the Bureau of Land Management and the Utah Geological and Mineral Survey.

Adequacy of Data. These data were judged to be adequate for the purposes of this study.

Results/Comparison of Locations. The Gibson Dome area is utilized for winter cattle grazing. The productivity of the area is such that 40 acres of rangeland are required to provide one Animal Unit Month (AUM) of grazing. The Elk Ridge area is considerably more productive at 9 acres per AUM. No prime farmland is present at either location.

Both areas are potential mining and petroleum use areas. The Gibson Dome area is somewhat more promising in this regard than the Elk Ridge area, but based on the difference in agricultural productivity, Gibson Dome is the preferred location.

5.2.9.2.3 Wilderness

Significance. The Wilderness Act of 1964 provides a mechanism for setting aside undeveloped lands to preserve their untouched state. The location of a repository on lands set aside for this purpose would therefore be disallowed as an unacceptable land use conflict.

Data Acquisition Methods. Information on wilderness areas was obtained by examination of the available literature, especially publications of the Office of the Federal Register.

Adequacy of Data. The available data are judged to be adequate for the purposes of this investigation.

Results/Comparison of Locations. The Gibson Dome location borders the Bridger Jack Mesa Wilderness Study Area and the proposed Lockhart Basin Wilderness Study Area. The Elk Ridge location is less than 5 miles from the proposed Cheesebox Canyon Wilderness Study Area. Construction and operation activities would require careful mitigation to avoid land use conflicts with the wilderness study areas. Elk Ridge is slightly preferred.

5.2.9.2.4 Archaeology

Significance. Construction of the repository facilities would remove an estimated 400 acres of land from the potential use category of archaeological preservation and study. The construction of road and rail service corridors to the repository would negatively effect still more land. In addition, the increase in population could increase vandalism and destruction of archaeological sites.

Data Acquisition Methods. Information on the presence of sites of archaeological interest was obtained by examination of the available literature, including a cultural resource study by the Bureau of Land Management (Thompson, 1979).

Adequacy of Data. The data were judged to be adequate for the purposes of this study. Specific site selection may require archaeological exploration.

Results/Comparison of Locations. Both locations contain Anasazi archaeological sites from Basketmaker through Pueblo periods. The Elk Ridge location, however, contains archaeological resources that "promise to yield substantial bodies of information that will be lost as a result of certain kinds of activity" (Thompson, 1979), while at Gibson Dome, "site density appears to be low and . . . the sites that do exist tend to be limited activity sites which are all very similar" (Thompson, 1979): mostly chipping stations, with a few campsites. On the basis of archaeological land use conflicts, the Gibson Dome location is preferred over the Elk Ridge location.

5.2.9.2.5 Forests

Significance. Because of their special significance for wildlife habitat and because of their economic importance, forests are given special consideration. Repository construction in a forested area would cause destruction of forest at the repository site and along transportation corridors.

Data Acquisition Methods. Information pertaining to forests in the considered location areas was obtained by examination of the available literature, in particular publications of the BLM and the U.S. Forest Service.

Adequacy of Data. The data obtained were judged to be adequate for the purposes of this study.

Results/Comparison of Locations. No forests occur within the boundaries of the Gibson Dome location. A portion of the Manti-La Sal National Forest is included in the Elk Ridge location. For this reason, the Gibson Dome location is the preferred location on the basis of land use conflict with forests.

5.2.9.2.6 Endangered Species

Endangered species were addressed in Section 5.2.9.1.4.

5.2.9.2.7 Wild and Scenic Rivers

Significance. Because of their special aesthetic value, wild and scenic rivers are afforded special consideration in land use conflict determination. The basis of this special consideration is the Wild and Scenic Rivers Act of 1968.

Data Acquisition Methods. Information on wild and scenic rivers was obtained by examination of the applicable issues of the Federal Register.

Adequacy of Data. The data were judged to be adequate for this study.

Results/Comparison of Locations. No wild or scenic rivers are in or near either location.

5.2.9.2.8 Wildlife Preserves

Significance. The Wilderness Act of 1964, the Wildlife Preservation Act of 1966, and the National Wildlife Refuge Act of 1966 establish mechanisms for establishing wildlife preserves as the principal land use of certain areas and for maintaining the primacy of this use in land use conflicts. Land use that conflicts with wildlife preserves established under these acts is not allowed. Construction of a repository in a widlife preserve would conflict with this land use and would therefore be disallowed.

Data Acquisition Methods. Information on wilderness areas was obtained by examination of the available literature, including publications of the Office of the Federal Register.

Adequacy of Data. The available data are judged to be adequate for the purposes of this investigation.

Results/Comparison of Locations. The Gibson Dome location borders the Bridger Jack Mesa Wilderness Study Area and the proposed Lockhart Basin Wilderness Study Area. The Elk Ridge location is less than 5 miles from the proposed Cheesebox Canyon Wilderness Study Area. Construction and operation activities would require careful mitigation to avoid land use conflicts with the wilderness study areas. No location preference is evident from this factor.

5.2.9.2.9 National Parks

Significance. Visual, air pollution, noise, and odor impacts from the construction and operation of the repository might interfere with recreational land use in the national parks. Of special importance is the visual impact because some of the most significant aesthetic values of the area parks and monuments are the magnificent vistas that are available in a number of locations.

Data Acquisition Methods. Information on national park use was obtained by examination of the available literature, including publications of the BLM and the U.S. Forest Service.

Adequacy of Data. The data were judged to be adequate for the limited scope of this investigation. More detailed study of recreational land-use conflicts will require more quantitative data.

Results/Comparison of Locations. The Canyonlands National Park is located west of the Gibson Dome location. This park contains a number of scenic locations and attracts a large number of tourists each year. Repository location at Gibson Dome might alter the aesthetic value of the park and affect tourism.

The Natural Bridges National Monument is located approximately 2 miles west of the Elk Ridge location. Repository location at Elk Ridge might reduce the aesthetic value of the monument and deter visitors. The Elk Ridge location also has a greater potential for visual impact because it is situated on the open plateau.

This inability to conceal a repository on the open plateau at Elk Ridge contributes to a preference for the Gibson Dome location over the Elk Ridge location.

5.2.9.2.10 Historic Sites

Significance. The protection and accessibility of historic sites is provided for by the National Historic Preservation Act of 1974 and the National Heritage Program. The location of a repository near an historic site may deter visitors. Air and noise pollution consequential of a repository may also reduce the aesthetic value of historic sites. Increased population in the area may increase the pressures of vandalism and destruction of unprotected sites.

Data Acquisition Methods. Information on historic sites was obtained by examination of available literature.

Adequacy of Data. The data were judged to be adequate for the purposes of this study.

Results/Comparison of Locations. The major historic sites in the area are archaeological sites. As noted in Section 5.2.9.2.4, the Gibson Dome location is preferred over the Elk Ridge location on the basis of archaeological land use conflicts.

5.2.9.2.11 Military Reservation

No military reservations are present in the vicinity of either location under consideration.

5.2.9.3 Normal and Extreme Environmental Conditions

The following subcriterion from U.S. Department of Energy (1981a) is the basis for addressing the extreme environmental condition factor: "The site shall be located with due consideration to normal and extreme environmental conditions."

Significance. Even if no environmental impact is expected under normal conditions, extreme meteorological conditions may result in environmental impacts associated with the location of the repository.

Data Acquisition Methods. Information on normal and extreme environmental conditions was found through regional literature searches of federal, state, and academic publications, meteorological surveys, and gauging stations.

Adequacy of Data. The data were judged to be adequate for the purposes of this report.

Results/Comparison of Locations. The possibility of flash floods, high winds, or tornadoes exists for both sites with approximately equal likelihood. Mitigation for these factors includes careful specific siting, emergency preparedness plans, and meteorological monitoring plans. Other extreme environmental conditions such as avalanche and hurricanes are not a possibility of either location.

5.2.10 SOCIOECONOMIC IMPACTS

NWTS Site Performance Criteria (U.S. Department of Energy, 1981a) state that "the site shall be selected giving due consideration to social and economic impacts on communities and regions affected by the repository."

5.2.10.1 Social

The following subcriterion from U.S. Department of Energy (1981a) is the basis for addressing the social issue:

> "The site shall be located so that adverse social and/or economic impacts resulting from repository construction and operation can be accommodated by mitigation or compensation strategies."

Significance. The construction and operation of a radioactive waste repository can have several negative effects on a community, including the displacement of residents, unbalances or changes in the social infrastructures, and conflict within the local industries. The community can experience changes in its demographic composition, income levels, educational requirements for its children, and housing needs. The community may find difficulties in handling an expanding economy. It may experience conflicts in the local distribution of investment capital or in land use or zoning. The local perception of risk is important in terms of avoiding delays in permit and land acquisition and construction by political protests, and in terms of long-term security of the repository.

Data Acquistion Methods. The data are derived largely from literature sources, including the U.S. Bureau of the Census, and the Utah Department of Employment Security.

Data Adequacy. The complete evaluation of the social impact of a major project on small communities is difficult because there is a myriad of interacting variables to consider. However, the data are adequate when used only in the context of site selection. Further studies will be required to determine strategies for mitigating or compensating for specific problems after a site has been chosen.

Results/Comparison of Locations. Moab and Blanding are very similar cities in terms of their demographic composition, occupations, socioeconomic backgrounds and education levels. The cities are expected to have nearly identical populations by the year 2000 without the influence of the repository construction. Both cities and their surrounding areas would experience similar changes if the repository were to be located in their respective vicinities.

Residential displacement will not occur to a large extent in either city or area. It is expected some manual laborers and supervisory personnel will transfer to repository construction or operation jobs from either location.

The social infrastructure of both cities may become more formalized as the populations increase and as set social roles are established. As neither city has any large single industry, no adverse effects caused by competition for laborers or land are expected.

The demographic composition is expected to change somewhat for either city as workers from other areas migrate to the repository jobsite.

The income level of the average resident in the community closest to the site is expected to rise. Identical effects would be expected for either location.

Education and housing requirements will increase as the repository construction force arrives. Both Moab and Blanding would have to prepare for these increasing residential needs. Blanding may be able to accommodate these changes more easily because it has already experienced a rapidly increasing population during the last 10 years.

The community that is close to the repository will experience an expansion in its local and area economy. This should be a positive influence on the local standard of living, although there could be competition for local capital or business investment and land use and zoning as local merchants grow to serve the increased population. These effects are to be expected in either town although more study into the fiscal capacity of each location is warranted.

The local perception of risk by the residents is similar in either location, based on their similarity in local political concerns. This question is difficult to research before the announcement of a repository location and deserves further study.

5.2.10.2 Access and Utility Requirements

The following subcriterion from U.S. Department of Energy (1981a) is the basis for addressing the access and utility requirements:

> "The site shall be located so that adequate access and utility capacity required for the repository either exists or can be provided without unacceptable impact on affected communities."

Significance. The movement of construction equipment and supplies and of waste to the repository during operation can create burdens on highway and rail systems. Both systems must be able to carry these loads and may need to be upgraded if current capacity is not adequate.

In addition, the repository will require a large labor pool to fill labor requirements. If surrounding areas cannot provide sufficient manpower, this commodity must be obtained from outside sources. The same holds true for services and utility connections.

Data Acquisition Methods. Data were acquired from available literature, including census documents and land use maps.

Adequacy of Data. The data available are deemed adequate for this study.

Results/Comparisons of the Locations. Both locations are lacking in manpower, utility connections and access capability. The locations are in remote, sparsely populated areas where such services have not been necessary. In order to make these services available, a labor force must be brought in; utility connections must be hooked up to existing services in other areas; and highways, railways, and airports must be built.

Because access and utility requirements are indistinguishable between the two locations, this subcriterion is not a differentiating factor.

5.3 IDENTIFICATION OF PREFERRED LOCATION

This section uses portions of the data presented in Table 5-1 in order to differentiate between the Gibson Dome and Elk Ridge locations. It should be emphasized that the evaluations and recommendations in this report are based on current thinking and currently available data and may change as more information is developed. Recommendations in this report are intended for consideration by all involved parties, and are not intended to be interpreted as final decisions.

5.3.1 DIFFERENTIATING FACTORS

An examination of the data in Figure 5-1 reveals that certain characteristics of the two locations are very similar, while others are distinctly different. The characteristics that differ between Gibson Dome and Elk Ridge can be used to recommend a preferred location. These characteristics, termed differentiating factors, are listed in Table 5-2.

5.3.2 PREFERRED LOCATION

Each differentiating factor, by itself, suggests that one of the two designated locations is preferred over the other. In Table 5-2, the more favorable location for each factor is indicated with an asterisk. Eight

factors favor Gibson Dome: "thickness of salt cycle 6," "size of area meeting screening criteria," "thickness of shale above repository level," "thickness of shale below repository level," "accessibility," "archaeological sensitivity," "agricultural productivity," and "forests." Four factors favor Elk Ridge: "distance to nearest dissolution feature," "distance to concentrated microseismicity," "distance to nearest suspected Quaternary tectonic fault," and "surface hydrologic system."

Based on the comparison of the two locations using differentiating factors shown in Table 5-2, the Gibson Dome location is judged to be preferable. The factors of salt thickness, thickness of shale above and below the repository, and minimum distance to dissolution features are believed to be the most critical in terms of influencing radionuclide travel path and residence times. Archaeological sensitivity and accessibility are the most important environmental factors.

At Gibson Dome, the Lockhart Basin dissolution feature and the Shay graben (Figure 5-1) will be siting issues to be addressed in later phases of study. In addition, the evaluation of seismic reflection and other geophysical data will continue in order to identify any additional subsurface structures not yet detected. The probability of detecting any presently unknown surface faults is judged to be low.

5.3.3 CHOICE OF PREFERRED PLACE AT GIBSON DOME

The Gibson Dome preferred location is 57 square miles in area. The comparison factors of cliff loading stress, topography, and potential flooding have been used to identify parts of this location that are relatively less favorable compared to the remainder of the location (Figure 5-7). That part of the location outside of the less favorable cliff loading zone is more favorable for siting of subsurface workings. Those parts of the location outside of the less favorable topography and

potential flooding zones are more favorable for surface workings. The remaining portions of the location (the unshaded area) are the most favorable portions of the Gibson Dome location. By definition, any place within the unshaded area of Figure 5-7 is acceptable for repository surface facilities, based on major geologic and environmental siting criteria, and other factors including topography, flooding, and lithostatic pressure increases from nearby cliffs. Subsurface facilities could be located anyplace within the boundary of the more favorable zone, as delineated on Figure 5-7.

Much of the data presented earlier in this chapter (and used to evaluate Gibson Dome vs. Elk Ridge) lacks the specificity to further differentiate between places within the most favorable zone of the Gibson Dome location. The meteorological data, for example, pertain to the general Utah/Four Corners region. Negligible differences in socioeconomic conditions would result from the choice of different places within the location because the area is predominantly rural. Demographic and economic data are similar throughout the region. Geologic conditions are relatively uniform throughout the favorable zone.

Numerous site performance criteria are currently under study by the RPM. Data are being collected on socioeconomics, threatened and endangered species, transportation risks and other factors. Based on existing knowledge, it is difficult to choose between different places within the Gibson Dome location on the basis of archaeological sensitivity. Site-specific archaeological investigations will provide data to further evaluate potentially suitable places to site an NWTS facility.

At this stage of the siting process, site selection involves close inspection of the preferred location, with emphasis on examining such distinguishing features as topography, access and aesthetics. Much of the intrinsic value of the southeastern Utah environment stems from its scenic and aesthetic character. Alterations to this aspect of the environment must be considered an issue. It will require additional study to determine the impacts of a facility on the visual resources of the area. However,

a facility located in any of the more open areas could be perceived as obtrusive. In particular, the visual impacts of the NWTS facility and rail line at Gibson Dome from State Highway 211 and Canyonlands National Park are key items in choosing a site. Aesthetic considerations are a key item in making the level, open areas in the northern portions of the location unattractive for siting.

The considerations discussed above indicate that the favored sites for an NWTS facility in the Paradox Basin lie in more concealed places in the southern part of the Gibson Dome preferred location (delineated in Figure 5-7) that are simultaneously within the more favorable zones for surface facilities and subsurface workings. Davis Canyon and Lavender Canyon are two prime examples of places that meet these siting criteria. The actual site of a principal borehole and subsequent test shaft facility will be determined based on more detailed engineering and aesthetic studies and confirmed by upcoming field studies.

Table 5-1

DATA MATRIX

Criterion	Comparison Factors	Gibson Dome Location	Elk Ridge Location	Screening Specification
Site Geometry 5.2.1				
Minimum depth 5.2.1.1	Erosion rate	1 ft/1,000 yrs	1 ft/1,000 yrs	
	Regional Quaternary uplift rate	1 ft/1,000 yrs	1 ft/1,000 yrs	
	Minimum depth at location: Salt Cycle 6	2,400 ft	NA	
	Salt Cycle 9	NA	2,350 ft	
				1,000 ft
Maximum depth 5.2.1.2	Temperature at 3,000 ft depth	86°F	83°, 85°F	
	Maximum feasible depth (regarding engineering)	3,500 ft	NE	
	In situ stress magnitude	Vertical and minimum horizontal ≥ lithostatic; maximum horizontal = 1.5 x lithostatic	NE	
	Maximum depth at location: Salt Cycle 6	3,400 ft	NA	
	Salt Cycle 9	NA	3,500 ft	
				3,500 ft
Thickness of host rocks 5.2.1.3	Thickness: Salt Cycle 6	160-240 ft	NA	
	Salt Cycle 9	NA	70-90+ ft	
	Impurities	Minor amounts of anhydrite. Hydrous saline minerals may be present.	Minor amounts of anhydrite. Hydrous saline minerals may be present.	
				70 ft
Lateral extent of host rocks 5.2.1.4	Subsurface area having potentially favorable characteristics	57 sq. miles	6 sq. miles	
	Potential for encountering complications in repository layer	Low	Low	
				3.1 sq. miles
Geohydrology 5.2.1 Geohydrologic regime/flow 5.2.2.1	Ground-water travel time via Paradox Formation from location to discharge (most probable case)	131,000 yrs	NE	
	Hydraulic communication between repository layer and surrounding units	Little or none	Little or none	
	Vertical hydraulic gradient	Downward flow	Downward flow	

NA = not applicable.
NE = not evaluated.

Table 5-1 (Continued)

Criterion	Comparison Factors	Gibson Dome Location	Elk Ridge Location	Screening Specification
Hydrologic regime modeling 5.2.2.2	Complexity of ground-water flow	Simple	Simple	
	Ability to produce simple defensible model	Excellent	Excellent	
Geohydrologic regime/shaft construction 5.2.2.3	Inflow into shaft	57 gpm	NE	
Dissolution 5.2.2.4	Minimum/maximum distance from location boundary to nearest known dissolution feature	5/17 miles	18/24 miles	
	Activity of dissolution features	NE	NE	
Geochemistry 5.2.3 Ground-water chemistry 5.2.3.1	Geochemical environment of ground water	Reducing Eh -75 mv to -124 mv	NE	
	Host-rock water content (not including water of hydration)	0.01-0.2 wt%		
Retardation potential 5.2.3.2	Radionuclide adsorptive properties	NE	NE	
	Total thickness of shale above repository	155-265 ft	125-142	
	Total thickness of shale below repository	230-480 ft	125-150	
Geologic Characteristics 5.2.4 Geologic characterization 5.2.4.1	Simplicity of geologic setting	Simple	Simple	
	Ability to define surface and subsurface geology	Excellent	Very Good	
	Extent and age of Quaternary deposits	Second best	Best	
	Potential climate changes	NE	NE	
Host rock characteristics 5.2.4.2	Host rock strength	4,300-5,100 psi (unconfined-preliminary)	NE	
	Thermal properties	See Section 5.2.4.2	NE	
	Fracture zone	Few/none	NE	
	Gas content	Low	NE	
	Permeability and porosity	See Section 5.2.4.2	NE	
	Water content (not including water of hydration)	0.01-0.2 wt%	NE	

NA = not applicable.
NE = not evaluated.

Table 5-1 (Continued)

Criterion	Comparison Factors	Gibson Dome Location	Elk Ridge Location	Screening Specification
Non-tectonic deformation 5.2.4.3 .	Location of large-scale gravity slide structures	Needles fault zone 15 miles distant; encroachment not plausible	Needles fault zone 24 miles distant; encroachment not plausible	
Tectonic Environment 5.2.5				
Tectonic element identification 5.2.5.1	Ability to detect surface faults and other tectonic elements	Excellent	Excellent	
	Ability to detect subsurface structures	Adequate	Little available data	
	Presence of anomalous geothermal gradients or volcanoes	None	None	
	General geologic stability of region	Stable	Stable	
	Minimum/maximum distance from location boundary to nearest known surface tectonic fault	5/25 miles (Shay graben)	5/9 miles (Hammond graben)	
Quaternary tectonic faults 5.2.5.2	Minimum/maximum distance from location boundary to nearest suspected Quaternary tectonic fault	5/25 miles (Shay graben)	13/17 miles (Verdure graben)	
	Ability to evaluate quaternary fault displacement on known nearest fault	Good	Fair/poor	
Quaternary igneous activity 5.2.5.3	Distance to nearest center of Quaternary igneous activity	170 miles	135 miles	
Long-term uplift and subsidence 5.2.5.4	Rate of uplift in region	1 ft/1,000 yrs	1 ft/1,000 yrs	
Ground motion from maximum credible earthquake 5.2.5.5	Maximum historical event	$M_L < 3$	$M_L < 3$	
	Character of local seismicity	Concentrated along a segment of the Colorado River 15 miles away	Diffuse, low-level seismicity 25 miles from Colorado River	
	Regional tectonic stress field	E-W compression	E-W compression	
Human Intrusion 5.2.6 Mineral resources 5.2.6.1	Uranium	Minor at or near surface	Moderate to minor at or near surface	
	Oil and gas	None at present; recent recent discovery 14 miles northeast of location boundary	None at present	
	Potash	Minor occurrences north of location	No potential	

NA = not applicable.
NE = not evaluated.

Table 5-1 (Continued)

Criterion	Comparison Factors	Gibson Dome Location	Elk Ridge Location	Screening Specification
	Other minerals	Low potential	Low potential	
	Potable water	Low potential	Low potential	
	Current commercial production	None	None	
Exploration history 5.2.6.2	Distance to nearest boring	2 kilometers	2 kilometers	
	Density of borings in vicinity	Sparse	Sparse	2 kilometers
Land ownership/access 5.2.6.3		Primarily federal, some state and private	Primarily federal, some state	
Surface Characteristics 5.2.7				
Surficial hydrologic system 5.2.7.1	Fluvial cycle	NA, minimal effect	NA, minimal effect	
	Floodplain disposition	In 500-yr floodplain	Not in floodplain	
Surface features and conditions 5.2.7.2	Proximity to dams	None	None	
	Proximity to surface water	Small springs and reservoirs; approximately 2 miles to segment of Colorado River	Small springs and reservoirs	
	Annual cycle	NA, minimal effect	NA, minimal effect	
	Probable maximum flood	Probable inundation by maximum flood (See Section 5.2.7.1)	Minimal flood potential	
	Probable maximum precipitation	Annual average 8-11 inches/year; 100-yr recurrence, 3 inches; 500-yr recurrence, 4-inches	Annual average, 8-20 inches/year; 100-yr recurrence, 3 inches; 500-yr recurrence, 4 inches	
Surface topographic features 5.2.7.3	Accessibility	State highway through location; RR length ½ miles	State highway 2 miles south; RR length 99 miles	
	Slope stability	NA	NA	
	Grades	variable	variable	
Meteorological conditions 5.2.7.4	Flash floods	May occur late spring or summer	May occur late spring or summer	
	Avalanche	None	None	
	High wind	NA, locally variable depending on topography	NA, locally variable depending on topography	

NA = not applicable.
NE = not evaluated

Table 5-1 (Continued)

Criterion	Comparison Factors	Gibson Dome Location	Elk Ridge Location	Screening Specification
Nearby hazards 5.2.7.5	Tornadoes	Tornadoes possible over long time periods	Tornadoes possible over long time periods	
	Hurricanes	None	None	
	Proximity to transportation routes	2 landing strips; state highway through location	1 landing strip; state highway 2 miles south	
	Industrial/military installations	NA, uranium exploration in area	NA, uranium exploration in area	
	Gas/petroleum pipelines or storage	None	None	
Demography 5.2.8				
Human proximity 5.2.8.1	Distance & orientation	Moab, 20 miles north, pop. 5,300	Blanding, 20 miles east, pop. 3,100	
	Population density	1.2 persons/sq. mile	1.2 persons/sq. mile	
Transportation risk 5.2.8.2	Roads, highways, rail	Less risk	Higher risk	
	RR class	None	None	
	Distance to source point (RR)	32 miles	99 miles	
Environmental Protection 5.2.9				
Environmental impacts 5.2.9.1	Flora/fauna	NA, locally diverse	NA, locally diverse	
	Ecosystem characteristics	Predominantly desert shrub	Predominantly pinyon pine-juniper	
	Spoil disposal	NA	NA	
	Threatened/endangered species	NA, 4 fish, 2 birds, 1 mammal listed in county, 23 plants proposed	NA, 4 fish, 2 birds, 1 mammal listed in county, 23 plants proposed	
	Natural resources	Some mineral	Minor mineral	
	Noise, odor	None	None	
	Air, water quality	Canyonlands, AQI	Arch, AQII	
	Wetlands	None	None	
Land use conflicts 5.2.9.2	Parks and recreation	Canyonlands National Park boundary, Bridger Jack Mesa & Lockhart Basin proposed WSA on boundary	Manti-La Sal National Forest; Natural Bridges National Monument	
	Industry and agriculture	Livestock productivity 40 ac/AUM	Livestock productivity 9 ac/AUM	
	Wilderness	Lockhart Basin & Bridger Jack Mesa proposed wilderness study area on boundary	Cheesebox Canyon WSA 5 miles NW	

NA = not applicable.
NE = not evaluated.

Table 5-1 (Continued)

Criterion	Comparison Factors	Gibson Dome Location	Elk Ridge Location	Screening Specification
	Archaeology	Low sensitivity	High sensitivity	
	Endangered species	See threatened/endangered species, 5.2.9.1	See threatened/endangered species, 5.2.9.1	
	Wild and scenic rivers	None	None	
	Wildlife preserves	None	None	
	National parks	Canyonlands National Park, 1 mile west	Natural Bridges National Monument, 6 miles SW	
	Historic sites	See Archaeology, above	See Archaeology, above	
	Military reservations	None	None	
Normal and extreme environmental conditions 5.2.9.3	Secondary impacts associated with high wind, tornadoes, flooding, rainfall, etc.	See 5.2.7.4	See 5.2.7.4	
Socioeconomic Impacts 5.2.10				
Social 5.2.10.1	Residential displacement	None	None	
	Social infrastructure	NA, formalize	NA, formalize	
	Industrial conflict	None	None	
	Demographic composition	NA, change	NA, change	
	Income levels	NA, increase	NA, increase	
	Education	NA, increase need	NA, increase need	
	Housing needs	NA, increase	NA, increase	
	Economic expansion	NA, yes	NA, yes	
	Fiscal capacity	Needs more study	Needs more study	
	Land utilization	NA, 400+ acres surface, 1,500+ subsurface	NA, 400+ acres surface, 1,500+ subsurface	
	Perceptions of risk	None	None	
Access and utility requirements 5.2.10.2	Labor pool	NA, requires 1,800 construction, 1,200 operation	NA, requires 1,800 construction, 1,200 operation	
	Services and utility connections			
	Highways and railways	State highway crosses in north	None	
	Airports	2 private landing strips	1 private landing strip 1 mile NE	

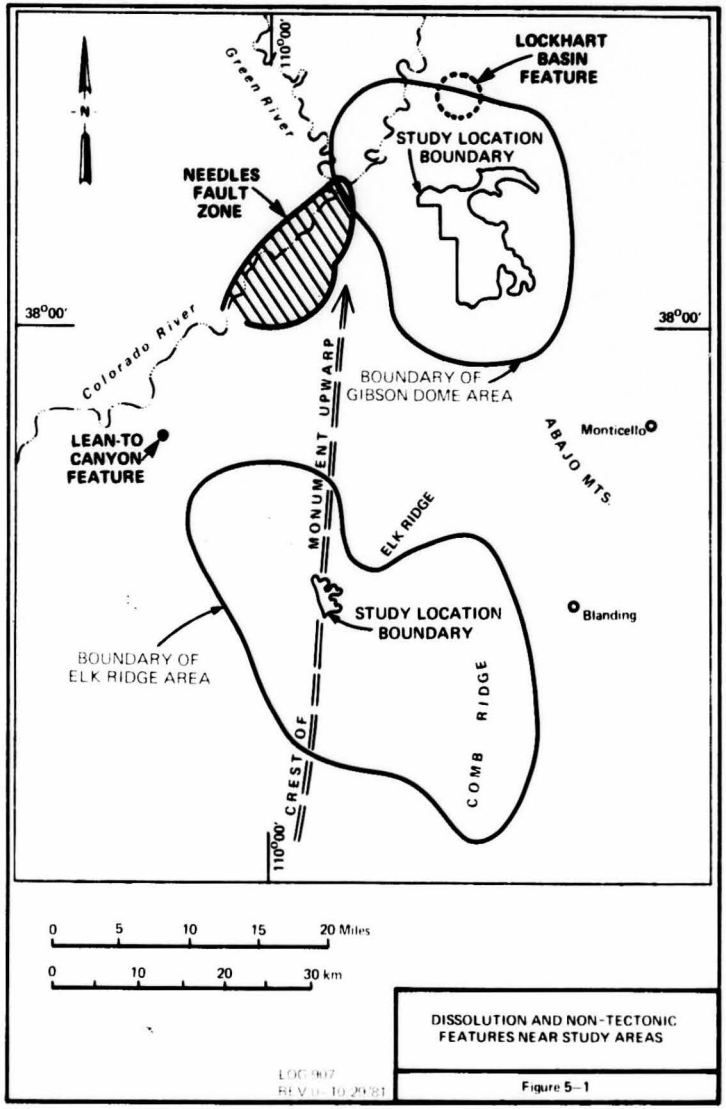
NA = not applicable.
NE = not evaluated.

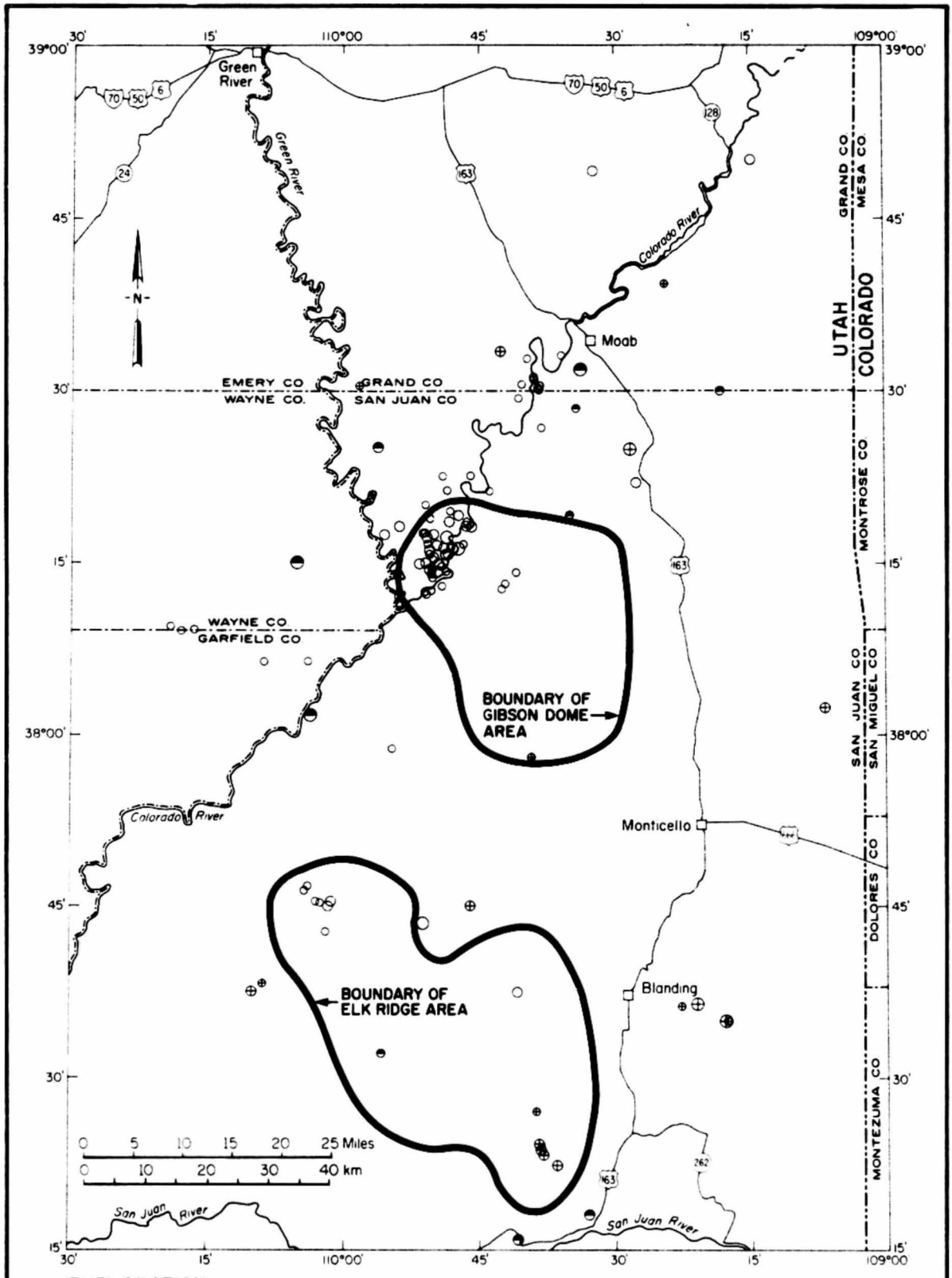
Table 5-2

PRINCIPAL DIFFERENTIATING FACTORS FOR
GIBSON DOME AND ELK RIDGE LOCATIONS

Differentiating Factor	Gibson Dome Location	Elk Ridge Location
Thickness of salt cycle 6	160-240 feet*	70-90+ feet
Area meeting screening criteria	57 square miles*	6 square miles
Thickness of shale above repository	155-265 feet*	125-142 feet
Thickness of shale below repository	230-480 feet*	125-150 feet
Minimum distance to nearest dissolution feature	5 miles	18 miles*
Minimum distance to concentrated microseismicity	15 miles	25 miles*
Minimum distance to nearest suspected Quaternary tectonic fault	5 miles	13 miles*
Surface hydrologic system (floodplains)	500-year floodplain present (See Figure 5-3)	Not in floodplain*
Accessibility	Smoother terrain in much of location; RR length: 32 miles*	Rough terrain RR length: 99 miles
Archaeological sensitivity	Low sensitivity*	High sensitivity
Agricultural productivity	40 acres per Animal Unit Month (AUM)*	9 acres per AUM
Forests	None*	Manti-La Sal National Forest

*Favored location





EXPLANATION

SEISMIC EVENTS

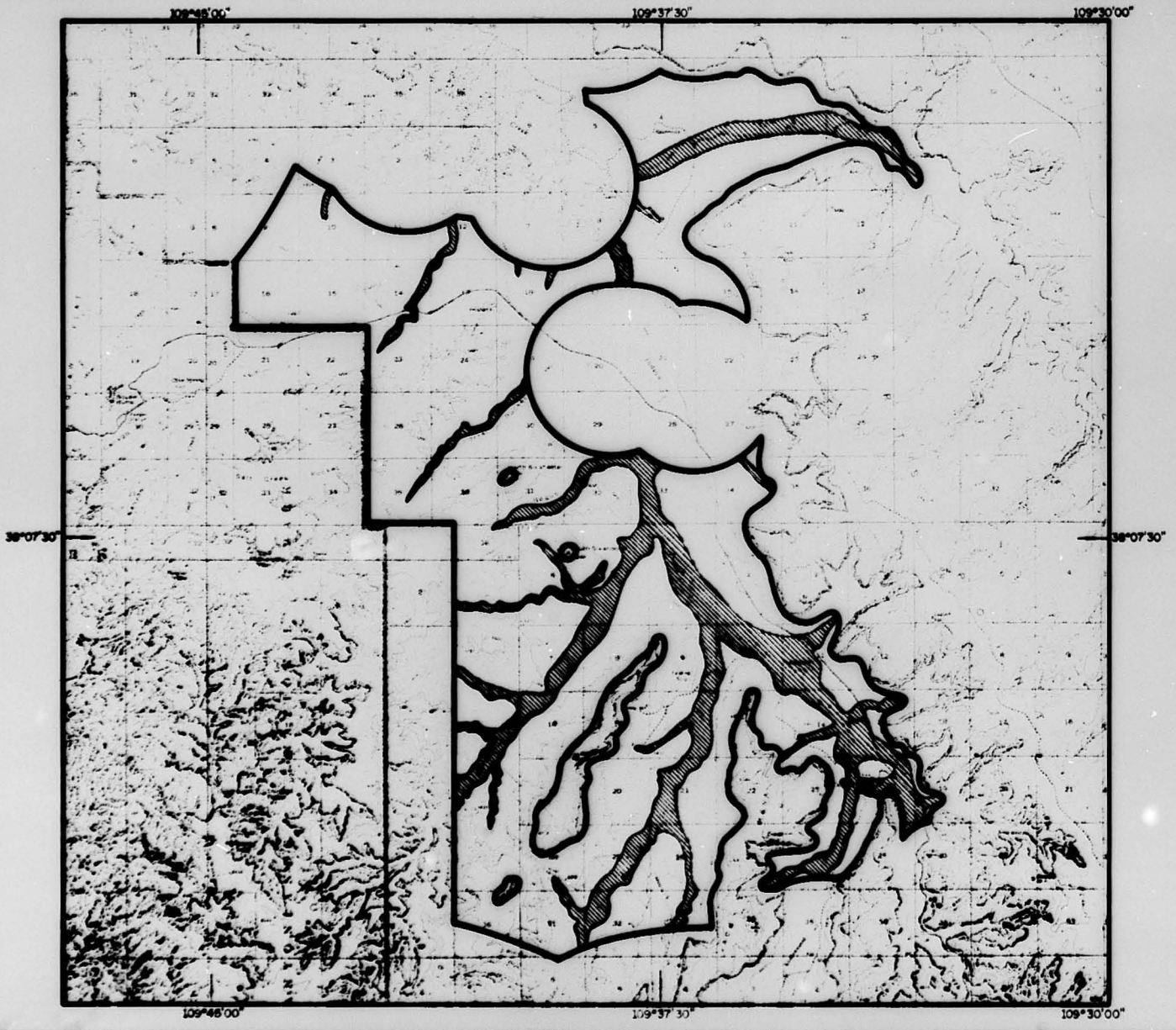
- ○ MICROEARTHQUAKE
- ⊕ SUSPECTED BLAST
- ◒ UNKNOWN ORIGIN
- ○ MAGNITUDE $M_L < 1.0$
- ○ $1.0 \leq M_L < 2.0$
- ○ $M_L \geq 2.0$

SOURCE
WOODWARD-CLYDE CONSULTANTS, 1981a

LOG 879
REV 0-9/11/81

SEISMICITY IN PARADOX BASIN

Figure 5-2



EXPLANATION

BOUNDARY OF DESIGNATED LOCATION

ESTIMATED EXTENT OF 500-YEAR FLOODPLAIN

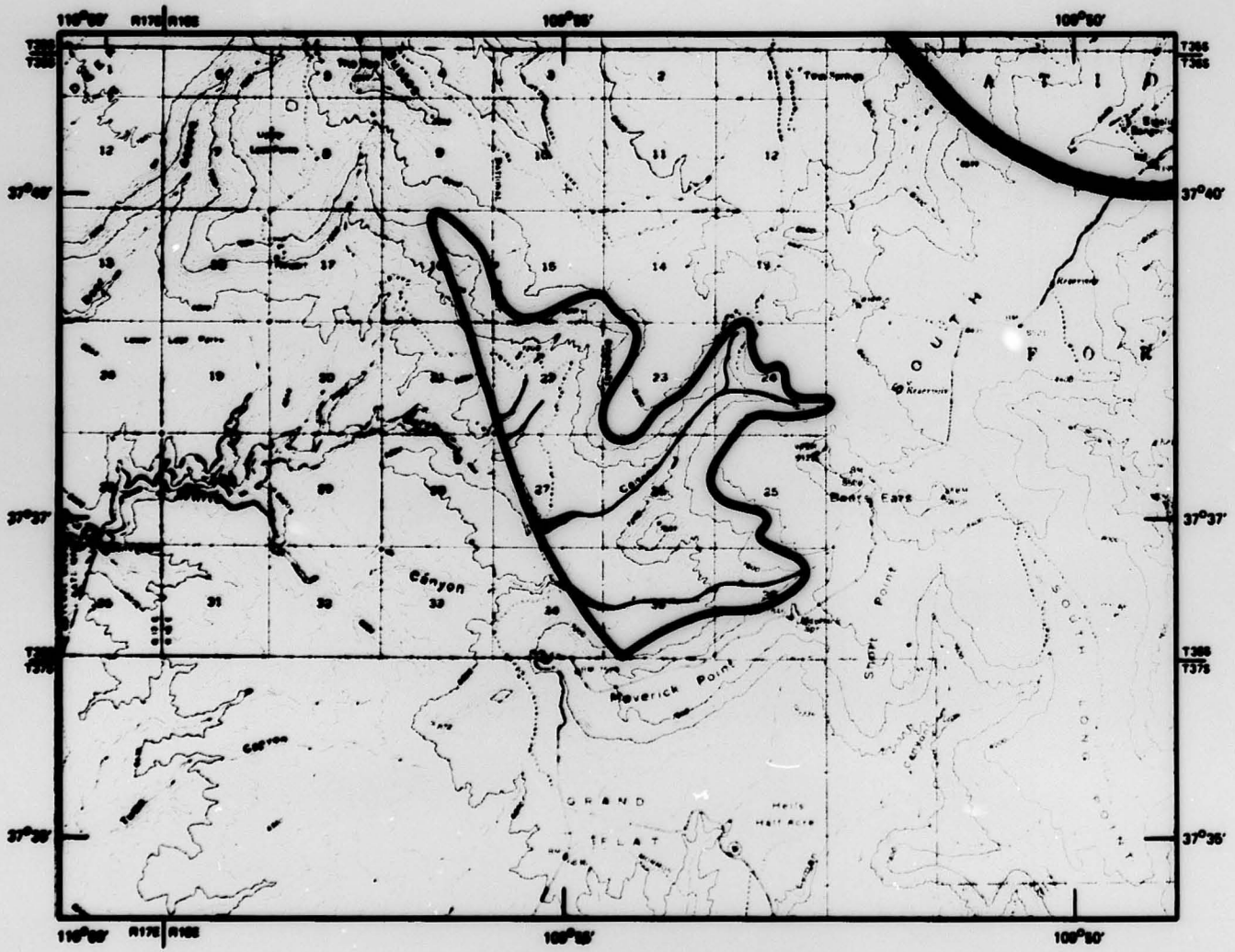
0 1 2 3 Miles

0 1 2 3 4 5 km

ESTIMATED EXTENT OF 500-YEAR FLOODPLAIN GIBSON DOME LOCATION

Figure 5 - 3

LOG 686
REV.0-10/30/81



EXPLANATION

BOUNDARY OF DESIGNATED LOCATION

ESTIMATED EXTENT OF 500-YEAR FLOODPLAIN

0 1 2 Miles

0 1 2 3 km

ESTIMATED EXTENT OF 500-YEAR FLOODPLAIN ELK RIDGE LOCATION

Figure 5-4

LOG 896
REV.0-10/30/81

EXPLANATION

BOUNDARY OF DESIGNATED LOCATION

LAND SURFACE SLOPES EXCEEDING 10% GRADE

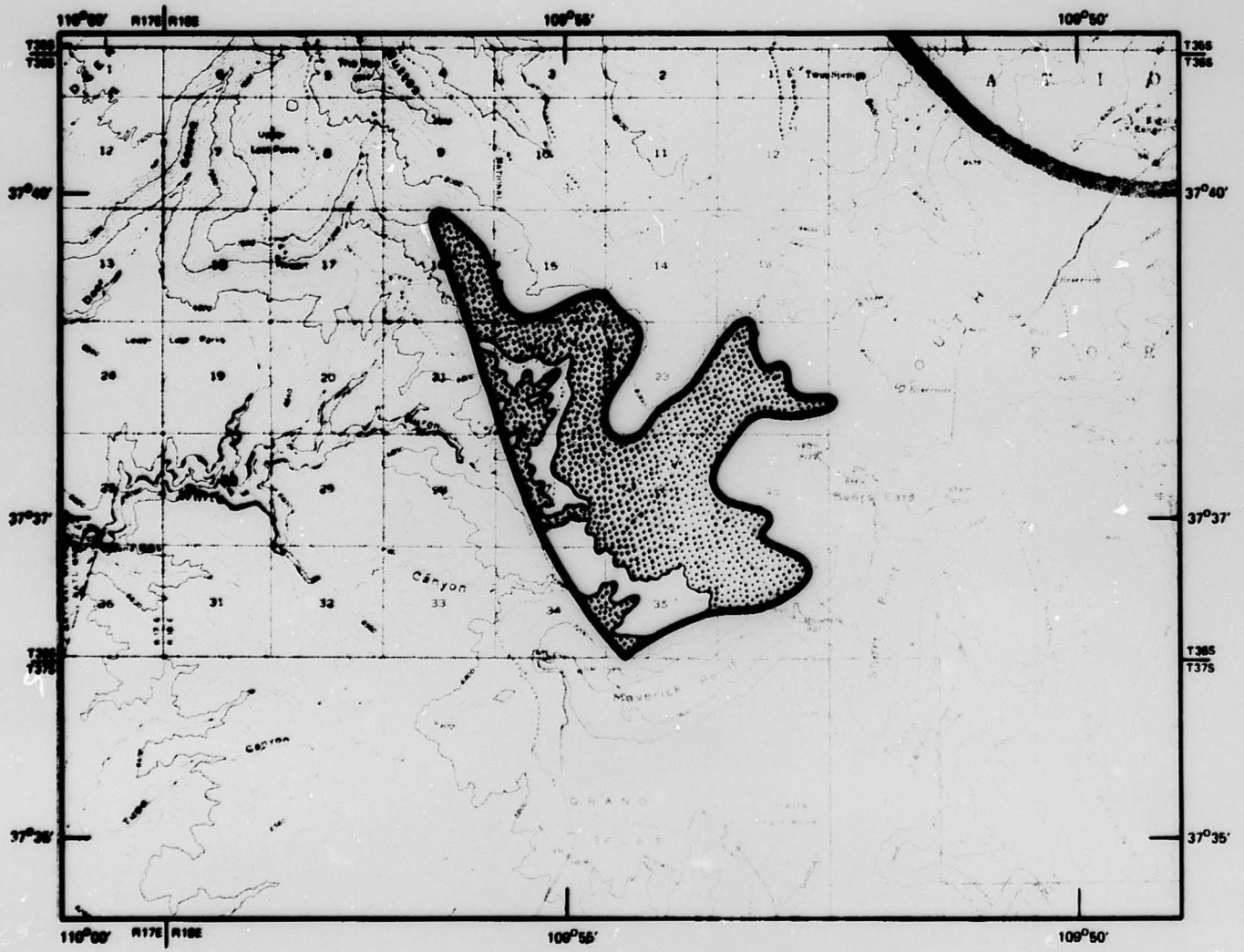
0 1 2 3 Miles

0 1 2 3 4 5 km

SLOPES EXCEEDING 10% GRADE
GIBSON DOME LOCATION

Figure 5-5

LOS 870
REV. 0-20/28/85



EXPLANATION

BOUNDARY OF DESIGNATED LOCATION

LAND SURFACE SLOPES EXCEEDING 10% GRADE

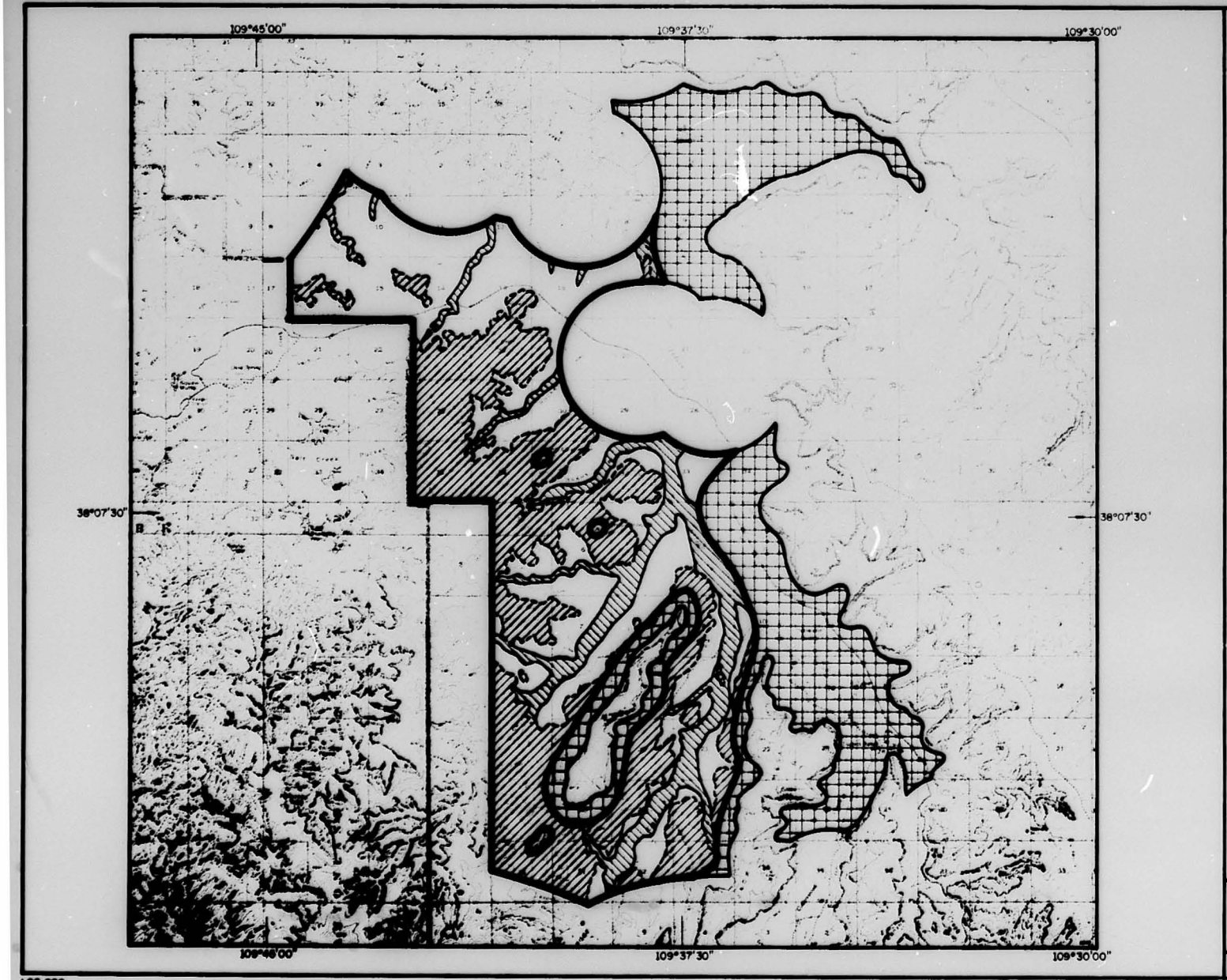
0 1 2 Miles

0 1 2 3 km

SLOPES EXCEEDING 10% GRADE
ELK RIDGE LOCATION

Figure 5-6

LOG 895
REV.0-10/30/81



EXPLANATION

BOUNDARY OF PREFERRED DESIGNATED LOCATION

SUBSURFACE WORKINGS:

LESS FAVORABLE ZONE—CLIFF LOADING: Effective depth of salt including cliff loading stresses greater than 3500 feet

BOUNDARY OF MORE FAVORABLE ZONE: Effective depth of salt less than 3500 feet

SURFACE FACILITIES:

LESS FAVORABLE ZONE—TOPOGRAPHY: Slopes exceeding 10% grade, includes mesa tops and benches surrounded by >10% slopes (located outside of cliff loading less favorable zones)

LESS FAVORABLE ZONE—FLOODING: Areas within estimated 500-year floodplain (located outside of cliff loading and topography less favorable zones)

MORE FAVORABLE ZONE FOR SURFACE FACILITIES:

- Effective depth to salt (considering cliff loading) less than 3500 feet
- Topographic slopes less than 10% grade
- Outside of estimated 500-year floodplain

0 1 2 3 Miles

0 1 2 3 4 5 km

PREFERRED LOCATION GIBSON DOME

Figure 5-7

LOS 909
REV.0-10/30/81

Chapter 6

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Appendix A

COMPARISON OF SITING CRITERIA FOR NATIONAL WASTE TERMINAL STORAGE PROGRAM

Department of Energy NWTS-33(2) NWTS Criteria for the Geologic Disposal of Radioactive Wastes: Site Performance Criteria:	Nuclear Regulatory Commission 10 CFR 60, Subpart E (July, 1981)
I. Site Geometry	
• Minimum Depth	• 60.122(c)(2) - Minimum Depth
• Thickness	• 60.122(a)(9) - Thickness
• Lateral Extent	• 60.122(a)(9) - Lateral Extent
II. Geohydrology	
• Hydrological Regime/ Path Length/Travel Time	• 60.122(a)(1),(a)(2),(a)(3), (a)(4),(a)(9),(b)(3), (c)(1) and (c)(2) - Hydrological Regime/Path Length Travel Time
• Water Bodies/Climatic Cycles	• 60.122(c)(2) - Water Bodies/ Climatic Cycles
• Aquifer Flow/ Construction	• 60.132(c)(2) - Aquifer Flow/ Construction
• Dissolution of Rock	• 60.122(a)(9),(c)(1) - Dissolution of Rock
III. Geochemistry	
• Chemical Interactions	• 60.122(c)(1),(a)(4),(a)(9) (b)(4) Chemical Interactions
• Radionuclide Retardation	• 60.111(c)(4), and 60.122(c)(1) Radionuclide Retardation
IV. Geologic Characteristics	
• Stratigraphy	• 60.122(a)(1-4), (b)(2),(c)(2) Stratigraphy/Host Rock Characteristics
• Host Rock Characteristics	
• Virgin Rock Strength	• 60.122(a)(9) - Virgin Rock Strength
• Geologic Stability	• 60.111(c)(4) - Geologic Stability

V. Tectonic Environment	
• Tectonic Elements	• 60.122(c)(1),(a)(3),(a)(4) - Tectonic Environment 60.122(b)(2) - Tectonic Elements
• Quaternary Faults	• 60.122(b)(2),(a)(2), b(3), Quaternary Faults
• Quaternary Igneous Activity	• 60.122(b)(2) - Quaternary Igneous Activity
• Uplift or Subsidence Rates	• 60.122(b)(2) - Uplift or Subsidence Rates
• Seismicity	• 60.122(b)(2) - Seismicity
VI. Human Intrusion	
• Resources	• 60.122(b)(1),(a)(2-4),(a)(8) - Resources
• Exploration History	• 60.122(b)(1), (a)(8) - Exploration History
• Ownership and Control	• 60.121 - Ownership/Control
VII. Surface Characteristics	
• Hydrological System	• 60.122(b)(3),(b)(1) - Hydrological System
• Water Bodies	• 60.122(b)(1) - Water Bodies
• Topographic Features	• 60.122(b)(1),(b)(3) - Topographic Features
• Meteorological Phenomena	
• Industrial/Transportation Military Installations	• 60.132(b)(3.5-7) - Industrial Transportation/Utility Hazards
VIII. Demography	
• Urban Areas	• 60.122(c)(2) - Urban Areas
• Transportation	
IX. Environmental Protection	
• Wilderness	
• Rivers	
• Wildlife	
• National Parks	
• Archaeology	
• National Heritage	
• Ambient Conditions	
X. Socioeconomic Impacts	
• Management of Impacts	
• Transportation Impacts	

APPENDIX B

Three draft reports were transmitted to the Utah Nuclear Waste Repository Task Force and the National Park Service by the Department of Energy several months ago. The reports and the dates of transmittal are as follows:

ONWI-290, Geologic Characterization Report for the Paradox Basin Study Region, Utah Study Areas, October, 1981

ONWI-291, Paradox Area Characterization Summary and Location Recommendation Report, November 1981

ONWI-301, Paradox Basin Site Characterization Report Preparation Papers, December 1981

On March 11, 1982, comments on these documents were received from the state. The comments were contained in six letters, one letter from Governor Matheson to J. O. Neff of the DOE, three letters from the Working Group chairpersons to the Coordinator of the Task Force, and two letters from Working Group Members to the Working Group Chairperson.

On April 1 and April 15, 1982, additional letters were received from the National Park Service.

A total of 109 comments were contained in these letters. Some of the comments are specifically directed toward items in the referenced reports, while others are of a general nature or are directed toward earlier reports. The 109 comments can be categorized as follows:

Fifty-one comments are directed toward ONWI-301, and one additional comment is assumed to be, although there is some room for doubt.

Twenty-eight comments are directed at ONWI-291.

Four comments are directed toward ONWI-36.

Ten comments are directed to ONWI-92.

Eight comments are general in nature, either referring to reports in general (collectively) or to the philosophy of some aspect of the program but not to any of the reports.

One comment is directed toward a specific criterion that has been adopted for use within the National Waste Terminal Storage Program, and thus can be said to be directed toward document NWTS-33(2), which was released to the public in draft form in January of 1980 and finalized in February of 1981. This comment is also pertinent to both ONWI-36 and ONWI-291, since this criterion was utilized in reaching the conclusions in both of these documents.

All of the comments have been addressed in the order of their receipt. This appendix, which contains both the comment(s) as received, and a response, will be attached to all three of the documents referenced. Comment letters are reproduced as received, with sections of the letters separated by responses to the comments, which are italicized.

SCOTT M. MATHESON
GOVERNOR

STATE OF UTAH
OFFICE OF THE GOVERNOR
SALT LAKE CITY
84114

February 17, 1982

Mr. Jeff Neff
Program Manager
NWTS Office
505 King Avenue
Columbus, Ohio 43201

Dear Mr. Neff:

Enclosed are the comments prepared by the Nuclear Waste Repository Task Force on the ONWI-301 Preliminary Draft (December 1981) and associated documents. Task Force members and their Working Groups have identified a number of serious concerns which will require attention prior to finalization of the document.

I wish to stress the need for sufficient time for state review of documents. In order to provide the DOE with the professional review necessary to protect the interest of the State of Utah, it is imperative that adequate time periods for review be established. Considering the significance of this issue and the complexity of the studies underway, I request a ninety day period for review.

Our's is a difficult task, and one depending largely upon the availability of information from the DOE. I trust that every effort will be made to keep us fully informed of all relevant data. The State of Utah will in turn provide you with a thorough and objective review.

Sincerely,

Governor

SMM:jc
Attachments

MEMORANDUM

February 16, 1982

TO: Governor Matheson

FROM: James Mason, Chairman, Nuclear Waste Repository Task Force

SUBJECT: Comments of the Governor's Nuclear Waste Repository Task Force

ONWI-301: Paradox Basin Site Characterization Report
Preparation Papers and Associated Documents
Gibson Dome Location

General Comments

ONWI-301 does not reflect the State's position, reiterated forcefully at the November 12, 1981 meeting, that a single Environmental Impact Statement (EIS), covering exploration for, construction, and operation of the Exploratory Shaft, the railroad, and the repository, be completed prior to the selection of a site for an Exploratory Shaft; that the main features of these activities can be defined now; that supplements to the single EIS can be prepared as detailed information becomes available.

The question of an EIS is a programmatic decision, not part of a technical work plan, and should not be addressed in this particular document. DOE's records indicate that the "state position" on EIS's was sent to DOE on March 8, 1982, from Governor Matheson to Secretary Edwards addressing a programmatic EIS, not an EIS focused on the exploration shaft. DOE responded to the programmatic EIS position on April 12, 1982. DOE would be interested in corresponding on a state position concerning the scope of the NEPA documentation for detailed site characterization studies if the State would formally submit their position to DOE as part of the review process. DOE has also pointed out to the State that an EA on the exploratory shaft would provide the basis for judging whether an EIS is required and that the State would be afforded an opportunity to review any EA and any findings.

ONWI-301, Site Characterization Report, Preparation Papers, includes a description of detailed field studies and efforts to collect data to resolve key geologic and environmental issues in the Gibson Dome location within the Paradox Basin region of Utah. As such, the contents of this document are in essence a technical work plan for Paradox activities. Applicable information from this Site Characterization Report, Preparation Papers, will be incorporated into the Site Characterization Report (SCR) required by the Nuclear Regulatory Commission (NRC), if the Paradox Basin is selected for an exploratory shaft.

An EIS is required for any major federal action. Clearly such a document will be required for a waste repository. Whether such a document is necessary in advance of an exploratory shaft, is open to question.

ONWI-301, Section 13.7.2, Unresolved Issues and Plans for Resolution, fails to respond to the serious concern about the proximity of the Gibson Dome site to Canyonlands National Park. This concern was solidly established at the public meetings, reaffirmed in subsequent letters to the State, and made clear by the Task Force to DOE staff at the meeting on November 12, 1981. The impacts of the shaft, railroad, and repository on the Park warrant separate, unified consideration in Section 13.7 in place of the present handful of scattered, cursory references.

It is clear that the proximity of the Gibson Dome location to Canyonlands National Park is an issue that must be addressed. In all studies and screening done to date, all National Parks have been excluded from consideration, and there is no reason to believe that this attitude would be modified in the future. Description of potential impacts of a repository near the Park appear to be scattered in ONWI-301 because this report was arranged by technical issue. In discussions with the Utah Task Force, it has been agreed to consolidate the several studies that relate to the Park in a separate report specific to all potential project impacts on Canyonlands National Park. This consolidation will be done on completion of the studies, outlined in ONWI-301, that relate to the park. Section 13.7.2.9 of ONWI-301 now describes these plans.

While the National Park has been considered excluded from siting consideration, is not clear that land adjacent to or in the vicinity of the Park should be considered similarly. There are many National Parks that have intense commercial and/or industrial development immediately outside the Park boundaries; indeed, in many instances the presence of the Park precipitates this development. In the case of a repository, the use of adjacent land would be a temporary arrangement, for a period of 30-50 years, after which the land would be returned to its previous state and on which further development would be severely restricted. The case can be made that for the very long-term, temporary development, restoration, and permanent restrictions on further development is much more compatible with the concept of a National Park than the unplanned development that has occurred in some areas around a number of other National Parks. A fairly sizeable segment of the local population believes that there is no incompatibility between the Canyonlands National Park and a repository at the Gibson Dome location. This includes the San Juan County Commissioners (letters to Governor Matheson and the Department of Energy dated March 9, 1982).

Timely distribution of documents, allowing adequate time for review, has not been regularly made by DOE. Of ONWI Reports 290, 291, and 301, scheduled to be reviewed at the December 15, 1981, meeting, ONWI-201 had not been received beforehand and ONWI-301 was received only in preliminary draft. The Task Force recognizes constraints of time upon DOE. Nevertheless, inadequate advance distribution seriously limits the State's opportunity for full, equal participation in consultation and concurrence. The Task Force has several times requested adequate advance distribution.

The December 15, 1981, workshop was purposely scheduled at the beginning of a 45-day review period to facilitate the initiation of the review. The December 10, 1981, transmittal letter of ONWI-291 and ONWI-301 to J. Mason from J. Neff clearly states that the workshop was to deal only with ONWI-301. The December 11, 1981, memorandum from J. Mason to Members of the Governor's High-Level Nuclear Waste Reporitory Task Force and Work Groups however, incorrectly relates that both reports were to be the subject of discussion at the December 15, 1981, workshop. This is an example of the State of Utah misunderstanding the purpose of the meeting not a case of inadequate advance distribution. Neither of the reports were finalized before the end of the requested comment period of February 1, 1982. Instead the state's comments, received on March 11, 1982, were incorporated into the final report.

ONWI-301 is inadequately referenced to previous ONWI Reports and to related work performed for ONWI by contractors. Tabular display of resolved issues and the bases for resolution, should be provided in a manner comparable to the table of unresolved issues. To avoid unnecessary duplication of effort, the State requests a comprehensive, annotated list of projects and studies contracted in the past to Woodward -Clyde and Battelle.

ONWI-301 has been revised to include a summary of Paradox Basin field studies and previous reports. Refer to Tables 1 and 2 in the Preface of ONWI-301 for this information. If these tables coupled with the May 24, 1982, letter to J. Mason with the list of contractors and ongoing projects does not fulfill your request, please resubmit your request in writing in more detail.

Detailed comments

Section 13.1, Issues Related to Geology
Items requiring consideration:
*Jointing patterns, and concentration of joints.

There are no plans to study joints in any detail during the location phase, the time period covered by ONWI-301. Should work continue into the next phase (site characterization) a plan will be developed to address joints in some detail.

The interest in joints is primarily geohydrological in scope including, for example, evidence of mineralization and leaching along or near joints and continuity of (or lack of) joint sets across formations and effects on the flow regime. The geochemical, mineralogical, geohydrological and geophysical data base developed during the location phase, together with the data base in ONWI-290 and the five regional hydrological reports being prepared by the USGS, will be used to make decisions concerning the types of investigations that should be conducted during the detailed site investigation phase.

*Loading factors related to the filling of Lake Powell.

Earthquake observations in the Glen Canyon/Lake Powell area commenced in 1960, three years before the first loading by the reservoir, and continued through 1968. Seismicity observed in the general area was not attributed to reservoir loading (W. V. Mickey, AGU Geophysical Monograph No. 17, pp 472-479, 1973). There are no project plans to install and operate a microearthquake net at Lake Powell.

*The need for more geophysics to define stratigraphy and structure.

Additional geophysical work is planned during the location phase studies, including additional seismic lines as well as gravity and magnetic data to be obtained and interpreted. A geophysical studies report is scheduled for completion in early 1983. A number of other types of geophysical investigations are currently under consideration, including:

- Vertical seismic profiling
- DC resistivity
- Audio-frequency magnetotellurics
- Telluric profiles
- Additional magnetic and gravity studies
- Heat flow measurements

Any and all of the above work that is carried out during the location phase will be incorporated into the Site Characterization Report that would be submitted to the Nuclear Regulatory Commission in advance of an exploratory shaft.

*The history of the Colorado lineament.

The above subject is discussed in detail in ONWI-290, Volume I, Chapter 6.6.2, under Northeast Trending Features and the Colorado Lineament.

*A discussion of super floods.

A flood potential study is planned as part of the location phase studies, which is discussed on pages 13-63 and 13-64 of ONWI-301. As part of this study, a determination will be made of the probable maximum flood (PMF). This is not expected to be a very large problem because of the relatively small catchment basins that are associated with drainage channels in the Gibson Dome location.

*Wind erosion as a geomorphic agent.

"Wind is an effective geologic agent locally because it is capable of lifting and transporting loose sand and dust, but its ability to erode solid rock is very limited. The main action of wind as a geologic agent is in transportation and deposition in arid regions" (W. Kenneth Hamblin, The Earth's Dynamic Systems, p. 299). Geomorphic effects of wind erosion have been included in Quaternary studies conducted to date in the Paradox Basin. Erosion and cliff-retreat rates given in ONWI-92 and ONWI-290 include the combined effects of wind and water. On the basis of information in those reports, aeolian processes were not identified as siting issues. However, investigations essentially of the same type as those conducted in the past will be continued as a normal part of the location characterization phase. Should these studies serve to identify wind erosion as a siting issue, any future site phase activities will be planned accordingly.

*52 weeks is not sufficiently long for climatologic conclusions.

This chapter heading according to the NRC outline for site characterization reports DOE is following what was originally entitled "Climatology" and pertained to both the climatology and meteorology at a site. Since this original outline, after which ONWI structured ONWI-301, the NRC has revised their outline. The new title for this topic is entitled "Climatology and Meteorology". Our text is now consistent with the new chapter heading, and precludes the interpretation that a 52-week meteorological survey is adequate to define the climatology of a site. Refer to Section 13.6 for the revision.

*The weather records at Hite should be examined.

Hite, Utah maintains an U.S. Weather Bureau Station which reports temperature, precipitation, and evaporation data. However, the station is approximately 40 miles from the Gibson Dome location and is about 1,500 feet lower in elevation. Therefore, these data would be questionable as representative of the Gibson Dome location. Valid meteorological characterization data for a site requires on-site monitoring which is an ONWI planned activity (see Section 13.6.2.1). However, the Hite data may be used to establish regional variation when integrated with meteorology data from U.S. Weather stations at Moab and Blanding, plus any private sources in the area.

Geologic hazards should be considered when locating the railroad.

Geologic hazards (e.g., faults, landslides, mudflows, falling rocks) do not preclude the construction of a railroad. Rather, they represent engineering considerations which must be incorporated into the railroad's layout and design. No known active faults are crossed by any of the potential railroad routes. When a final route is determined, this subject will be addressed in the engineering design.

Under the section on geoseismicity it should be noted that the numerical modeling should take place before the tilt meters are put down the hole.

Tiltmeters are mentioned on page 13-56 under Section 13.3.2.3 Salt Dissolution, rather than in Sections 13.1.2.4, Maximum Credible Earthquake or 13.1.2.5, Subsurface Ground Motions which are related to geoseismicity. Tiltmeters, if utilized, would be directed toward a resolution on the question of possible hydrological dissolution of salt in the Lockhart Basin. Hydrological modeling is a continuing process, and is updated continually as new data becomes available.

WESTERN BOUNDARY OF THE SALT: During the Geologic Work Group discussions on December 15, 1981, it was noted that the western boundary of the Paradox salt in the ONWI reports is farther east than in some other published works. Two well logs from areas near the ONWI "zero thickness line" indicate significant thicknesses of salt (see attached copies of the logs). The UGMS publication "Mineral Resources, San Juan County, Utah, and Adjacent Areas" delineates the western boundary of the salt further west than ONWI-92, etc.

During the research that preceeded the preparation of ONWI-92, it was found that many different interpretations of the exact position of the "zero salt thickness line" exist.

The legend of Figure 5-12 of ONWI-92, which is an isopach map of the saline facies of the Paradox formation, states that the zero thickness line shown is the "Approximate location of zero thickness of saline facies" (emphasis added). This map is a composite from 14 referenced published sources plus new interpretations of well logs from a large number of wells, the locations of which are shown on Figure 5-12. The zero thickness line always represents an interpolation of a position between two wells, in this case, one of which has salt and one of which does not. It is not surprising that no two maps show the line in precisely the same position. We do not believe the difference between the map in ONWI-92 and other published sources is significant enough to invalidate the conclusions drawn.

OTHER POTENTIAL AREAS SUITABLE FOR DISPOSAL OF RADIOACTIVE WASTE IN SALT: Two areas (see attached maps) may be as or more suitable than the Gibson Dome as repositories for nuclear waste:

Dolores Valley, San Miguel County, Colorado: Triassic rocks outcrop on the surface and it would appear that bedded salt of the Paradox formation would be within 3,500 feet of the surface.

Happy Valley, in the "Fremont Embayment" area, west of the Gibson Dome site: Triassic rocks outcrop at the surface and it would appear that sufficient thicknesses of salt exist within suitable distances of the suraface for a salt repository.

The State requests explanations for the elimination from consideration of these two areas.

This comment refers to ONWI-36, "Summary Characterization and Recommendation of Study Areas for the Paradox Basin Study Region", which was provided to the State for comment on April 2, 1981.

The Delores Valley area in San Miguel County, Colorado, is taken to be the Delores Anticline area located northeast of Dove Creek, Colorado. The Delores Anticline is a non-diapiric fold similar to the Lisbon Valley Anticline. Data from 24 existing wells in this area were utilized in determining the depth and thickness of the salt units. Salt thickness does not appear to be a problem in this area. Only two wells in the area, however, penetrate the salt at depths of less than 1,000 feet. These two wells are located near the crest of the anticline and are along the Delores River at the bottom of the deep river canyon. The only areas where the top of salt is less than 1,000 feet deep is in the deep, narrow river canyon, where any engineered project would face flood problems. Depths to salt on the mesa surfaces on either side of the canyon are substantially greater than 4,000 feet. The area of the anticline that is [illegible] 4,000 feet is too small to be suitable for a study or a

The "Fremont Embayment" was interpreted to be the area of the Orange Cliffs located west of Canyonlands National Park between Hanksville and the Gibson Dome area. Data from three existing wells in this area were utilized in determining depth and thickness of the salt bed(s) in this area. Depths to salt were interpreted as significantly greater than 4,000 feet and individual salt beds approach marginal thicknesses. The National Park and the Glen Canyon National Recreation Area also eliminate a significant part of the area. Areas that might have salt beds at suitable depths because of the influence of local topography would be very small, would have a greater "effective" depth because of the influence of adjacent mesas, and would be located in the bottom of canyons which are less than optimum places to locate any facilities because of the potential for flooding.

Section 13.1.1

Some statements in ONWI-301 are stronger than others because of their grammatical construction For example, on page 13-35: "The studies that have been completed indicate the construction of a repository in the Gibson Dome location is feasible from a geotechnical engineering standpoint." The strength of this statement, whether intentional or inadvertant, was questioned. Most other "Summaries of Resolved Issues" use the expression "appear feasible" rather than "is feasible."

The document has been modified to be consistent. In all cases, "appear feasible" has been used. Feasibility has not been demonstrated. The phraseology is intended to convey the message that as a result of work done to date, there is no reason to believe that construction of a repository is not feasible.

Section 13.5 Surface Hydrology

The effect of subsurface activities in repository construction and operation, as well as possible drawdown on the water table, on surface water such as springs should be considered. This could adversely affect grazing, wildlife, and human use.

The springs and seeps in the Gibson Dome study area, many of which flow only in the spring to early summer, represent local perched aquifers. None of the springs are discharging from the regional saturated part of the upper hydrostratigraphic unit that is going to be penetrated by the boreholes or a shaft.

Drilling of the exploration holes will not involve withdrawal from local ground-water sources. No final decision has been made concerning sources of water for drilling a shaft and operation of a repository. Even if local groundwater is utilized as one source of water supply for these activities such usage has not been identified as an issue for reasons which include the following:

1. *Some springs are emanating from perched aquifers in units above the formations to be penetrated by the boreholes in the Gibson Dome study area. As a result, none of the planned activities will influence these springs.*

2. *The springs emanating from the formations that are to be penetrated by the proposed boreholes are also the result of local perched aquifers with limited areal extent and are not hydrologically connected with the regional ground-water system in the Gibson Dome area.*

Section 13.7, Issues Related to Environments, Land Use, and Socioeconomic Characteristics:

The nature, extent, and impacts of security measures for the repository, rail line, and utility corridors during construction and operation and after decommissioning should be addressed in this section.

Security restrictions may affect land access in the vicinity of a repository. The NRC requires protection of both the surface and subsurface facilities. The exact boundaries of these control zones can only be delineated after the final repository design is prepared. However, general areal requirements and the associated control boundaries can be determined from the present conceptual repository design. How these boundaries affect access to existing jeep trails through Davis and Lavender Canyons will be addressed in the report concerning the effects on Canyonlands National Park (Section 13.7.2.9). Transportation and utility corridors will not require any special security measures.

Section 13.7.1 Summary of Resolved Issues

"Potential conflicts with significant land uses have been minimized." This conclusion is insupportable given the proximity of Canyonlands National Park and the Salt Creek Archeological district.

The original statement was correctly based on the screening criteria employed to identify the Gibson Dome location. However, the text has been modified to clarify the intent (see Section 13.7.1).

Section 13.7.2.5 Noise

The impacts of noise from the projected railroad should be considered as well as the impacts of noise from the repository site.

Railroad noise will be included in the discussion of noise impacts (Section 13.7.2.5).

Section 13.7.2.6 Archeological Sites

Omission of mention in this section of the Salt Creek Archeological District, abutting the prospective site of the repository, is disturbing. The district was listed on the National Register of Historic Places in 1975 and contains 170 known sites. Lavender and Davis Canyons are the two main canyons in the district. Termination of the district on the boundary of Canyonlands National Monument, abutting the prospective site, reflects administrative convention, not the distribution of archeological sites. The secondary impacts as well as primary impacts of exploration, construction, and operation on archeological sites should be considered in this section.

The exclusion of the Salt Creek Archeological District from any discussion of direct impacts is valid because surface disturbing activities are not planned for that area. All 170 known sites within the District are outside of the Gibson Dome location. In fact, all these sites occur within Canyonlands National Park. The heads of both Davis and Lavender Canyons are situated within the Park, and are not part of the Gibson Dome location. Only one recorded archaeological or historic site occurs outside the boundary of the Park in Lavender Canyon, and this cliff dwelling was excluded from the Gibson Dome location. Archaeological surveys are required for all proposed surface disturbing activities. This activity was already planned (Section 13.7.2.6) and the Utah State Historic Preservation Office will be kept informed. Secondary impacts are a concern and will be included in the report addressing potential impacts on Canyonlands National Park (Section 13.7.2.9).

January 7, 1982

MEMORANDUM

TO: Juline Christofferson

FROM: Genevieve Atwood

SUBJECT: Additional Comments on ONWI 290, 291, and 301.

A couple more specific points were brought up during the meeting of December 15th and 16th which were left off our previous report.

1. Some stratigraphic nomenclature concerning the Jurassic appears to be in error.

This comment presumably refers to the Glen Canyon group and whether it is Jurassic or Triassic in age. In ONWI-92, the unit was assigned to the Triassic on the basis of work, for example, by Pipiringos and O'Sullivan (1975). Later studies, however, assigned the unit to the Jurassic on the basis of regional correlation studies (Imlay, 1980). Imlay's nomenclature was adopted for ONWI-290.

2. The petentiometric surface in the charts of 291 appears in error.

This comment apparently refers to report ONWI 291; yet there are no potentiometric charts in this report.

3. There is no discussion of the relationship of salt dissolution and migration of water toward a heat source.

It is not known which document this comment is directed toward. Migration of water toward a heat source (emplaced waste) is a near-field phenomenon (tens of feet from the heat source). There is no known dissolution within several miles of the proposed location.

4. The reports are not clear on the kind of hydrologic modeling that will be applied to the area.

The hydrologic modeling that will be applied is the finite difference numerical model, developed by the U.S. Geological survey for simulating ground-water flow. This model, which has been more commonly called the Trescott-Larson three dimensional flow model, is widely used and has been well documented (Trescott, 1975; Trescott and Larson, 1976). The model is capable of handling three-dimensional multi-layer flow problems with a large number of irregularly spaced grid cells.

5. Some of the early errors spotted in ONWI 92 have been carried on in later reports.

No response to this comment is possible, since the supposed "errors" in ONWI-92 are not identified.

6. The Paradox Basin which lies in Colorado should not have been summarily eliminated from further study.

This comment refers to ONWI-36, which was provided to the State of Utah for review in draft form on April 2, 1981. In the work that led to that report, political boundaries were totally ignored. No areas were summarily eliminated. Rather, the four areas that were considered to have the highest potential for eventually locating a suitable repository site within the Paradox Basin were recommended for further investigation based upon pre-established technical criteria. It happened that all four areas were in Utah and none in Colorado. This certainly would also have been the case had a smaller number of areas been selected and might well have been the case had a larger number been selected. There are budgetary constraints on the number of areas that can be investigated during any phase of the program, and it is not possible to investigate every area that might ultimately be proven to be suitable.

STATE OF UTAH
NATURAL RESOURCES & ENERGY
Utah Geological & Mineral Survey

606 Black Hawk Way • Salt Lake City, UT 84108 • 801-581-6831

Scott M. Matheson, Governor
Temple A. Reynolds, Executive Director
Genevieve Atwood, State Geologist

February 8, 1982

MEMORANDUM

TO: Juline Christofferson

FROM: Sandy Eldredge

SUBJECT: Geologic Work Group Review of ONWI 290, ONWI 291, ONWI 301

The work group met on January 25 to review ONWI 290, 291, and 301. The following comments are in addition to previous comments communicated to Tom Frazier, December 30.

Members in attendance were: Genevieve Atwood, Hank Goode, Lee Stokes, Howard Ross, Thure Cerling, David Tillson, and Donald Gillespie.

GENERAL COMMENTS: Virtually every member of the committee expressed a dissatisfaction with the specificity of the reports. The committee agreed that the present documents do not contain sufficient information on which to base decisions. It was generally agreed that this was due to omission of significant pieces of information that had been gathered and that such information could probably be provided by Woodward-Clyde.

All technical documents are to some degree summary documents. It is safe to say that, without exception, every piece of supporting data or information is never included in a technical report. Time, space, and fiscal considerations always demand some summarization.

Subsequent to the release of the draft reports referred to, the investigators have met with the Geologic Working Group of the Utah Nuclear Waste Repository Task Force and the Utah Geological and Mineral Survey personnally, and discussed in detail exactly what studies were done and how, and what information was utilized in preparing these reports.

It is the intent to share with the State all backup documents that are produced in the course of the Paradox Basin investigations. In the case of geological studies, copies of

backup information will be deposited with the Utah Geological and Mineral Survey, which is the cognizant geological agency for the state.

The members are concerned with the difficulty in collecting needed information. Also of concern are the hydrological issues. One member stated that more holes could be drilled in areas other than Gibson Dome to better understand the hydrogeology at Gibson Dome.

This comment is made with reference to ONWI-301. It is certainly true that hydrologic information from a much bigger area than the Gibson Dome location itself is necessary, in order to fully understand the hydrogeology. Of the 10 hydrogeological holes proposed in this report, 7 of them are outside the Gibson Dome location.

It is the general opinion of Work Group members that "depth to salt" maps which were initially used to screen areas were too general. Local topography should be taken into consideration earlier.

This comment refers to ONWI-36, which was provided to the State for review on April 2, 1981. The objective of the screening done to select the four areas was to identify broad areas within which multiple sites might be present and which were thought to have the highest probability of ultimately containing a site which could be shown to be suitable. Topography was taken into consideration, but only large topographic features since the screening objectives were large. Small topographic features were not considered. Actually, one of the concerns at that time was that small topographic features might invalidate the conclusions drawn with regard to the larger areas and reduce the possibility of finding a suitable site. In some regards this turned out to be true, since further investigation showed that only a very small portion of the Lisbon Valley and Elk Ridge areas, for example, were suitable.

The committee needs more hard data than are available in ONWI 290, 291, and 301, including a table of wells drilled and a list of the drill stem test data, more detailed depth temperature information, geochemical data, hydrological data, and seismic data interpretation. Copies of logs of the geophysical and hydrological tests that were run should be included in ONWI 290. ONWI 290 includes a general description of the core and it was felt that it would not increase costs to include a detailed description of the core. One member questioned the broad generalities concerning the characteristics of transmicivity, permeability, and transport times without specific data back up.

The investigators have met personally with the Working Groups of the Utah Task Force and the Utah Geological and Mineral Survey, and have shared with them the information and data that was utilized in the referenced reports. As pointed out earlier, it is not feasible to include every piece of information or data that was utilized in the characterization reports, and it is not standard practice to do so in scientific and technical reports. Much of the information referred to as omitted will be included in other backup documents (for example, the GD-1 Well Completion Report) which will be shared with the state. These backup documents, which contain a large number of well logs, are in some cases more voluminous than the characterization reports themselves, and will have a much more limited distribution.

SPECIFIC COMMENTS: In ONWI-301:

o The base maps are hard to read and also they do not necessarily reflect the information in the test.

Information showing the location of proposed activities were superimposed on copies of USGS topographical maps. The baseline information (topography) is, in some cases, difficult to read due to the poor quality of reproduction of this draft report and to the fact that contour lines are sometimes very close together. Even so, we believe the maps are much more useful than they would be if the topography were not shown at all.

Since no examples were given on where the maps do not reflect the information in the text, we are unable to respond to this comment.

o Figure 13-1 uses the wrong map scale. It was felt that this map in general is misleading. The map should include the limited area within the Gibson Dome location that is actually under consideration. It might be more useful if this map was of the same scale as Figure 5-7 in ONWI-291. In addition, it might be more useful if Figure 5-7 in ONWI-291 was included in ONWI-301.

The scale on Figure 13-1 is, in fact, in error. This error is corrected in the final version of this document. We will also attempt to superimpose on this map the actual Gibson Dome location, which is shown in a separate figure (Figure 1). The scale of Figure 13-1 is approximately 4 miles to the inch, while Figure 5-7 in ONWI-291 is 1.67 miles to the inch. The scale of Figure 13-1 in ONWI-301 was chosen in order to show all location phase activities on a single map of reasonable size. ONWI-301, of course, contains many other maps of individual activities, many of which are of a similar scale to that of Figure 5-7 in ONWI-291.

contains many other maps of individual activities, many of which are of a similar scale to that of Figure 5-7 in ONWI-291.

The two reports, ONWI-291 and ONWI-301, address different topics. Figures were selected for each document that are appropriate to the topics the documents address. It is not surprising, therefore, that the figures are different. To add the figure suggested would also require the addition of much explanatory textual material which is not pertinent to the subject of ONWI-301.

o Figure 13-3 would be more helpful if Shay Graben and its boundary faults were drawn on the map. The text refers to the trenches crossing the fault but the trenches should be dug across both the north and south faults. More seismic line information is needed on Shay Graben than is indicated. The area as far as Kelly Ranch should be mapped in detail (large scale).

Shay Graben faults are shown on maps and are described in some detail in ONWI-290. Also, the graben is shown on other readily available geologic maps, for example, the Geologic Map of Utah (UGMS, 1980) and the USGS Moab and Cortez Quadrangles.

ONWI-290, -291, and -301 are a sequential series of complementary reports, the first being the data base supporting the other two. That being the case and because the purpose of ONWI-301 is to identify siting issues and describe planned activities that address those issues, the ONWI-290 data base is not duplicated in ONWI-301.

As indicated in ONWI-301, a trench is planned across one fault of the Shay Graben as a part of the location phase. The north fault was selected because of gravel pediments that cross that fault. Depending upon trenching results and other data to be acquired during the location phase, a trench across the south fault may or may not be excavated in the site phase.

Decisions concerning the need for more seismic lines across Shay Graben other than those shown in ONWI-301 will be made after data from those as well as existing lines and data from other planned activities are interpreted.

During the area phase, numerous locations were examined along the strike and general trend of Shay Graben, including the Kelly Ranch area, using a seven and one-half minute quadrangle base. Three previously unmapped faults that may be associated with the

Shay Graben were identified and mapped (see Volume II, ONWI-290). Data acquired during these investigations are documented, including photographs, as required by the project's QA program. Any large scale maps that would be required for a license application would be prepared during the site characterization phase.

o Figures 13-1 and 13-12 contain incorrect scales.

This comment refers to ONWI-301.

The scale on Figure 13-1 is correct. The scale on Figure 13-12 should be the same as that in 13-1. The error has been corrected in the final report.

o Figure 13-4, Needles Fault Zone Exploration Activities does not include areas to be mapped by Quaternary and structural mapping teams.

Initially, aerial photographs of the fault zone will be mapped. Based on this effort, areas that appear to be most promising in terms of determining whether Quaternary movement has occurred will also be field mapped. As a result, the exact definition of areas to be mapped in the field cannot be identified at this time.

o p. 13-27, it is not assured that full chemical analyses of water will be done on waters obtained from the holes.

This comment refers to ONWI-301.

The fluids recovered during drill-stem tests and pumping tests will be analyzed in the laboratory for: TDS, density, Al, As, B, Ba, Ca, Fe, K, Li, Mg, Mn, Na, NH_3 P, Si, Sr, U, Rb, Cs, Cl, Br, I, F, Zn, No_2, So_4, CH_3CooH, C_2H_5CooH, C_3H_7CooH, total organic carbon, pH, Eh, O^{18}/O^{16}, deuterium, C^{13}/C^{14}, S^{32}/S^{34}, U^{234}/U^{238}, and As speciation.

o p. 13-30, some members felt that the search for fossil spring sites is not needed.

This comment refers to ONWI-301.

In order to fully address those sections in 10CFR 60 that are dealing with past and future natural changes in the hydrogeologic regime (60, 122(b); 60, 122(c); 60, 122(d); 60 123(a); 60 123(b), it is necessary to search for fossil spring sites that are excellent indicators of past ground-water levels.

o p. 13-42 states "where possible, samples of the fluids produced will be geochemically analyzed..." The weakness of this statement is criticized.

This comment refers to ONWI-301.

The statement that is commented on refers to the fact that many of the stratigrahic units have such a low water content that fluid samples cannot be obtained. This was true in test hole GD-1, and is anticipated to be also true in future drill holes. Anytime a sample is recovered in adequate volume, a thorough chemical analysis of that sample will be done. Many units, however, simply do not yield a sample. It is as important to (hydrologically) test the dry as well as the water-bearing units, however, because the permeability and water-bearing characteristics of the units are critical to the investigations.

o p. 13-43. In regards to Federal criteria 10 CFR 60.122 which refers to low ground-water content of the host rock, the Work Group questions how Woodward-Clyde interprets "low ground-water content". The formation strata should be dry.

This comment refers to ONWI-301.

The terms "low" and "dry" are relative terms. Crustal rocks contain water in amounts ranging from significantly less than 1 percent to approximately 40 percent in the case of some shales. We interpret the term "low ground-water content" as representing the lower end of this range. In the case of typical sedimentary rocks, this would probably be less than 5 percent. In case of salt, which is at least among the most dry rocks, if not the most dry, "low" would imply a water content considerably lower than that.

o Figure 13-10 does not show Verdue Graben and the stream gaging sites on Verdie Graben.

This comment refers to ONWI-301. The error was corrected. The report should have referred to Figure 13-8.

o p. 13-37, the last paragraph refers to Figure 13-1 instead of 13-2.

This comment refers to ONWI-301.

The comment is correct; the text refers to the wrong figure. This will be corrected in the revised version of the report.

o Figure 13-2. Are there going to be any test pits and seismic lines in Lavender Canyon?

This comment refers to ONWI-301.

At the suggestion of reviewers of ONWI-301, a seismic line has been added to the exploration program subsequent to the release of the draft of ONWI-301. No test pits are currently planned in Lavender Canyon.

o See additional comments.

ACTION ITEMS:

1. The Work Group would like to know when the revised ONWI-291, ONWI-301, and ONWI-92 will be published.

The current schedule for publishing the revised (final) version of these reports is as follows:

ONWI-92	*8/82*
ONWI-291	*8/82*
ONWI-301	*8/82*

2. The Group would like to know when the USGS will publish ONWI-290, Volume V.

Subsequent to the release of the draft of ONWI-290, it has been determined that the USGS does not have adequate resources to complete the Salt Valley volume of that report. Instead, the USGS will complete topical reports on all of the work that they have done on Salt Valley. Information from these topical reports, previous USGS reports on Salt Valley, and all other available information on this area will be combined into a single Salt Valley report by Woodward-Clyde Consultants in early 1983.

3. The Nuclear Waste Task Force will be meeting February 13. The Geologic Work Group would like DOE to invite several Woodward-Clyde scientists to the meeting including a geohydrologist, a surficial/Quaternary geologist, a seismologist, someone familiar with geophysical testing, and anyone else whom Woodward-Clyde feels could be of use at the meeting.

The Work Group would like to meet with Woodward-Clyde on February 17 and February 18.

The Woodward-Clyde staff did meet with the Geologic Work Group and the Utah Geological and Mineral Survey on February 17 and 18. The Woodward-Clyde staff included task leaders for all of the studies previously done and currently anticipated. ONWI and DOE geological staff also attended that meeting.

4. The committee recommends a reassessment of the criteria dealing with faults. The designation of capable faults, nonactive faults and active faults may be misleading in determining the safety of areas.

The following definitions were taken from the Glossary of Geology, 2nd edition, American Geological Institute, 1980:

Capable Fault: A fault is defined by the Nuclear Regulatory Commission as one that is "capable" of "near future" movement; in general, a fault on which there has been movement within the last 35,000 years.

Active Fault: A fault along which there is recurrent movement, which is usually indicated by small, periodic displacements or seismic activity.

It is in this context that these terms are used in the repository siting investigations. A nonactive fault is one which is not active.

5. The Work Group again recommends 3-D seismic studies be performed extensively in Gibson Dome. As one member stated, "A $100,000 spent now could save millions later."

Seismic reflection surveys are presently anticipated to cost $4,000 a line mile; high resolution seismic surveys will cost $10,000 a line mile. Some seismic surveys are

planned during the location phase. A seismic line was completed down Davis Canyon several months ago. This data has been obtained and interpreted. Additional seismic lines will probably be done across Davis Canyon at its widest part and down Lavender Canyon. This latter line was added to the location plans after conferring with the Geologic Working Group of the Utah Task Force and with the ONWI Geologic Review Group, an independent group of consultants that are well known and widely respected in the geologic community, who were retained to independently review and advise on the program content.

A three-dimensional survey will no doubt be done if and when an actual site is selected. At this phase of the prgram, however, it is still the objective to determine the broad characteristics of the location so that this location can be compared to other locations in the country that are also being considered and to determine whether or not it would be prudent to sink an exploratory shaft in this, or any other, location.

UNIVERSITY OF UTAH RESEARCH INSTITUTE

UURI

EARTH SCIENCE LABORATORY
420 CHIPETA WAY, SUITE 120
SALT LAKE CITY, UTAH 84108
TELEPHONE 801-581-5283

January 26, 1982

Ms. Genevieve Atwood
The Utah Geological and Mineral Survey
606 Black Hawk Way
Salt Lake City, Utah 84108

Dear Genevieve:

Listed below are a few minor errors in text noted during my review of ONWI-290, and 291.

ONWI-290 Vol. 1 Regional Overview.

Pg. 9-18 Lockhart Basin is north of Gibson Dome, not northeast.

This comment is correct; a correction was made in the final version of this report.

ONWI-290 Vol. 2 Gibson Dome

pg. 2-1 Inaccurate conversion of meters to feet; should be 0.7 and 1.6 ft. not 0.8 and 1.8.

pg. 6-3 Inaccurate conversion of meters to feet; 110 m = 361 ft.

pg. 6-9 Inaccurate conversion of meters to feet; 1 m = 3 ft.

These comments are correct; corrections were inadvertantly not included in the final report except as acknowledged here.

pg. 6-2 Mentions axial trace of Gibson Dome on Figure 6-5, but it is not shown on figure.

This comment is correct. The axial trace of Gibson Dome is shown on Figure 6-27. Figure 6-3 was incorrectly referenced on Page 6-2.

A more important consideration which did not receive enough discussion in our meeting of January 25 should result in some revision to ONWI-301. The occurrence of even minor amounts of oil and gas from 1818-1829 m in GD-1 and the fact that the Leadville limestone is a producing horizon elsewhere increases the potential for human intrusion and conflict with resource potential. The Geologic Work Group should recommend sufficient CDP reflection seismic coverage to indicate that no major structural or lithologic traps are present within the Gibson Dome target area. A minimum amount of seismic data (in addition to the Davis Canyon line (ONWI-301, pg. 13-9, Fig. 3-2) would be a line of approximately 8 miles length in Lavender Canyon. If structural complexities are observed on either the Davis or Lavender Canyon lines, then 3-D seismic coverage may be required to prove the area acceptable for an exploratory shaft.

I recommend that the UGMS and our Geologic Work Group encourage BLM cooperation in approving this seismic work. It is relatively inexpensive and non-destructive compared to drilling and shaft sinking activities. ONWI-301, Figure 3-2 should be revised to include provision for this additional seismic work.

A seismic line down Lavender Canyon was added to the program as a result of this comment. We concur with the opinion that "if structural complexities are observed on either the Davis or Lavender Canyon lines, then 3-D seismic coverage may be required to prove the area acceptable for an exploratory shaft." After the Davis Canyon and Lavender Canyon lines have been interpreted, and these lines fit into the structural picture obtained from the overall network of seismic work that has been done in the area, we will determine whether or not 3-D coverage is called for. We would expect to confer with the State in making that determination.

With the exception of the oil and gas show and insufficient subsurface geophysical data, I see no major negative factors in the geologic data base presented to us to date. The hydrology is still a large unknown factor which must be resolved. The environmental issues, such as proximity to Canyonlands National Park and the effects of railroad construction are major negative aspects of the site that should be evaluated before a decision is made to sink a shaft.

This comment is correct. The oil and gas shows referred to are quite minor, but will be more thoroughly investigated. Much of the future geologic program is directed toward more adequately defining the hydrological characteristics of the area. Environmental issues are also in the activity plans, and these will be combined in a single report that addresses the possible impacts on Canyonlands National Park, as mentioned in several previous comments. We concur that we have found no negative

factors in the geologic data base accumulated to date, and are pleased to see that there is some concurrence on this point.

Sincerely,

Howard

Howard P. Ross
Senior Geophysicist/Project Manager

United States Department of the Interior
NATIONAL PARK SERVICE
ROCKY MOUNTAIN REGIONAL OFFICE
655 Parfet Street
P.O. Box 25287
Denver, Colorado 80225

IN REPLY REFER TO:

L24 (RMR-D)
NWTS - Gibson Dome

MAR 26 1982

RECD APR 1 1982

Mr. J. O. Neff
Program Manager, U.S. Department of Energy
NWTS Program Office
505 King Avenue
Columbus, Ohio 43201

Dear Mr. Neff:

We appreciate the opportunity to review the preliminary draft of ONWI 291, Paradox Area Characterization Summary and Location Recommendation Report, December 1981, and offer these comments:

2.5.1.5. HUMAN INTRUSION - RESOURCE POTENTIAL/EXPLORATION p.2-15

The proximity of the Overthrust Belt to Gibson Dome and Elk Ridge should be thoroughly considered. Much has been learned since the 1979 survey you cite. Intensive seismic surveys by a major oil company are currently being conducted in the area from Moab south through Lockhart Basin. Deep hole oil and gas exploration is underway in southeast Utah with intended depths of 18,000 to 25,000 feet.

The tectonic history of the Colorado Plateau Province, in which the Paradox Basin is centrally located, and the relationship to surrounding provinces is discussed in some detail in ONWI-290, Geologic Characterization Report for the Paradox Basin Study Region, Utah Study Areas. The Plateau "is one of the largest consistently stable provinces in the North American Cordillera" (ONWI-290, Volume I, Page 7.2). This is in contrast to the overthrust belt, which is tectonically more related to the basin and range and Middle Rocky Mountain Provinces. The overthrust belt, because of its history of low angle reverse faulting (overthrust), provides structural traps for hydrocarbons. This type of structural activity has not taken place in the Gibson Dome or Elk Ridge locations where the stratigraphic units are essentially flat lying and such traps or potential hydrocarbon reservoirs are not present. Therefore, the hydrocarbon resource potential of the study areas is not enhanced by its proximity to the overthrust belt and studies to date have confirmed the low hydrocarbon resource potential of the study areas. Any possible traps due to folding will be identified by seismic reflection and would be evaluated by drilling before licensing of a repository. Although some seismic surveys are being conducted in the Gibson Dome and Elk Ridge areas, we would not classify them as "intensive". Additionally, it must be remembered that at least some of this seismic exploration is being carried out with the objective of selling the data to the oil industry. [illegible] National Waste Terminal Storage Program. [illegible] not being conducted in the vicinity of either [illegible]

2.5.2.3. LAND USE STUDIES p.2-18

The National Register of Historic Places is updated annually and appears in the Federal Register. Reference should be made to the current list rather than the 1969 listing. The Salt Creek Archeological District, which comprises the entire southeast corner of the national park, was added to the National Register in 1975.

Title 36, Code of Federal Regulations, Parts 60 and 800 contains a listing of historic places. This list is updated annually in the Federal Register. Additions to the Original list were obtained by contacting the Utah State Historic Preservation Officer as noted in the remainder of the sentence referred to on Page 2-18.

3.3.3. GIBSON DOME STUDY AREA p.3-18, para. 3

Please refer to our comment on 2.5.1.5. above.

Refer to response in Section 2.5.1.5, above.

Paragraph 4 - Page 3-19

"Land use in the Gibson Dome Study Area is limited to several uranium and vanadium mines (not currently operated) and isolated ranches." is a totally inaccurate statement. Figure 3-5 clearly delineates the study area as consisting of about one-third national park lands. Even excluding the park lands, the predominant use of the area is recreational. The recreational use is mostly non-local with 35 percent coming from the Mountain States. Visitation to the Needles District of Canyonlands alone was over 42,000 in 1981, accounting for 788,000 visitor hours. Average growth in numbers of visitors has been approximately 10 percent increase per year.

As stated in ONWI-36, (Summary Characterization and Recommendation of Study areas for the Paradox Basin Study Region), Canyonlands National Park was removed from further consideration as a potential repository site. The presence of a wilderness area within the Park boundary does not increase environmental constraints (e.g., air quality provisions of the Federal Clean Air Act) on adjacent activities (i.e., siting a NWTS facility).

The land use description on P. 3-19 for the Gibson Dome study areas has been revised in the final report.

Paragraph 1 - Page 3-20

In addition to the two proposed wilderness study areas, that area of Canyonlands NP immediately adjacent to the preferred site for the repository has been studied and recommended to Congress for wilderness status. You may also wish to reassess the "low to medium" archeological sensitivity since the preferred site is within 1-1/2 miles of the previously mentioned Salt Creek Archeological District.

ONWI-144 (Environmental Characterization Report for the Paradox Basin Study Region, Utah Study Areas) references the archaeological study by Richard A. Thompson. Thompson's evaluation is appropriate for the reasons developed in ONWI-144. Moreover, extensive site specific archaeological surveys are planned in subsequent phases of the exploration program to determine any direct and indirect impacts on the cultural resources.

5.2.1.4.1. SIGNIFICANCE p.5-11

The preferred Gibson Dome site, as we understand, lies in section 6, immediately southwest of South Sixshooter peak. According to your figure 5-7, there does not appear to be 3.1 square miles available to accommodate the dimensions of the repository. The only area that would appear to meet this criteria are sections 10, 11, 14, and 15, in the northwest corner of the area shown in figure 5-7.

Figure 5-6 indicates that there also would not be 3.1 square miles available at the Elk Ridge site.

About 3.1 square miles is needed for underground workings, but less than one section (one square mile) of land is needed for above ground ("surface") facilities. Also, the surface area need not be totally uninterrupted open space, but can be spaced to accommodate topgraphic features. Both the Gibson Dome and Elk Ridge locations meet both of these requirements. The area meeting the requirements at Elk Ridge is substantially less than that at Gibson Dome, however, (6 square miles versus 57 square miles). Refer to Table 5-1, Criterion 5.2.1.4.

5.2.6.1. MINERAL RESOURCES p.5-40

Please refer to our comments on section 2.5.1.5 and 3.3.3.

Refer to response on Section 2.5.1.5, above.

5.2.6.3. LAND OWNERSHIP/ACCESS p.5-43, par. 3

See our comment on 3.3.3. p.3-19, par. 4. The statement "The Gibson Dome location is utilized primarily for agricultural purposes" is in error.

Refer to response on Section 3.3.3, Page 3-19, Paragraph 4, above.

5.2.7.5. NEARBY HAZARDS p.5-49, last paragraph

Highway U-211 does not cross the Gibson Dome location. The State highway ends southeast of the Dugout Ranch. The road mentioned was constructed and is maintained by the National Park Service to provide access to Canyonlands NP.

The text has been revised to incorporate this comment.

Page 5-50

The airstrip nearest the Gibson Dome site has, in the past, served as a base for scenic flights over the park and in the future will probably continue. Due to a fire that destroyed the facility, the strip is currently inactive. However, the present lessee's plan is to rebuild.

Due to the current status of the referenced landing strip in Lavender Canyon, the statement on Page 5-50 is correct.

5.2.8.1. HUMAN PROXIMITY p.5-51, par. 3

The methods and sources referred to fail to take into account transient populations such as visitors to national parks. Attached to these comments are visitor use figures for Canyonlands National Park and Natural Bridges National Monument. It may be relevant to note that in the latest 30-year period (1951-1981) visits to nearby Arches National Park grew from 18,000 to 326,000, or an increase of over 1800 percent. A 30-year record is not available for Canyonlands NP as it was established by Congress in 1964, but visitation has increased from 19,468 in 1964 to 90,920 in 1981.

Human proximity as defined in the siting criteria document [NWTS 33(2)] refers to developed areas. Transient tourist populations are more appropriately addressed in Section 5.2.9.2, Land Use Conflicts. Impacts of a repository on recreational land use was considered in the selection of Gibson Dome over Elk Ridge (cf., Section 5.2.9.2.1). Futhermore, the issue of potential impacts on the Park (which includes study of transit populations) has been added as a separate section of ONWI-301, the technical work plan, (Section 13.7.2.9).

5.2.8.2. TRANSPORTATION RISK p.5-53, par. 2

It is our understanding that one of the railroad alternatives is down the Colorado River approximately 20 miles. This canyon in the past has been subject to minor landslides. The Colorado River supplies potable water for a large part of Southwestern United States. In 1980, over 7,000 boaters (whitewater, canoe, and motorboat) traveled the Colorado River below Moab.

A report on this subject has not been completed at this time. Several alternatives have been proposed and are being evaluated. The information on minor landslides is appreciated and will be considered.

5.2.9. ENVIRONMENTAL PROTECTION p.5-54

The impact of locating a repository next to a national park should be addressed as a separate issue.

The criteria used to screen the Gibson Dome study area for suitable locations avoided siting in a National Park. Being adjacent to a National Park or any other federally dedicated land is an impact issue. Consequently, it is outside the scope of ONWI-291.

Plans for studying this issue are described in Section 13.7.2.9 of ONWI-301.

5.2.9.1.5. NATURAL RESOURCES p.5-58

See our comment on 2.5.1.5

Refer to response on Section 2.5.1.5, above

5.2.9.2.1. PARKS AND RECREATION p.5-61

See our comment on 3.3.3. p.3-19

Refer to response on Section 3.3.3, Page 3-19, above.

Data Acquisition Methods p.5-62, par. 2

It is interesting to note that information on recreational land use was obtained from the Bureau of Land Management and the U.S. Forest Service. The National Park Service was not listed as a data source.

The information used provided a sufficient comparative basis between the Elk Ridge and Gibson Dome locations. Specific data will be required to assess the impacts of future NWTS activities on recreation. The National Park Service has been contacted for data for this more specific purpose.

Results of Comparisons of Location p.5-62, par. 4

We concur with the statement "Repository location in the Gibson Dome area would have a negative effect on recreational land use by interrupting the vistas and discouraging visitors."

The conclusion drawn that aesthetic conflicts would be less at the Gibson Dome site vs. the Elk Ridge site is surprising, to say the least. This is apparently based on the possibility that the actual repository might not be visible. All other aesthetic conflicts are apparently discounted.

A number of comments have been received on this section and the text has been revised. A typographic error occurred in the draft and has been corrected. Any statement that positively states a repository will discourage tourism is conjecture. The potential impact of a repository on tourism will require additional analysis. There are many National Parks that have intense commercial and/or industrial development immediately outside the Park boundary. An analysis of how tourism has or has not been affected by these developments will help assess the issue. However, this impact analysis is germane to NEPA documents and not this screening report.

The natural relief of the Gibson Dome location facilitates the concealment of a repository better than the Elk Ridge location, thus differentiating between the two. The same distinction holds true for railroad access into the two locations. Impacts of a railroad on the visual resources of a location can only be made after an alternative route has been identified and evaluated. This issue is outside the scope of ONWI-291.

5.2.9.2.2. INDUSTRY AND AGRICULTURE p.5-63, par. 4

Again, see our comment on 3.3.3. p.3-19, par. 4

Refer to response on Section 3.3.3, Page 3-19, Paragraph 4, above.

5.2.9.2.3. WILDERNESS p.5-63

The location of the repository in Lavender or Davis Canyon would seem to violate the criteria "The location of a repository in or adjacent to lands set aside for this [Wilderness] purpose would therefore be disallowed as an unacceptable land use conflict. That area of Canyonlands NP immediately adjacent to Lavender and Davis has been studied and recommended to Congress for wilderness.

The text has been revised to delete the phrase "or adjacent to" to reflect the intent of the NWTS-33(2) criterion cited.

Results/Comparisons of Locations p.5-64

The Gibson Dome location also borders upon the Canyonlands Recommended Wilderness.

Refer to response on Section 5.2.9.2.3, above.

5.2.9.2.4. ARCHEOLOGY p.5-64

The cultural resource study referred to was a 1 percent survey that did not include national park lands.

Refer to response on Section 13.7.2.6 above.

5.2.9.2.7. WILD AND SCENIC RIVERS p.5-66

We request that National Park Service administered areas receive the same special consideration as is given these rivers. Although not designated Wild and Scenic, the Colorado River within the national park meets all the criteria for Wild and Scenic and, excepting Grand Canyon, is the best known white water section of the entire Colorado River.

As stated in an earlier response (on Section 3.3.3, Page 3-19, Paragraph 4), the Gibson Dome location does not include any portion of Canyonlands National Park. Nether does it include any portion of the Colorado River and thus is receiving special consideration in our studies.

5.2.9.2.9. NATIONAL PARKS p.5-67

The opening sentence of this section seems to conflict with the statement on p. 5-62 and p.5-75 concerning the impacts on recreational lands. As stated on p. 5-62, repository construction would have a negative effect on recreational land use.

Section 5.2.9.2.1 has been revised, and the apparent contradiction removed.

We are curious as to why BLM and Forest Service publications were used as reference instead of, or in supplement to, National Park Service publications.

Refer to response on Section 5.2.9.2.1, Page 5-62, Paragraph 2, above.

P. 5-68

Since the National Park Service administeres both Natural Bridges National Monument and Canyonlands National Park, we are truly amazed by the statement "Because of the more limited size and larger tourist interest of the Natural Bridges National Monument, the Gibson Dome location is preferred."

The text has been revised to incorporate this comment.

Sincerely,

Lorraine Mintzmyer

L. Lorraine Mintzmyer
Regional Director
Rocky Mountain Region

Enclosure

Visitor Use Figures for

Canyonlands National Park and Natural Bridges National Monument

1960 - 1981

	Natural Bridges	Canyonlands	
1960	6,499	-	
1961	7,689	-	
1962	10,146	-	
1963	11,576	-	
1964	10,531	-	(Park established 1964)
1965	19,278	19,426	
1966	29,779	20,234	
1967	36,621	23,155	
1968	37,759	26,318	
1969	37,780	26,035	
1970	39,921	33,360	
1971	49,115	55,444	
1972	58,500	60,757	
1973	42,724	62,574	
1974	40,300	58,988	
1975	48,431	71,774	
1976	71,865	80,006	
1977	75,193	75,621	
1978	69,941	86,307	
1979	80,314	75,133	
1980	63,988	56,965	
1981	60,681	90,920	

United States Department of the Interior
NATIONAL PARK SERVICE
ROCKY MOUNTAIN REGIONAL OFFICE
655 Parfet Street
P.O. Box 25287
Denver, Colorado 80225

RECD APR 19 1982

IN REPLY REFER TO:
L24 (RMR-DO)
NWTS-Gibson Dome

APR 15 1982

Mr. J. O. Neff, Program Manager
U.S. Department of Energy
NWTS Program Office
505 King Avenue
Columbus, Ohio 43201

Dear Mr. Neff:

The following are our comments on the December 1981 Preliminary Draft of ONWI-301, Paradox Basin Site Characterization Report.

p. 13-17: Figure 13-4

Much of the seismic line within Canyonlands National Park, as shown, does not follow established roads and would be in violation of the wilderness recommendation that has been transmitted to Congress.

p. 13-19: Figure 13-5

The national park boundary is improperly located. The boundary was revised in 1971, and approximately 2½ miles of the western end of the proposed seismic line would be within the park.

p. 13-22: Figure 13-7

Approximately the last 3 miles of the proposed seismic line is along a four-wheel drive road that could block access for large trucks.

Any seismic work within the park would require permits and would be subject to all applicable National Park Service rules and regulations.

All seismic lines within Canyonlands National Park have been deleted from the program plan, including those portions shown on Figures 31-4, 13-5, and 13-7.

pp. 13-64 and 65

13.5.2.3 Water availability

In addition to "Defining locally available water," the Department of Energy needs to determine, by submitting permit applications now, whether or not sufficient water would actually be available. We note an apparent conflict between the recommendations on page 5.0-1 of ONWI-265, January 1981 and this section. ONWI-265 recommends that applications for water sources be initiated as soon as the repository location has been determined. According to ONWI-265, apparently the availability of water will not be a factor in the site selection process.

The question of water availability will be addressed further during the location phase, and a discussion of this topic will be included in the NEPA document that accompanies any recommendation regarding an exploratory shaft and/or a repository. The availability of water will be evaluated in the site selection process.

p. 13-70

13.7.1 SUMMARY OF RESOLVED ISSUES

We do not believe land use conflicts have been resolved. Although it is true that the location is not near State or federally designated wild and scenic rivers, the site is adjacent to an area recommended to Congress for wilderness and is also adjacent to the Salt Creek Archeological District which is listed on the National Register of Historic Places. In ONWI/SUB/81/E 512-01600-61(2) (to be designated ONWI-291), it is stated that, "The location of a repository in or adjacent to lands set aside for this purpose [wilderness] would be therefore disallowed as an unacceptable land use conflict." Why is this statement being overlooked?

Conflicting land use and negative impact on Canyonlands National Park cannot be avoided or satisfactorily mitigated, should the repository be located in the Gibson Dome area. The conflict is with the humanistic values for which the park was established. Any development of the scope of a repository will negate in great measure these humanistic park values.

The conflicting statement in the draft of ONWI-291 was a misstatement with respect to the use of the work "adjacent" and has been corrected in the final report to refer only to the true meaning of the exclusionary siting criteria. Section 13.7.1 (Page 13-70) states that "Potential conflicts with significant land uses have been minimized and there are few alternative uses of the site" (emphasis added. Canyonlands National park was excluded from consideration as a repository site, and the potential impacts of a

repository near the Park will be addressed in the studies planned for the immediate future. The presence of a wilderness area within the Park boundaries will not increase the environmental constraints from those caused by the presence of the Park itself. While the Park has been considered inviolate, the land adjacent to the Park has not been considered similarily, and there is no obvious reason to do so. The case can be made that a repository, which will be temporary facility and which will be on land that will have severely limited use restrictions permanently, is quite compatible with the humanistic values for which the Park was supposedly established.

Urban population centers have been taken into account but not the transient recreationist population in Canyonlands National Park and vicinity. Projected increases of this recreationist population can be considerable. Visitation at Canyonlands National Park, established in 1964, increased from 19,468 in 1965 to 90,920 in 1981. This visitation will undoubtedly increase to hundreds of thousands per year, if not more, in one generation. To imply that recreational use is insignificant in the area, indicates a serious lack of knowledge about the area. Accidents at a repository or in transport in the vicinity of the park might expose relatively few people to radiation hazard but could prevent visitors from entering the park for extended periods, denying them access to a national treasure set aside for their enjoyment. As stated in ONWI-291, page 5-62, the mere presence of a repository "would have a negative effect on recreational land use by interrupting the vistas and discouraging visitors."

The potential impact of a repository will require additional analysis. There are many national parks that have intense commerical and/or industrial development immediately outside their boundaries. An analysis of how this development has or has not affected tourism will help to address this issue. The final report of ONWI-291 now acknowledges the impact of a transient recreational population and has corrected the typo of "would" to "could". Analysis of this issue will be appropriately more detailed during location phase studies.

UNRESOLVED ISSUES

13.7.2.1 Transportation Risks

Refer to comments above (13.7.1) on transient recreationist population in vicinity of transportation route.

We believe that the potential of exposure to radiation by Park visitors would be virtually non-existent, and that potential impact to access to the Park could be easily avoided by means of an overpass or re-routing of the Park entrance road. This issue will be addressed during the location phase studies.

Hazard to the Colorado River and its visitors should be resolved. Transportation crossing and drainage into the river must be addressed. In 1980, 7.344 users (whitewater, canoe, and motorboat) travelled the Colorado River.

We concur that the potential for impact to the Colorado River and its visitors needs to be addressed, and are appreciative of your bringing this issue to our attention. The location phase studies will be an opportunity to study these issues.

p. 13-79

13.7.2.6 Effects on Archeological Sites

An issue to be addressed is the proximity of the Salt Creek Archeological District (listed in the National Register of Historic Places) in Canyonlands National Park, immediately adjacent o the repository study area.

A complete archeological survey of Lavender or Davis Canyon (dependent on shaft location) should be made prior to the decision on the shaft to aid in decisionmaking and to identify protection needs of sites now unknown.

A complete archaeological survey of any lands having potential for use during detailed site exploration activities, (including an exploratory shaft) would be undertaken during the location phase.

p. 13-81, paragraph 3 (Secondary Effects from Increased Rail Access)

In addition to gathering data on likely types of industrial growth, research should be performed on future recreational growth.

Future potential for recreational growth will be addressed and considered.

p. 13-82

13.7.2.8 Visual Aesthetic Effects

The issue has escalated from one of "local concern" to one of regional concern and is likely, due to its proximity to Canyonlands National Park, to become an issue of interest nationwide. Because of this likelihood, and the fact that many of the issues listed may have direct impacts on the national park, we request that those impacts be treated as a separate and distinct issue. Canyonlands National Park is a mandatory Class I air quality area under the Clean Air Act, amended 1977 (Public Law 95-95).

The potential impacts of a repository to the Park appear to be scattered in ONWI-301 because this report is arranged by technical issue. The several studies that relate to the Park will be consolidated into a separate report specific to the potential impacts on Canyonlands National Park as described in Section 13.7.2.9 of the final report of ONWI-301.

p. 13-84

13.7.2.9 Social and Economic Effects

A major portion of the economy of southeast Utah is dependent upon the tourism industry. If the mere presence of a repository would have a negative effect on recreational land use by interrupting vistas and discouraging visitors (as stated in ONWI-291), then it would appear that this impact on nearby towns must be thoroughly assessed.

The statement in ONWI-291 has been corrected to read "could" rather than "would" since no study of the issue has been done to date making any definitive statement unqualified conjecture. Potential impacts on nearby towns, as well as on the National Park, of both a repository work force and possible effects on the tourism industry, will be addressed in appropriate NEPA documents that relate to either an exploratory shaft or a repository. Section 13.7.2.9 of ONWI-301 also describes a future report that will address this issue.

p. 13-86

13.7.2.10 Electric Power Availability

The impacts of any new utility transmission corridors must be assesssed.

Potential impacts of any new utility transmission corridors will be addressed in appropriate NEPA documents.

p. 13-87

13.7.2.11 Transportation Upgrading

In addition to the impact on "affected communities," the impact on visitors to the national park should be considered.

Refer to response on Sections 13.7.2.8 and 13.7.2.9, above.

p. 13-88

The "Discussion of Issue" ignores the fact that the existing highway, constructed by the National Park Service, is the only two-wheel drive access to the most popular section of the national park. The existing road would not be adequate to accommodate repository development.

The text has been revised to more clearly show the potential conflicting use of U-211 with an access road to Canyonlands National Park.

Sincerely,

James B. Thompson
Regional Director
Rocky Mountain Region

Action

HARRY D. GOODE
Consulting Geologist
2275 South 2200 East
Salt Lake City, Utah 84109
Telephone (801) 466-6894

CERTIFIED PROFESSIONAL GEOLOGIST
2435
American Institute of Professional Geologists
Consulting in
Ground Water *Hot & Cold Springs*
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23 October 1981

Ms. Genevieve Atwood
Director, UGMS
Salt Lake City, Utah

Dear Genevieve,

Here's a listing of some of the errors I picked up in ONWI 92, Overview of the regional geology of the Paradox Basin study region.

1.- Fig. 4-1 — Explanation is upside down: oldest unit should be on bottom.

This comment is correct; the explanation does not conform to standard geologic practice. However, we believe the figure is easily understood. The expense that would be required to redraft a colored plate is not justified.

2.- Fig. 7-2 — Population data stops at 1960: add info from 1970 and 1980 censuses.

Population data is incidental to this report, the subject of which is the geology of the Paradox Basin. Better and more recent population data can be found in ONWI-68, "Regional Environmental Characterization Report for the Paradox Bedded Salt Region and Surrounding Territory, and ONWI-144, Environmental Characterization Report for the Paradox Basin Study Region, Utah Study Basin Study Region, Utah Study Areas".

3.- Fig. 10-12 — refers to UGMSociety instead of Survey.

4.- Table 41, opp. p. 44 — Sacagawea Ridge glaciation is Illinoian, not Yarmouth; Durango glacial deposits are Illinoian, not Yarmouth.

In bibliography:

p. 137, Birkeland and others — conterminous, not coterminous.

p. 141, Cooley and others — Harshbarger, not Harshburger; Akers, J.P., not Akens, T.P.

p. 144, Gere and others — Utah Geological and Mineralogical Survey, not U.S. Geological Survey.

p. 158, Seager — evolution, not evoluation.

p. 159, Smith, R.B., 1972, not Smith, R.E. (This error is in original publication.)

p. 161, Add new reference — Sumsion, C.T., 1971, Geology and water resources of the Spanish Valley area, Grand and San Juan Counties, Utah: Utah Dept. Natural Resources, Tech Pub No 32, 40 p.

The above errors are correctly identified. All were corrected in the final version of ONWI-92.

Sincerely yours,

Hank

Harry D. Goode