SITING OF LOW-LEVEL RADIOACTIVE WASTE DISPOSAL FACILITY IN TEXAS

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ABSTRACT

The Texas Low-Level Radioactive Waste Disposal Authority was established by the 67th Legislature to assure safe and effective disposal of the state's low-level radioactive waste. The Authority operates under provisions of the Texas Low-Level Radioactive Waste Disposal Authority Act, V.A.C.S. 4590f-1.

Prior to beginning the siting study, the Authority developed both exclusionary and inclusionary criteria for site selection.

Major requirements of the siting guidelines are that the site shall not interfere with: 1) existing or near-future industrial use, 2) sensitive environmental and ecological areas, and 3) existing and projected population growth. This would reduce the potential for inadvertent intruders, increasing the likelihood for stability of the disposal site after closure.

The identification of potential sites for disposal of low-level radioactive waste involves a phased progression from statewide screening to site-specific exploration, using exclusionary and preferential criteria to guide the process. This methodology applied the criteria in a sequential manner to focus the analysis on progressively smaller and more favorable areas. This study was conducted in three phases: I. Statewide Screening, II. Site Identification and Ranking, and III. Preliminary Site Characterization.

SITING OF LOW-LEVEL RADIOACTIVE WASTE DISPOSAL FACILITY IN TEXAS

The Texas Low-Level Radioactive Waste Disposal Authority was established by the 67th Legislature to assure safe and effective disposal of the state's low-level radioactive waste. The Authority operates under provisions of the Texas Low-Level Radioactive Waste Disposal Authority Act, V.A.C.S. 4590f-1, and other general administrative statutes. The Authority is governed by a board of directors composed of a medical doctor, a health physicist, an attorney, a geologist, and two members from the general public, at least one of whom must reside in the county in which the site is located. Responsibility for general administration is delegated to a general manager. The Authority is specifically charged with the responsibility of site selection, design, construction, operation, maintenance, decommissioning, closing, and financing of a low-level radioactive waste disposal site solely for Texas.

In Texas, low-level radioactive waste is defined as any radioactive material that has a half-life of 35 years or less or that has less than 10 nanocuries per gram of transuranics, and may include radioactive material not excluded by this definition with a half-life of more than 35 years if special disposal criteria are established.

The first major project of the Authority was to perform a source-term study of the volumes and types of waste which could be expected during the operating life of a facility. The second major study was the siting study. Prior to initiating the site selection study, a set of siting guidelines were established with primary consideration given to public health protection.

In order to protect public health and safety, low-level radioactive waste (LLW) near-surface disposal facilities must be located, operated, and closed so as to assure that the following performance objectives are met: 1) protection of the general population from releases of radioactivity, 2) protection of individuals from inadvertent intrusion, 3) protection of individuals during operation, and 4) stability of the disposal site after closure.

The general requirements and criteria for LLW facility siting are cited in 10 CFR 61, 10 CFR 51, TRCR Part 45, and Texas Regulatory Guide 6.1.

Based upon a review of these documents, the following siting criteria were established for siting the facility in Texas.

Exclusions

1. Disposal sites shall not be located in the 100-year flood plain, coastal high hazard zone, or wetlands.

2. The site should be located so that upstream drainage is minimal and drainage is easily manageable. This generally indicates an area with an existing grade of 5 percent or less.

3. Sufficient depth to the water table should be present so that groundwater intrusion, perennial or otherwise, into the waste will not occur. It is the desire of the Authority to locate the disposal site so that all disposal shall occur in the unsaturated zone. Further, it is desirable to locate the site in an area where at no time will the water table rise to within 50 feet of the trench bottom, assuming that the site will be a conventional shallow-land operation.

4. Any groundwater discharge to the surface within the disposal site shall not originate within the hydrogeologic unit used for disposal. It is desirable that the site be located where naturally occurring groundwater discharge is not present.

5. The site shall not be located on the recharge zone of the major or minor aquifers in Texas.

6. The disposal site shall not be located in an area where future population growth or development are likely to affect the ability of the site to meet its performance objectives. In general, an exclusion zone of at least 25 miles from the limits of a SMSA should be maintained.

7. The disposal site shall not be located in a county which has a population density above 400 persons per square mile.

8. Areas must be avoided where tectonic processes, such as faulting, folding, seismic activity, or vulcanism occur with such frequency and extent to significantly affect site performance.

9. Areas should be avoided where surface geological processes such as mass wasting, erosion, slumping, landsliding, or weathering occur with such frequency and severity as to adversely affect site performance.

10. The site shall not be located in an area where severe meteorological conditions such as tornadoes, excessive winds, or thunderstorms occur with sufficient frequency as to adversely affect site performance.

11. The disposal site shall not be located where nearby facilities or activities could adversely impact the site's ability to meet performance objectives.

12. The site should not be located within or adjacent to national or state parks, monuments, or wildlife management areas.

13. The site should be located in an area of minimal archaeological significance and should not be located adjacent to an historic site designated by the State Historic Commission.

14. The site should not be located in an area where disposal operations could adversely affect the habitat of endangered or protected species.

15. Areas should be avoided which have economically significant, recoverable, natural resources which, if exploited, could result in the failure of the site to meet performance objectives.

16. The site should have no recorded easements upon it. These include, but are not limited to, pipeline and utility easements.

Inclusions

1. The proposed site should be readily accessible to state highways. Easy access to rail transportation is desirable.

2. The site should be located where calcareous and/or low permeability soil occur.

3. Preferably, the site should be located on existing state or federally owned land to minimize site acquisition problems and cost.

4. It would be desirable to locate the site on land where an Environmental Impact Statement (EIS) has been previously prepared.

5. The site should be located in an area of net evaporation and/or evapotranspiration.

6. The site should be located such that transportation problems from major radwaste generators is minimized.

7. Preferably, the site should be located in an area where there is little public opposition.

8. The site should be capable of being characterized, modeled, analyzed, and monitored.

Major requirements of the siting guidelines are that the site shall not interfere with: 1) existing or near-future industrial use, 2) sensitive environmental and ecological areas, and 3) existing and projected population growth. Therefore, the site should be located away from currently known recoverable mineral, energy and water resources, population centers, and areas of projected growth. This would reduce the potential for inadvertent intruders, increasing the likelihood for maintaining integrity after closure.

Another consideration is that the need for active maintenance of the disposal facility should be minimal after facility closure. This requires that site location, design, and construction should be such that physical alterations of site conditions due to natural processes (e.g., erosion) over its operational and post-closure periods are minimal.

A fundamental principle of siting a LLW facility is that the interaction of wastes with surface water and groundwater is minimized. In general, water is the media through which wastes interact with the environment. Because management of water has been the primary difficulty encountered at existing closed commercial disposal sites, it warrants special attention.

Site conditions must also be such that the performance of the disposal system can be predicted with confidence. Reliable site characterization and modeling are required to enable this predictable performance. To accomplish this, the natural site conditions must be both geologically and hydrologically as simple as possible.

The predictability of performance has not received adequate attention in previous studies for existing LLW disposal facilities. The possibility exists that unforeseen difficulties might have been avoided if individual site performance had been reliably predicted; hence, the need for confident predictability of performance was a prime consideration for siting the LLW facility in Texas.

The identification of *potential sites* for disposal of low-level radioactive waste involves a phased progression from statewide screening to site specific exploration, using a set of exclusionary and preferential criteria to guide the process. This methodology applied the criteria in a sequential manner to focus the analysis on progressively smaller and more favorable areas. The study was conducted in three phases:

I. Statewide Screening,
II. Site Identification and Ranking, and
III. Preliminary Site Characterization.

PHASE I

The purpose of statewide screening was to identify areas of Texas which would be generally acceptable for development of a low-level radioactive waste disposal facility. Phase I was conducted as two tasks. Several of the Authority's siting criteria were used as exclusionary during Task 1. These criteria were applied at the statewide level to exclude those areas which could be geotechnically or environmentally unsuitable for a low-level radioactive waste disposal facility. Other criteria were applied during regional screening to focus on more favorable areas for siting.

Nine exclusionary criteria were used to map less favorable areas of the state. These were applied at a scale of 1:1,000,000 in the following areas of study:

- Geology
- Groundwater
- Oil, Gas, and Uranium
- Coal and Lignite
- Hydrometeorology
- Environmental
- Demography

The selection of these exclusionary criteria was made on the basis of the ability to define areas at the 1:1,000,000 scale of study for this phase. Not all mapped features were used as exclusionary, just those judged incontrovertible and accurately defined at this scale. Figures 1 and 2 illustrate geological and groundwater exclusions at the scale of 1:1,000,000.

A composite map was prepared to show those areas of Texas which, on a statewide scale, appeared to be more favorable for the location of a low-level radioactive waste site. A review of the composite showed about 35,000 square miles, including all or portions of 105 counties available for further study as potential siting areas. These were divided into 16 "Potential Siting Areas" by general physiographic designation. These regions are shown in Figure 3.

Fig. 1. Geology Exclusions

Fig. 2. Groundwater Exclusions

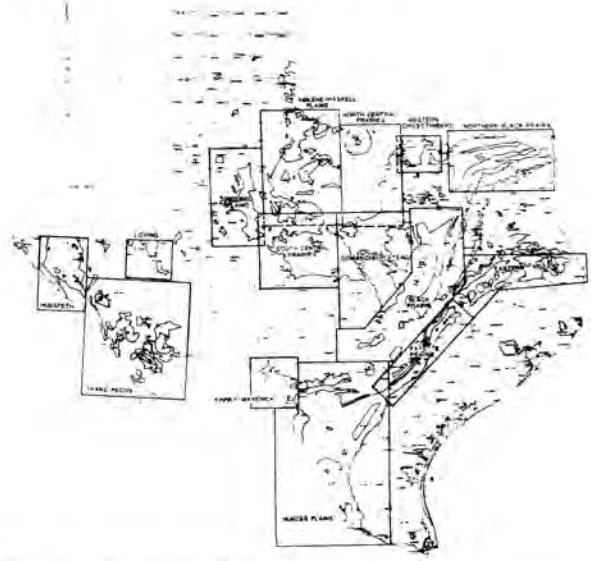

Fig. 3. Statewide Exclusions - Composite

The three major exclusionary criteria used in developing the composite were:

1. Groundwater hydrology (major and minor aquifers). Application of this criterion eliminated an area within 100 miles of the Gulf Coast and most of the Texas Panhandle.

2. Geology. Complex geology and mountainous areas in west, west-central and the Panhandle of Texas were excluded through application of this criterion on a 1:1,000,000 scale. Less preferred geologic features (e.g. areas of potential growth faulting, Karst areas, and evaporites) were also used as exclusionary at this stage of mapping.

3. Demography. Large areas near major urban populations were excluded. Application of this criterion did not affect the western two-thirds of

Texas except for isolated cities such as El Paso, Lubbock, Amarillo, and Midland-Odessa.

Criteria pertaining to mineral resources, environmental features, and areas of flooding did not result in major areas of exclusion at the statewide scale. However, these factors will come under more careful scrutiny on a county, or site-specific scale of study.

Task 2 of Phase I involved a more detailed look at the 15 physiographic regions previously defined. The following describes the work performed to investigate the 15 areas with respect to various criteria.

Geology

The principal data sources for this work were the Geologic Atlas of Texas maps (1:250,000) produced by the Texas Bureau of Economic Geology, supplemented by regional geologic literature. The following specific geological conditions were considered less favorable for siting and mapped in each potential siting area.

- Areas of faulting not mapped during Task 1 due to scale.

- Additional areas of complex geology and mountains.

- Uncemented (recent) or poorly cemented sand, gravel, and other coarse-grained surface deposits which could be geologically unstable and/or highly permeable.

- Highly variable lithostratigraphic units, such as thin-bedded, cross-bedded, and jointed limestones.

- Other areas of fractured or jointed rocks.

- Areas subject to dissolution (limestone and evaporite formations) leading to dissected topography or surface instability.

Favorable geologic conditions identified during this task include:

- Massive, homogeneous formations that are continuous on a relatively broad scale.

- Thick bedded, fine-grained deposits (sandy clays, silty clays, and clays).

- Argillaceous limestones (marls) and shales.

- Flat to rolling, relatively undissected topography (generally less than 5 percent slope).

Groundwater

The groundwater considerations employed in evaluating the 15 potential siting areas addressed during Task 2 of Phase I were:

- Avoid recharge (outcrop) areas of aquifers identified in publications of the Texas Department of Water Resources and the U.S. Geological Survey.

- Exclude those parts of the potential siting areas where published reports show depth to water is less than 100 feet below the land surface.

Surface Water

Several characteristics about floodplains make them less suitable for waste disposal activities. These include: the potential for frequent flooding; the potential for rapid and unpredictable erosion, the occurrence of surface and subsurface sand and gravel bars; the existence of shallow groundwater tables; the potential use as ground and/or surface water supply; and the possibility for nonhomogeneity of subsurface geological conditions. In Task 2, major river floodplains and surface water developments such as reservoirs and lakes were identified and excluded.

Soils

Soil data were reviewed at the level of the county soil maps within each of the 15 potential siting areas. Although soil cover constitutes only a small portion of the total depth of the disposal site (generally 12" to 80"), certain types of soil cover were considered more or less favorable due to the characterization of the underlying parent material.

Soil descriptions were reviewed at the county level using U.S. Soil Conservation Service (USSCS) General Soil Maps. Soil surveys for counties in which a published survey is available were also reviewed. The soil surveys provided data regarding permeability, erosion potential, and structure of parent material.

Mineral and Energy Resources

Mineral resources are diverse and of variable economic value. For example, coal can be found underlying a large part of the state, however, barite would be found only as small, isolated deposits. For the purposes of this study, therefore, the mineral resources of Texas were divided into three groups:

- Materials occurring over a large part of the state and having a relatively high value per unit weight.

- Materials of relatively high value per unit weight which occur sporadically in relatively small deposits (often only a few acres in extent). Many of these deposits are not currently being mined.

- Broadly distributed materials, having a relatively low value per unit weight, and for which there are many present or potential extraction sites.

Meteorology

Several aspects of meteorology were considered during this task. These include:

- Coastal high hazard areas subject to hurricane-related flooding.

- The soil water balance -- it is preferable to locate a site in an area in which potential evapotranspiration exceeds precipitation to reduce the chances of infiltration of surface water.

- Areas in which severe wind conditions (tornadoes and wind storms) occur with higher-than-average frequency -- this may affect site operation through dispersal of unburied waste.

Historical and Archaeological Sites

Location of the low-level radioactive waste facility in an area of historical or archaeological importance may hinder research or public use of these valuable resources. In addition, many of these sites are protected from encroachment or impairment by various state and federal laws such as the Historic Preservation Act.

Most of these sites cover very small areas (often only single buildings), or are located in towns or in state or federal parks. The locations of these sites were identified and tabulated so that they may be considered on an individual basis during Phase II when potential sites for the LLW facility are identified.

Each of these criteria were used to evaluate the relative potential of locating technically and environmentally suitable sites within the 15 potential siting areas. This resulted in the identification of 8 preferred siting areas (Fig. 4) where the identification of potential sites would be concentrated in Phase II.

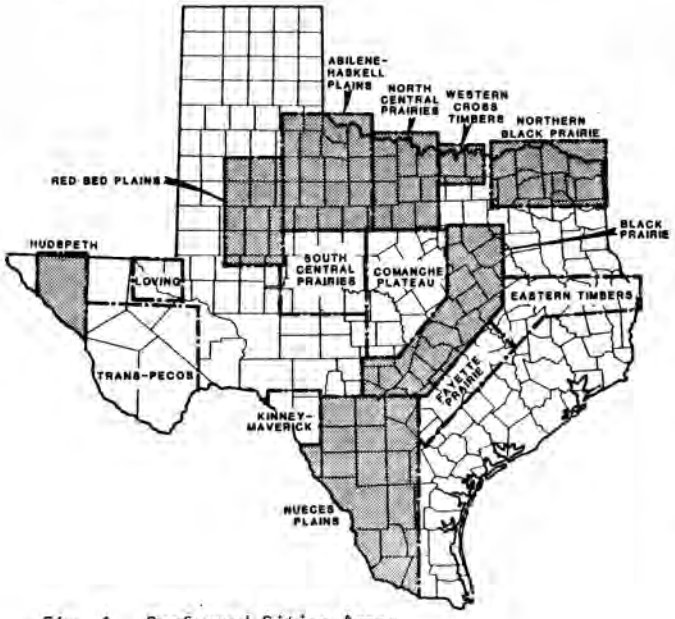

Fig. 4. Preferred Siting Areas

PHASE II

The principal objective of Phase II was to identify two to five sites that could be recommended to the Authority's Board of Directors for selection as a prime site for the proposed facility. Several tasks were included in this phase of the study.

Although technical and environmental criteria form the major thrust of the site selection process, legal requirements must also be satisfied. Therefore, Phase II studies were conducted as a two-pronged effort. This represented the following:

1. Continued technical screening of preferred areas to define and evaluate sites with respect to engineering, environmental, and economic constraints and criteria.

2. The coincident identification of available properties that satisfied legal and statutory requirements of the Authority as defined by Texas law.

Lacking the power of eminent domain, the Texas Low-Level Radioactive Waste Disposal Authority must purchase available property for the facility. The property must be acquired on a fee simple basis and must include both surface and mineral rights. Because of the difficulty in identifying properties that would meet these stringent requirements, an independent, but coordinated effort was undertaken to identify available land at the same time that the detailed technical screening process was being undertaken. Once available properties were identified, they were then subjected to technical screening and evaluated with respect to engineering, environmental, and economic constraints and criteria.

The goal of the study effort undertaken during Phase II was to select two or more sites that satisfied both legal and technical requirements to the maximum extent possible. A convergence of the technical screening and land acquisition efforts resulted in the identification of the candidate sites.

Eleven criteria or techniques of evaluation were cited to be used during Phase II to identify sites for evaluation. These included:

1. Site specific evaluation of mineral and energy resources.

2. Meteorological conditions.

3. Transportation factors (environmental and economic).

4. Demographic trends.

5. Land use patterns.

6. Regional and site-specific geotechnical and hydrological conditions.

7. Land availability (surface and mineral rights).

8. Environmental and cultural factors.

9. Topographic design requirements.

10. Local water-level data.

11. Site uniformity.

Each of these 11 considerations was used in the Phase II process of site identification, evaluation, and ranking. Considerations 1 through 7 were examined on both a regional and site-specific basis, whereas considerations 8 through 11 were more site-specific in nature.

Task 1

Task 1 of Phase II was devoted to assessing criteria 1 through 7 on a regional basis to define the most promising areas for siting in the eight preferred siting areas. This was accomplished in two steps. The first step consisted of a review of the regional characteristics of each of the preferred siting areas. The second step consisted of the application of refined geological information and transportation constraints to identify preferred

areas of study within the eight preferred siting areas.

Detailed geological data were obtained from the Texas Bureau of Economic Geology (TBEG). These additional data allowed better definition of more favorable soils and geologic conditions for siting the proposed LLW facility. Detailed discussions were held with Bureau personnel who had personal experience mapping each of the preferred siting areas. Through this interview process, large areas available for siting were narrowed to those preferable from a soils, geological, and hydrological point of view.

In combination with the mapping of preferred or favorable geological formations, a quantitative criterion for transportation access to the disposal facility was established to restrict areas from further consideration.

Transportation

Consideration of site access is an important element in the site selection process. It is desirable to minimize the distance traveled over secondary roads in transporting the LLW from waste generators to the site for two reasons:

1. Optimize the safety aspects of transport by traveling as much as possible on major, divided highways.

2. Reduce site development and operation costs with regard to upgrading and maintenance of light-duty roads.

Combining the areas of favorable geology with the "highway access corridors" in a single map thus defined the portions of the preferred siting areas which are geologically more promising and/or accessible to transport.

Task 2

The first step in identification of potential sites was to locate a large number of potentially suitable tracts for siting. "Tracts" are defined as contiguous parcels of land, covering an area at least the size of one site, in which geohydrologic, geomorphic, and other conditions are relatively uniform and which does not encompass or cross undesirable features such as highways, pipelines, rivers, steep terrain, etc. Each tract was then examined in detail on available maps, categorized, and later evaluated through aerial and ground reconnaissance.

Tracts were identified by screening USGS topographic quadrangle maps (7½' at a scale of 1:24,000) which encompass the sections of the potential siting areas previously defined. In some areas 15' maps were used. The tracts and the surrounding areas were then examined in detail. Those which did not meet standards for the following factors were eliminated.

- Topography and physiography.
- Surface and subsurface hydrology.
- Demography.
- Land use and accessibility.

The most promising locations for one or more specific sites (250-400 acres) within each of the remaining tracts were then labelled for further detailed examination and ranking.

Each topographic quadrangle within potentially suitable siting areas was examined to identify tracts for siting. A screening format was devised to be objective and compatible between areas. The standard format included the preparation of a sketch map of the available areas for siting. The tract(s) and major features such as towns, highways, rivers, and county lines were identified. The presence of features which could detract from the site were also identified, these included:

- Nearby population centers, churches, schools, and cemeteries.
- The presence of buildings on the tract.
- Nearby oil wells, quarries, gravel pits, or windmills.
- Nearby springs, swamps, marshes, sinkholes or saltpans.

The identification of tracts resulted from a preliminary screening of over 300 topographic maps. As such, detailed evaluation of all possible siting flaws was not completed. Air and ground reconnaissance of all areas were also conducted to supplement data obtained from the map review. All details were reviewed eventually as sites were selected for evaluation.

The guidelines used for identifying tracts of land included consideration of the following characteristics:

- Contiguous area.
- Slope.
- Non-conforming land use.
- Surface drainage and topography.
- Groundwater discharge.
- Surface water resources.
- Demographic/cultural/recreational features.

Task 3

The principal objective of Phase II is to recommend two to five sites for conducting preliminary site characterization studies (Phase III). Through Task 2 of Phase II, the technical screening process progressed from consideration of the entire state of Texas (Phase I) to the identification of approximately 50 potential sites. Each of these sites contain promising geotechnical, environmental, engineering, economic characteristics, and some less favorable qualities.

To assist in identifying the most attractive and unsuitable attributes of the 50 sites, a site ranking process was employed. The ranking was designed to evaluate pertinent site characteristics, accounting for the relative importance of each characteristic within the siting process. This resulted in numerical environmental and engineering/economic comparisons of about 50 sites. The separate numerical rankings of each site from environmental and engineering/economic prospectives should not be judged as

absolute or rigid. They were developed from published data and judgement for use in comparing the relative merits of each site as an aid to the final selection process.

The ranking process was not rigorous because this siting study, as with most siting studies of broad scope, requires subjective evaluation and professional judgement. This site ranking was quantitative, but represents just one of the tools used in the final site selection process. Legal, political, and social realities were equally as important and cannot often be incorporated in the ranking process. Nevertheless, the ranking used in this study provided a fundamental basis for evaluating the sites considered, and allows for comparison with other technically acceptable and available sites that might be identified at a later date.

The essence of the ranking process is the identification of major issues which can be evaluated technically at each site by professional investigators and assigned relative importance weightings by independent assessment. Two key elements are important:

1. The assignment of the "importance weightings," or relative importance of the issues, is accomplished by a panel of individuals with diverse and varied background with interest in the results of this siting study. Civic and political leaders in addition to managers and technical personnel were involved.

2. Each issue, whether of an environmental or engineering/economic nature, is defined by a series of technical or quantifiable factors. Because of their training and experience, professional investigators assigned rating values for each factor for each site under consideration.

The ranking results were calculated by combining the importance of the issues with the factor ratings. Therefore, the results reflect both the professional investigators' opinions of the technical merit of each site and the evaluation of the importance of each issue as judged by a panel of individuals representing varied interests.

The ranking process was conducted in the following sequence.

1. Defining the major siting characteristics or issues and their component factors.

2. Development of factor weights within each issue.

3. Assignment of issue importance weightings, which define the relative importance of each of the issues (environmental and engineering/economic conducted separately).

4. Rating each of the sites for all factors, and combining these to obtain the rating of each site by issue.

5. Ranking all sites to compare their relative suitability.

6. Assessing the sensitivity of the ranking results.

All ranked sites were potentially licensable. The task then evolved to selection of those sites which were not only technically suitable, but which fulfilled all the legal and other requirements necessary to establish a site.

PHASE III

The Phase III work involved on-site investigations at sites identified during the ranking process, and which were available for purchase. Studies include the drilling of several borings to confirm the site lithology and to confirm the absence of shallow groundwater. This confirmation was necessary to ensure that there were no "fatal flaws" on the property that might not have been cited in the literature.

Site specific evaluations of the geology, surface hydrology, and meteorology were also conducted. This included determining the presence or absence of any creek beds which might only have seasonal water flow. Both surface soil samples and borings were lab tested in order to determine site specific hydraulic conductivity measurements. This on-site work also included an evaluation of the local biota and archaeological significance. This was necessary to ensure that no protected or endangered species would find the site a suitable habitat or were presently living there.

Upon completion of the Phase III preliminary site characterization work, the Authority was able to provide detailed information about the qualitative and quantitative criteria for each site.

CONCLUSIONS

The detailed results of this project enabled the Texas Low-Level Radioactive Waste Disposal Authority to recommend several potential sites to the Board of Directors with the confidence that any site designated by the Board would be technically suitable and licensable as a low-level radioactive waste disposal site. Upon the Board of Director's naming the site, more lengthy and detailed site characterization studies would be conducted to validate initial findings and provide data for the final design.