REGIONAL SCREENING AND SELECTION OF CANDIDATE SITES FOR CALIFORNIA'S LOW-LEVEL RADIOACTIVE WASTE DISPOSAL FACILITY

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ABSTRACT

California law requires that a low-level radioactive waste (LLRW) disposal facility be established in California.* The facility is required to meet the responsibilities of the state under the Federal Low-Level Radioactive Waste Policy Act of 1980 for the safe disposal of LLRW generated within the state by nonfederal activities.

INTRODUCTION

Criteria development for the location of a technically suitable site in California began with a study by the California Department of Health Services (DHS) in 1982. The study identified several criteria for site location including those related to land use, population, access, economic impact, geology, and hydrology. Geologic and hydrologic criteria included:

- Exclusion of areas of more than 10 inches average annualrainfall,
- Exclusion of active fault zones,
- Avoidance of areas with recent volcanic activity,
- Exclusion of wetland, coastal high-hazard, or 100-yearfloodplain areas,
- Exclusion of contact between waste and ground water, and

Avoidance of economic mineral resource areas where exploitation for resources would impair site performance.

Using those criteria that were regionally applicable, DHS screened the state and developed an initial set of maps indicating portions of the state that might contain suitable sites.

Of the regionally applied DHS criteria, the most important in regard to technical suitability was the requirememt that mean annual rainfall be less than 10 inches.

Areas of less than 10 inches mean annual rainfall exhibit many of the necessary characteristics which satisfy the technical requirements and per-formance objectives associated with LLRW facility siting. Flooding, ponding, on-site springs and seeps, and large water table fluctuations (all of which are to be avoided) occur with far less frequency in arid climates. Because surface and ground water in both vadose and saturated zones are the primary potential transport pathways for potential migration of waste from a disposal site, arid areas that limit the potential for contact between the waste and surface or ground water are considered optimal for siting.

The criteria for further screening of candidate areas defined by DHS were formulated by extending the DHS criteria to include federal requirements as given in 10CFR61. These requirements state that a disposal site must be capable of being sufficiently characterized, analyzed, modeled, and monitored to enable confident prediction of the fate and expected environmental concentrations of any nuclides that may be released from the site. U.S. Ecology and HLA formulated a conceptual model of the "ideal" site that would come the closest to meeting the combined criteria of the DHS and the Nuclear Regulatory Commission (NRC). This conceptual model and its application in the further refinement of the DHS-identified candidate site areas are described in this report.

CONCEPTUAL MODEL DEVELOPMENT

The conceptual framework for screening was based upon both the State and Federal regulations requiring that the natural attributes of a prospective site allow full characterization, modeling, monitoring, and analysis of geologic, meteorologic, hydrologic, and radiologic factors. Since geologically and hydrologically simple sites are more likely to meet the conditions for characterization, modeling, monitoring, and analysis than more complex sites are, the attributes that qualify a site as simple for the purposes of establishing a consistent screening model were reviewed. These attributes are discussed in the following sections.

* Assembly Bill 1513 (1982).

HYDROLOGIC CONSIDERATIONS

Hydrologically simple sites have the following general characteristics. Ground-water conditions are less complex when:

- Ground-water recharge and discharge areas and processes relative to the site are well defined or definable,
- Ground water occurs and moves in porous geologic material (primary porosity), and its movement is more consistent, predictable, and easier to characterize. Ground-water flow is more difficult to characterize when it occurs in fractures or solution cavities in indurated rock (secondary porosity). In rocks with fractures and solution cavities, water movement is complex and the degree of heterogeneity and anisotropy is increased. These features increase the uncertainty in predictive modeling of possible ground-water transport.(Freeze and Cherry, 1979, pages 30-36, 409; University of Arizona,1980, page 1).
- The three-dimensional direction(s) of ground water is (are) rela- tively easy to establish, and flow is least affected by the presenceof subsurface barriers to ground-water flow (i.e., faults) or numerous withdrawal points (i.e., wells or well fields).
- The ground-water system is in a state of dynamic equilibrium; i.e.,ground water is not influenced by large withdrawals or highlyirregular recharge events that could result in large water levelchanges.
- Surface indications of ground-water discharge, such as springs andseeps, do not occur.
- Surface-water conditions are less complex in the following instances:
- Upstream drainage areas are relatively small and well defined, and
- The terminus of surface water flows is well defined.
- Geologically simple sites have the following general characteristics:
- Geologic conditions are relatively stable (i.e., less seismic activity and evidence of historic or recent fault activity),
- Geologic units containing ground water are not fractured, warped, orfolded,
- Subsidence is not known to occur, and

The probability of volcanism occurring within the 500-year regulatorytime frame for the wastes is low.

Specific components of the regional screening model were developed by considering the various types of geologic and hydrologic environments that would incorporate the above characteristics to the greatest degree. Figure 1 presents a block diagram and cross-sectional view of the area that best suits the conceptual screening model.

TOPOGRAPHICALLY CLOSED BASINS

Topographically closed basins were chosen as a key feature of the screening model. Such basins provide locations where hydrologic and geologic conditions are likely to be less complex than in the large, regionally extensive or open drainage systems. In a topographically closed basin, any potential transport of contaminants from a site via surface or subsurface pathways (e.g., surface runoff or ground-water flow) will more than likely be easier to define.

The terminus of any surface-water flow or runoff is easily identified if adequate topographic control within a basin is provided. In most basins, surface water terminates in a playa or dry lakebed where it may pond periodically. The ability to define the limits of a surface-water system within a basin increases the likelihood that a potential site will meet performance objectives.

Research at the Beatty, Nevada LLRW site (U.S. Geological Survey, 1986) and other studies (Harding Lawson Associates, 1986) indicate that deep recharge of the water table is extremely low in some areas of desert basins. For example, the long-term deep percolation rate at the Beatty, Nevada site was estimated by the USGS to be approximately 4 cm every 1000 years (USGS, 1986). The lack of significant deep percolation is the result of low rain-fall (typically less than 10 inches/year) and high evaporation (generally more than 100 inches/year) in desert areas. In the arid desert environment, rainfall percolates a relatively short distance into the ground before it is absorbed by capillary forces that "wet" the dry moisture-deficient soils. The downward movement of the moisture that does percolate is countered by evaporative drying and plant transpiration at or near the soil surface. With-in topographically closed basins, the areas where recharge is unlikely to occur are bajada or alluvial plain surfaces that are remote from the upper portions of alluvial fans (see Figure 1). Although the potential for recharge is low in desert basins, certain portions of those basins have a higher prob-ability of receiving recharge. Significant recharge can occur in major washes and ponded-water areas (playas) where precipitation runoff is concentrated.

The likelihood that ground-water flow terminates within a topographically closed basin is also high. In many closed basins, ground water flows from the margins of the basin towards the basin center where it is discharged as evaporation or transpiration (see Figure 1). In such cases, the ground-water system is more easily characterized, modeled, and analyzed because recharge and discharge points can be more readily defined.

In basins where there is known subsurface ground-water outflow, the out-flow area may be readily identifiable

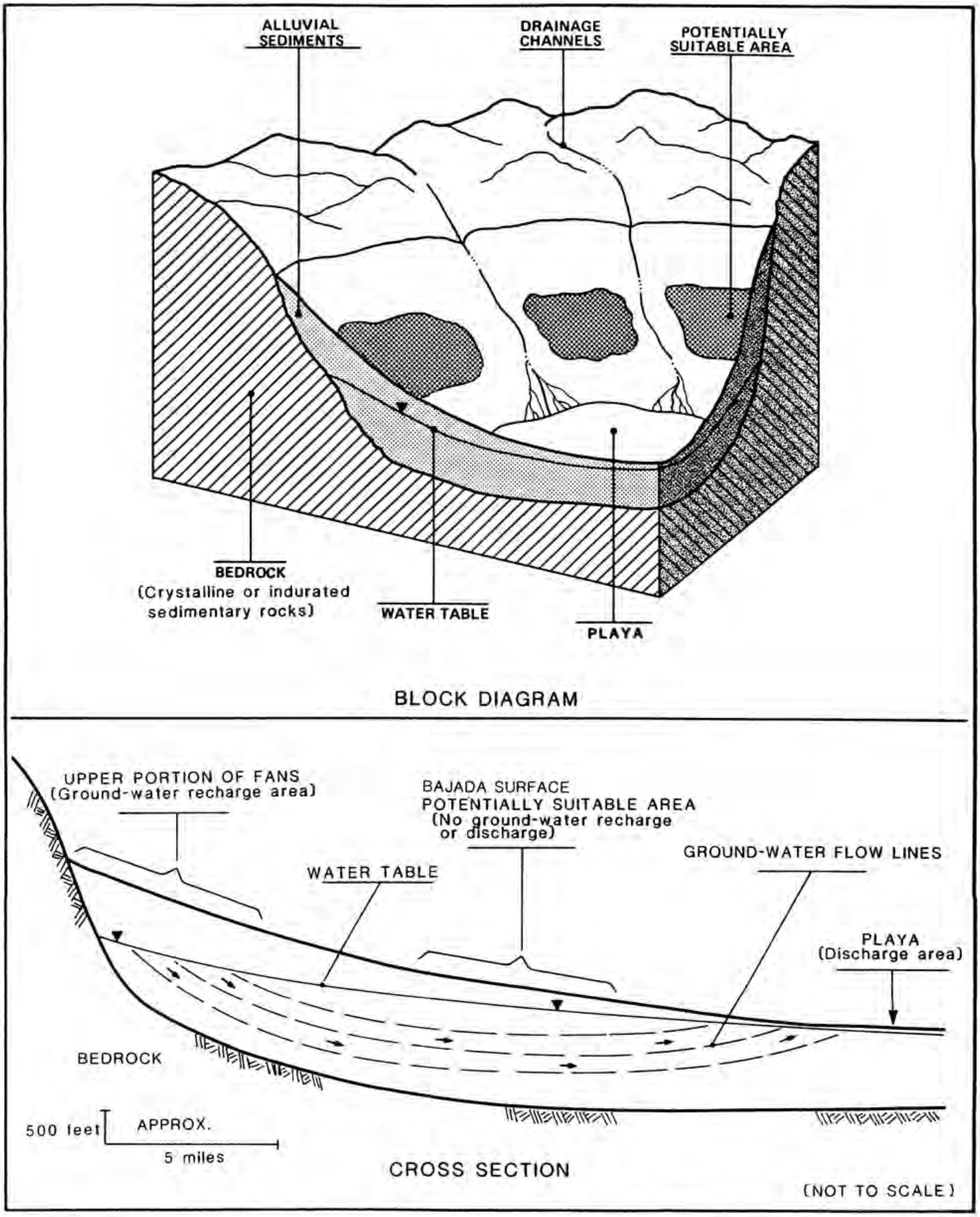

Fig. 1. Schematic Diagrams of Potential Site Areas.

(e.g., it occurs through an alluvial gap or pass between valleys) and flow conditions easily definable on a spe- cific site or area basis.

POROUS GEOLOGIC MATERIALS

Site areas that have subsurface movement of water (and potential trans-port of any contaminants) in the vadose and saturated zones occurring in primary porosity associated with porous, nonindurated geologic materials (e.g., alluvial sediments) were considered to be more easily characterized than those sites where movement occurs via secondary permeability associated with fractures and solution openings in indurated rocks. Areas of indurated rock were therefore excluded.

GROUND WATER DEPTH

For the screening process, a limit of 30 meters was chosen for the mini-mum depth to ground water. Placing arbitrary but realistic limits on the depth to ground water enabled the model to meet many of the siting require-ments including:

- The disposal site should not be located in wetlands,
- Wastes should not come in contact with ground water, and
- There should be sufficient distance between the waste and the under- lying ground water to allow for early detection of any leakage beforeit contacts the ground water.

If it is assumed that wastes can be buried as deep as 15 meters, the 30-meter criterion allows for a minimum 15-meter vadose zone between the waste and the water table. The waste is unlikely to come in contact with ground water because water table fluctuations in arid areas (that are not greatly influenced by pumping or artificial recharge) are highly unlikely to fluc-tuate as much as 15 meters.

The use of the criterion for minimum depth to ground water also excludes areas where springs or seeps are likely to occur.

GROUND WATER QUALITY

For regional screening, the existing quality of ground water was not considered as the basis for exclusion of a particular area.

FAULTING

For conceptual model development and screening, major active* and poten-tially active faults were avoided. Minimum setbacks of 1/2 mile from the mapped trace of a fault and the projected trace (2 miles) were established along each fault to avoid areas that were potentially subject to ground rupture during seismic activity.

UNSTABLE SOIL AREAS

As indicated in 10CFR61** and the State criteria, areas where surface geologic processes may impair the site's ability to meet performance objectives should be avoided. One of the most important surface processes that could affect the site is the presence of unstable soils. In the model used for screening, this consideration was included by exclusion of areas with unstable soils including:

- Areas on or in the path of large landslides or slumps,
- Sand dunes,
- Eolian (wind deposited) sand deposits or dune sand deposits, and
- Subsidence areas.

A 1-mile buffer zone was used in areas where sand dunes were present to allow for potential shifts or migration of the dunes. In areas where the eolian surficial sediments were present, but in which topographic expression of eolian features were not evident, a buffer zone was not used.

VOLCANISM

For regional screening, areas near known volcanoes or historic volcanic activity were excluded. This is consistent with both Federal*** and State objectives. The setback was considered to be a minimum of 5 miles from a Recent-age volcano or cinder cone. The minimum setbacks were used on a regional basis considering, that for specific areas, the nature of the volcanic deposits, their age, location, and relationship to surrounding features would require further evaluation.

SURFACE WATER

As indicated in State and Federal regulations, surface water conditions are important criteria in site selection. The screening model incorporated this aspect in the exclusion of flood-prone areas that could be identified on a

* Active faults are those with known historical activity (last 200 years) and potential active faults are those that show evidence of movementduring Quaternary time (last 2 million years). Reference: California Division of Mines and Geology, 1975. Faults in these categories include capable faults as defined by the Nuclear Regulatory Commission.

** Subpart D, 61.50(a)(10).

*** 10CFR61, Subpart D,61.50(a)(9).

regional basis. The areas excluded included dry lake beds and major regional river beds and washes.

Exclusion of areas based upon more localized conditions related to smaller specific washes and drainage areas was reserved for more site-specific screening.

CRITERIA APPLICATION

Criteria developed for the screening model were first applied on a regional scale and then on an area-specific scale. The screening scale determined when specific criteria were applicable. Screening was performed using both published and unpublished data from agencies, including the U.S. Geological Survey, the California Division of Mines and Geology, the California Department of Water Resources, and various private sources.

The result of the screening was the identification of numerous geologically and hydrologically suitable sites. Final selection of three candidate sites, each 1 square mile in size located in the Ward and Silurian Valleys (San Bernardino County) and in the Panamint Valley (Inyo County) was based upon their satisfaction of the geologic and hydrologic regional screening criteria and various other land use and environmental criteria. The three candidate sites also received strong public support from a Citizen's Advisory Committee established as part of the overall siting study.

During the latter half of 1987, detailed site characterization studies were initiated. The purpose of the characterization was to determine if the three sites were technically suitable and to provide necessary information to compare the three candidate sites and select a preferred site. This site will then be characterized, analyzed, modeled, and monitored as required for licensing by the State of California.

- The characterization studies included:
- Geologic mapping,
- Geophysical surveys (seismic reflection and refraction, resistivity,gravity, and magnetics),
- Drilling and installation of monitoring wells, and
- Installation of a meteorologic station.

The geophysical surveys identified fatal flaws (potentially active faulting) at the Panamint site, and it was removed from further consideration.

Currently (February 1988), the Ward Valley and Silurian Valley sites are being considered and a preferred site has not been selected. Future characterization activities to be performed at the preferred site include:

- Installation and monitoring of additional wells, including severalscreened near the water table and at least one deeper well,
- Installation and monitoring of a series of soil probes (thermocouplepsychrometers and tensiometers) in the upper 10 meters of soil,
- Drilling and sampling of soil for geotechnical and geochemical test- ing, and
- Performance of infiltration and aquifer tests.

Field data will be analyzed and used as input for geochemical modeling, vadose zone modeling, groundwater flow, and transport modeling. Model results will be used to perform dose assessment analysis to meet licensing requirements.

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