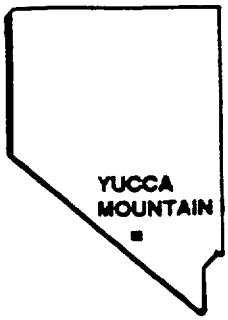
YMP/90-97

U.S. DEPARTMENT OF ENERGY

OCRWM



YUCCA MOUNTAIN
SITE CHARACTERIZATION PROJECT

RESPONSES TO CALIFORNIA ENERGY COMMISSION COMMENTS ON THE SITE CHARACTERIZATION PLAN

DECEMBER 1990

UNITED STATES DEPARTMENT OF ENERGY

U.S DEPARTMENT OF ENERGY'S COMMENT RESPONSES FOR THE COMMENTS RECEIVED FROM THE CALIFORNIA ENERGY COMMISSION

The California Energy Commission (CEC) submitted comments on the Site Characterization Plan in a letter dated April 14, 1989. The U.S Department of Energy first renumbered the pages contained in the letter received from the CEC and identified individual comments within the letter. The comments were then enumerated from the aggregate package that was submitted; the total number of comments was 38. A copy of the enumerated comment package is provided under separate enclosure for cross reference. Each comment number is marked in the margin of the page and the page number is marked in the upper right hand corner of the page. Where multiple comments occur on one page, each is bracketed by horizontal lines.

For each comment, the DOE response package provides a description of the comment, followed by the response to the comment. Each comment was either furnished an individual response, or cross-referenced to a response addressing comments pertaining to the same overall theme.

U.S. DEPARTMENT OF ENERGY RESPONSES TO COMMENTS
RECEIVED FROM THE CALIFORNIA ENERGY COMMISSION
ON THE SITE CHARACTERIZATION PLAN

COMMENT 1:

The most important geologic issue relevant to California is potential groundwater contamination resulting from an accidental radionuclide release at the site. Preliminary site characterization studies conclude that Death Valley is hydraulically connected to, and down-gradient of, the aquifer beneath the Yucca Mountain site. The potential for migration of radionuclide contaminants into eastern California aquifers (i.e., into the Death Valley regional groundwater basin), therefore, is of concern as are potential impacts on water supplies for California fish and wildlife populations in and near the Death Valley National Monument.

In order to determine whether potential impacts within California might occur, the Site Characterization Plan (SCP) should include complete regional, as well as local, aquifer characterization. Emphasis should be placed on adequately qualifying and quantifying potential aquifer contamination down-gradient of the site. Future studies should concentrate on developing an accurate local and regional hydrogeologic model, with consideration of factors of the hydrogeologic regime that are dynamic over the post-closure time frame. In addition, the SCP should include provisions to assess potential effects on fish and wildlife populations dependent on potentially affected groundwater supplies, if contamination is a realistic concern.

Response:

Although water levels in Death Valley are indeed lower than those beneath Yucca Mountain, Death Valley is not necessarily "down-gradient" from Yucca Mountain, in the sense that continuous flow paths connect the two areas. Investigations that, at least initially, will emphasize hydrochemical methods are planned to determine whether springs discharging in Death Valley derive their flow from the Cenozoic basin-fill deposits of the Amargosa Desert, to which flow beneath Yucca Mountain contributes, or from continued westward flow from the Ash Meadows ground water system in deep aquifers composed of Paleozoic carbonate rocks. The principal reasons for these and other regional hydrologic investigations are (1) to estimate the rates of southward flow beneath Yucca mountain; and (2) to evaluate the effects of changes in the hydrogeologic regime in the postclosure time frame.

It is neither feasible nor necessary to study the regional hydrology as intensely as that of the site itself. The regulatory criteria for licensing of a repository limit the allowable releases at five kilometers from the site (or to the atmosphere above the site) to standards established by the Environmental Protection Agency. Therefore, satisfaction of the release criteria at the 5-km (meter) perimeter also indicates that more distant locations will not be subject to contamination.

Refer also to the response to Comments 28 and 38 which address plans for monitoring spring/seep discharges and quality during site characterization.

COMMENT 2:

We request that the State's Division of Mines and Geology be notified in advance of any studies, for example geologic/seismic studies, to be conducted in California as part of the Yucca Mountain Repository Site investigation. California has geologic information which may prove to be useful to the federal government's investigation of the Yucca Site. In turn, geologic studies conducted within the state as part of the site characterization program would be of value to the state.

Response:

The Yucca Mountain Site Characterization Project Office of the U.S. Department of Energy (DOE) will notify the California Division of Mines and Geology (DMG) before undertaking major data acquisition activities in California that are part of the site characterization program for Yucca Mountain. On occasion, scientists involved with the Project may undertake reconnaissance investigations in the Death Valley National Monument, or in this general region of the Mojave Desert province. Such reconnaissance work may, for example, involve the examination of surficial features, or the collection of monitoring data from instruments or the servicing of these instruments. An example of the type of activity for which DOE would notify DMG would be a major research project such as the investigation of any potential seismic line that may transect the Death Valley National Monument area.

The information developed from all Project characterization work is part of the public record. Convenient references that can be consulted to become acquainted with work of this type would be the semiannual Site Characterization Progress Report, which reports the nature of characterization studies and the information developed from them, and also the semiannual Yucca Mountain Project Bibliography Updates issued by the Yucca Mountain Site Characterization Project Office in Las Vegas. The latter reference provides an annotated description of the contents of technical reports and other research products resulting from DOE's program of characterization for Yucca Mountain. The California Energy Commission (CEC) has been placed on the mailing list for the Site Characterization Progress Report. If the CEC has information that could be of benefit to the Project, the DOE would appreciate a list of pertinent references. If the CEC would like to receive the Project Bibliography Updates, please contact the Project Office:

U.S. Department of Energy
Yucca Mountain Site Characterization Project Office
P.O. Box 98608
Las Vegas, NV 89193

COMMENT 3:

Not all figures show the repository location. Each figure should depict this location. Without this information, it is difficult to place the Repository in relation to the natural and man-made features which have been discussed throughout the Overview. Staff was not able to ascertain the relative location for the exploratory shafts to be dug in relation to the proposed Repository. It is difficult to determine if the location for this testing is close enough to the proposed Repository site to test the same depositional environment, but far enough to prevent creating a potential conduit for ground water into this same Repository. We would be happy to complete the evaluation when the figures are amended.

Response:

The Site Characterization Plan (SCP) Overview presents summaries of selected topics covered in depth in the SCP; it is not a substitute for the SCP. The Overview is intended primarily for those persons who want to understand the general scope and basis of the Department of Energy's (DOE) site characterization program, the activities to be conducted, and the type of facilities that would comprise a hypothetical repository at Yucca Mountain, without spending the time necessary to become familiar with with all of the technical details in the SCP. DOE agrees that the criticism is justified in regard to the figure(s) and hopes the enclosed figures (3-2 and 3-3) together provide information enabling the reader to place the Exploratory Shaft Facility (ESF) locations in relation to the repository perimeter drift (line surrounding "Underground Facility" in Figure 3-2), and in relation to the boundaries of land controlled by the Nevada Test Site, the Air Force, and the Bureau of Land Management (Figure 3-3). ESF specific locations are currently under study in the ESF Evaluation.

One of DOE's primary concerns is to study the site in a manner that allows characterization but does not affect its ability to isolate waste. Section 8.4.3 of the SCP, "Potential impacts of site characterization activities on postclosure performance objectives", contains an in-depth discussion as to the potential for interference between, and among, the many surface-based and ESF testing programs that are planned. For penetrations of natural barriers, drillholes for example, a sealing program is planned to preclude them from becoming a potential path of radionuclide migration.

YUCCA MOUNTAIN PROJECT
PROPOSED PROTOTYPE BOREHOLES

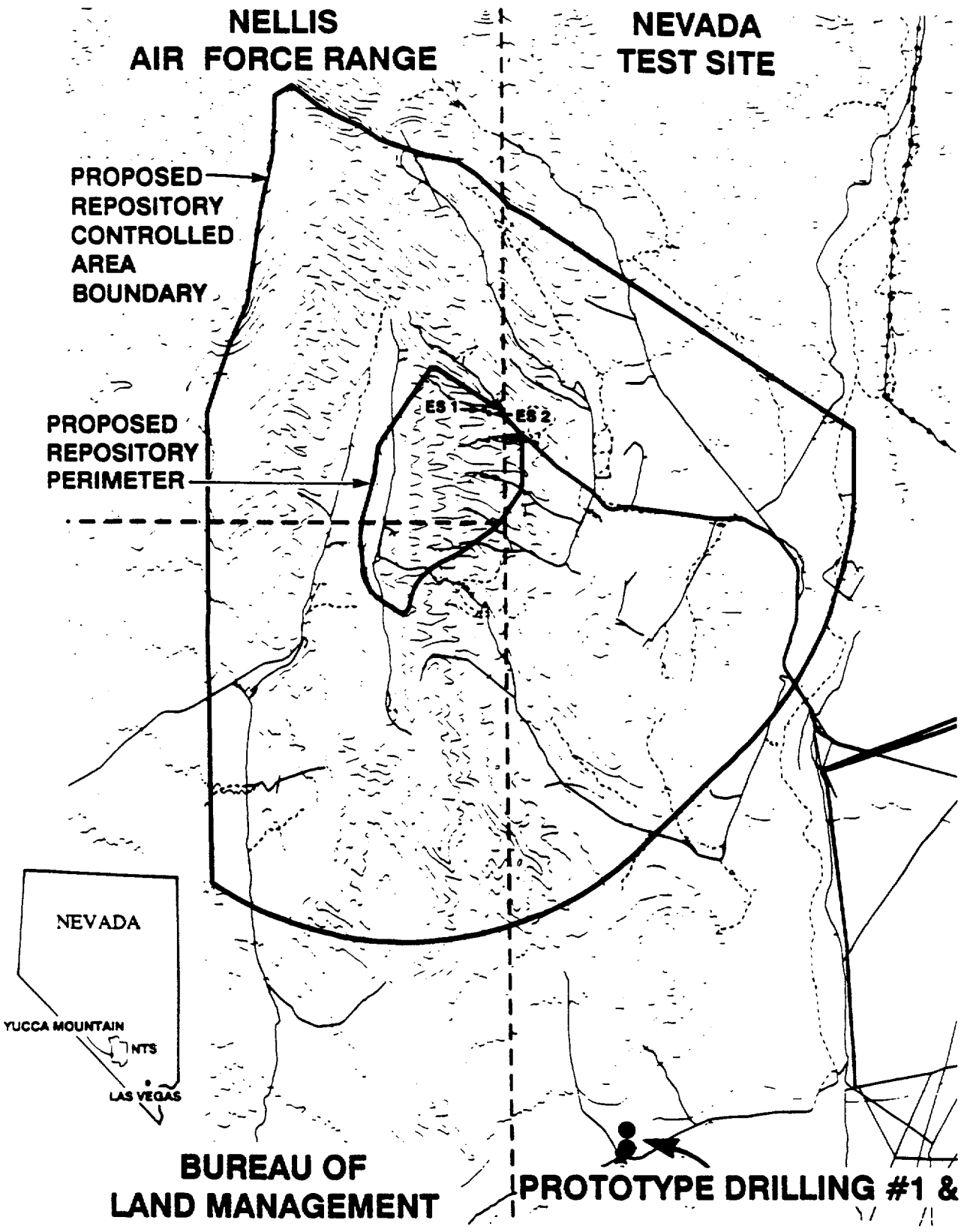


Figure 3-2.

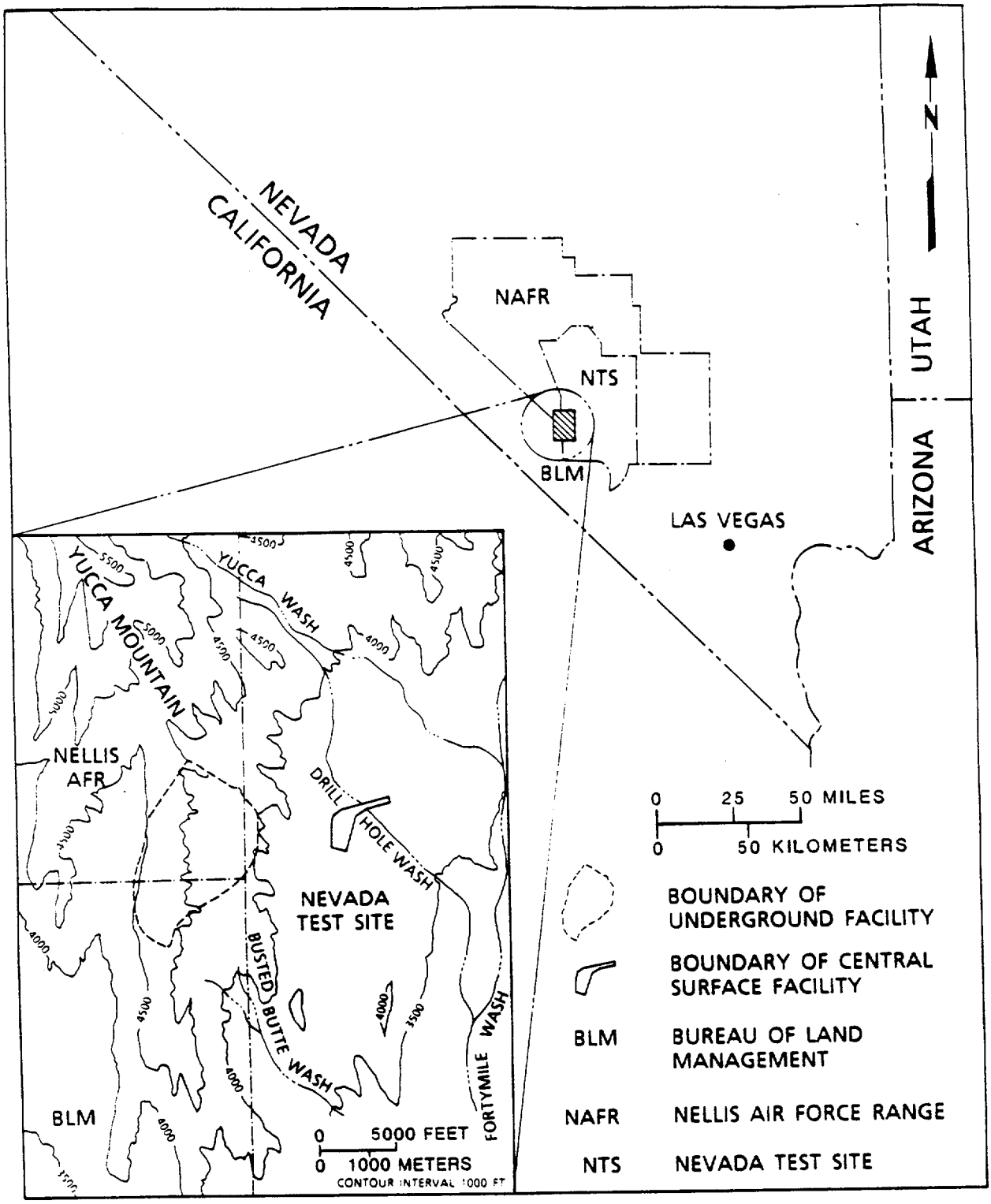


Figure 3-3. **Location of Yucca Mountain site in southern Nevada. Modified from SNL (1987).**

COMMENT 4:

The Overview states "Measurements made since 1978 show that within about six miles from the proposed repository the release of seismic energy has been 100 or 1,000 times lower than that in the surrounding region." This statement is not clear as to its intent. It may be that the site is storing up energy (locked fault segment) which indicates increased probability of relatively large fault movement in the future.

The prediction of future seismicity has only been presented in general terms. The theory of eduction (Dixon, Farrar, 1979) should be discussed in terms of predicting future seismicity. This paper states that the upwelling and lateral flow of mantle material associated with the subducted East Pacific Rise produced the horizontal extension of the Basin and Range Province. This scenario may indeed describe the mechanism which created the Yucca Mountain area. In this case, the seismicity expected may be different than that proposed previously for Basin and Range geographic provinces.

Response:

The Site Characterization Plan (SCP) describes Study 8.3.1.17.4.12 (Tectonic Models and Synthesis) which will consider existing data and additional data derived from site characterization in order to evaluate possible future tectonic events, including the significance of relative seismic quiescence at the Yucca Mountain site and of the effects of various driving mechanisms for tectonism. No less than 16 additional studies, of the 106 contained in the SCP, are devoted to a program of data gathering and analysis of the faults in the site area to determine the potential for seismic activity during the operational period of a repository at Yucca Mountain and the period after its closure and sealing.

COMMENT 5:

Hydrothermal veining due to nearby volcanism may have been the cause for calcite-silica-sepiolite veining seen in the area. Thus, their presence may indicate the existence of a volcanic body at depth near this site. The potential for future volcanism and the associated ground water rise upwards through new veins needs to be defined in terms of their effect upon the Repository. The origin of these calcite-silica-sepiolite deposits should be examined.

Response:

A determination of the origin of the calcite and opaline silica veins formed in the Yucca Mountain area is indeed a planned high-priority activity involving a broad range of scientific methods and technical procedures. These are outlined in the Site Characterization Plan Activity 8.3.1.5.2.1.5 (Studies of Calcite and Opaline Silica Vein Deposits) which is part of Study Plan 8.3.1.5.2.1 (Characterization of the Quaternary Regional Hydrology).

The approaches being used in this activity have been developed through the concurrence of numerous program participants, including the NRC, during two workshops conducted in 1986. The established methodology was subsequently endorsed, with minor modifications, by a multidisciplinary peer panel of nationally recognized experts in 1987. The methodology includes analyses of the vein-filling materials, the fractured wallrock, and potential sources of the vein-filling minerals. These materials will be analyzed in terms of their geochemical and isotopic compositions, total mineralogy, geochronology, and paleontology; these analyses will provide the data base that bear upon the origin of the calcite/silica veins. A determination of potential for future volcanism and for associated changes in water-table levels are also planned activities outlined in Activities 8.3.1.8.3.2.1 (Thermal and barrier-to-flow effects of igneous intrusions on water-table elevation), 8.3.1.8.3.2.2 (Assessment of the effects of igneous intrusions on water-table elevations), and 8.3.1.8.3.2.3, (Assessment of the effect on strain changes or water-table elevations).

Investigations of the potential for future igneous activity, including possibly associated hydrothermal processes, and of the origin of the calcite-silica-sepiolite deposits are described in SCP sections 8.3.1.8 (Postclosure tectonics program) and 8.3.1.5 (Climate program), respectively. The study plans that extend and provide more detail than the SCP specifically address the possible effects on a repository at Yucca Mountain that might result from volcanism or ground water rise, as well as the possible implications of the calcite-silica-sepiolite deposits.

COMMENT 6:

The Overview discusses the welded tuff, the rock type into which the Repository may be installed. However, much of the investigation to date, as well as future investigation of this lithologic bed, must rely upon the use of geophysics predominantly so as not to disturb the in-place material at the Repository site. However, it is difficult to characterize welded tuff deposits by the use of geophysics due to the fact that welded tuffs are dense and have no definitive structure and because of the complexity and heterogeneity of the site. Thus, the exploratory shafts will need to serve, by the use of direct sampling, to extrapolate and infer the distinguishing characteristics of the rock materials at the proposed Repository site. Staff has not been able to determine where these exploratory shafts will be dug, nor were they able to find in the report the rationale as to why the exploratory shaft site is similar geologically to the proposed Repository site. It is not clear in the report if the investigators are planning to drill these exploratory shafts in the same lithologic bed as the proposed Repository. Since much data must be derived from these exploratory shafts to aid in the understanding of the rock material at the proposed Repository site, it is important that staff understands the rational for their placement. We would be happy to complete the evaluation when the information is submitted.

Response:

Characterization of the rocks constituting the repository block will be carried out with a wide variety of studies and methods, including drilling, that go far beyond geophysical studies. These studies are described in Section 8.3.1.4 of Chapter 8 of the Site Characterization Plan (SCP) that are explained in study plans and technical procedures that support the SCP.

The location of proposed exploratory shaft facilities (ESF) are described in Chapter 6 of the SCP. SCP Section 8.4.2.3, Subsurface-based activities, discusses the exploratory shaft facility (ESF) location and layout. The ESF design is different from that in Chapter 6 in that DOE deferred excavation into the Calico Hills unit underlying the repository unit pending an analysis of the risks/benefits of penetrating that unit and a subsequent review by the NRC. In addition, DOE is conducting a comparative study of alternate ESF construction methods, layouts, and locations.

COMMENT 7:

The report states that no high temperature geothermal resource exists in the area. The report considers 190 degrees Fahrenheit to be the minimum temperature for a high temperature resource, although the actual temperature at which electricity can be produced (albeit inefficiently) may be below this temperature. Because the report does not quantify the surrounding heat flow gradient anomalies, the potential for geothermal development in the future is unknown. Also, with the probable future advent of new technologies, as well as dwindling energy supplies, a fairly low heat flow gradient may be indicative of future energy reserves. Investigation of these reserves at a later date may result in future disturbance of the Repository site.

Response:

Regional geothermal resources are classified as low-temperature (less than 190 degrees Fahrenheit). Warm springs do discharge at the Ash Meadows area that are believed to result from deep circulation of ground water; however, these are not potential geothermal resources.

The U.S. Department of Energy believes Activity 8.3.1.9.2.1.3 (Assessment of the Potential for Geothermal Energy at Yucca Mountain), as outlined in the Site Characterization Plan, will address the concerns expressed in this comment. The assessment will be supported by Study 8.3.1.15.2.2, (Characterization of the Site Ambient Stress Conditions), and by Activity 8.3.1.8.5.2.3 (Heat Flow at Yucca Mountain and Evaluation of Regional Ambient Heat Flow and Local Heat Flow Anomalies).

COMMENT 8:

In the Overview, the designation "speculative, undiscovered" was applied to gold, silver, mercury, uranium, and base metals occurring in the area of the facility. These terms should be defined. No indication was given in the report as to whether further exploration for these minerals would be performed. If there is some potential for these minerals to exist at the proposed Repository site, then it should be determined whether they do indeed exist at the site.

Response:

The designation of "speculative, undiscovered" on page 24 of the Overview comes from Figure 1-74 (Section 1.7, Volume 1, Part A), "Major elements of mineral resource classification," which graphically illustrates a scheme of classification proposed by the U.S. Bureau of Mines and the U.S. Geological Survey (USBM/USGS, 1980). The quoted designation refers to resources not yet discovered that may be "in types of deposits as yet unrecognized for their economic potential" (USBM/USGS, 1980) as well as in known types of deposits. They represent the rank of least geologic certainty in a graded hierarchy of categories. The source of the Overview statement is Section 1.7.1.2.3, p. 1-283, "Yucca Mountain is considered to have a low potential for precious and base-metal deposits... The existing data base does not indicate the presence of identified resources and, until new data are obtained, they are considered as speculative, undiscovered resources of subeconomic grade."

A planned Site Characterization Plan (SCP) Activity, 8.3.1.9.2.1.1. (Geochemical Assessment of Yucca Mountain in Relation to the Potential for Mineralization) will conduct a geochemical sampling program to evaluate the potential for precious, base, and strategic metals. The selection of elements for analysis will be guided by a review of the literature of similar geologic environments and a review of the available data base for the nearby mineralized areas of Bare Mountain, Wahmonie, and Calico Hills. Both surface rock and available drill core will be sampled. Study Plan 8.3.1.9.2.1 (Natural Resource Assessment of Yucca Mountain), will provide additional details of planned work and assessment methodologies.

REFERENCES:

USBM/USGS (U.S. Bureau of Mines (U.S. Geological Survey), 1980. Principles of a Resource/Reserve Classification for Minerals, Geological Survey Circular 831, U.S. Geological Survey.

COMMENT 9:

A full description of the ground water below the proposed Repository was not included in the Overview. This description should include water quality analyses (Chloride, Iron, Manganese, Sodium, Phenols, Sulfate, pH, specific conductance, total organic carbon, total organic halogens, gross alpha, gross beta, total gamma, radionuclides), yield, and storage coefficient.

Response:

A full hydrochemical description of the ground water beneath the proposed repository was not considered to be appropriate for the Site Characterization Plan (SCP) Overview. The commentor is referred to the following sections of Chapters 3 and 4 of the SCP for much of the requested information: 3.7.3, 3.9.1.3, 3.9.5, and 4.1.2. Extensive plans to obtain additional hydrochemical data are contained in Chapter 8, particularly in Study Plan 8.3.1.2.2.7 (Hydrochemical Characterization of the Unsaturated Zone), and 8.3.1.2.3.2 (Regional Hydrochemical Characterization); and in Investigation 8.3.1.3.1 (Studies to Provide Information on Water Chemistry Within the Potential Emplacement Horizon and Along Potential Flow Paths). As is discussed on page 4-46 of the SCP, the concentrations of total organic carbon in the ground water are very small (<0.7 mg/L), indicating that complexing of radionuclides organic ligands would be insignificant.

COMMENT 10:

No age dating information on the ground water has been supplied. The age of this water would give an approximation of surrounding lateral and vertical permeabilities as well as recharge and discharge rates and locations.

Response:

The currently available ground water dating results are supplied to the reader in Section 3.7.3.2 of the Site Characterization Plan (SCP), and additional discussion of their significance is provided in Section 3.7.4. SCP Study Plans 8.3.1.2.2.2 (Water Movement Tracer Tests Using Chloride and Chlorine-36 Measurements of Percolation at Yucca Mountain), 8.3.1.2.2.7 (Hydrochemical Characterization of the Unsaturated Zone), and 8.3.1.2.3.2 (Regional Hydrochemical Characterization), describe plans for additional hydrochemical and isotopic-dating techniques to be used in support of recharge and flowpath studies.

COMMENT 11:

It is not clear as to whether the underlying aquifer is confined or unconfined, which would help to indicate potential flow paths and discharge points, such as the Furnace Creek area of Death Valley National Monument.

Response:

As is described in the Site Characterization Plan (SCP) Section 3.9.2.2, the rocks in the saturated zone beneath the proposed site do not constitute an aquifer in the sense of a discrete hydrostratigraphic unit that transmits water readily. Rather, they have small primary permeability but have been fractured and faulted, resulting in moderate to large effective permeability at some locations. The degree to which individual fracture sets are confined hydraulically is also quite variable, depending in part on the depth beneath the water table at which they are penetrated. In general, areas of more pervasively fractured rock probably have lesser confinement at a given depth. The potential flow pathways from Yucca Mountain to Death Valley, if such actually exist, would not occur in a single hydrostratigraphic unit; in fact, the tuffs that are at least as thick as two kilometers at Yucca Mountain thin greatly to the south and may be absent beneath the central Amargosa Desert.

COMMENT 12:

The estimates of rainfall infiltration given in the report are 0.3 percent. It is not clear if pan evaporation rates were used. If so, then slow, steady precipitation events should be factored into the calculations to determine actual infiltration.

Response:

Pan evaporation greatly exceeds precipitation in the vicinity of Yucca mountain and, therefore, is not of use in estimating either infiltration or recharge. The estimate in the Site Characterization Plan (SCP) is based on values reported from arid zones throughout the world and on a method introduced by Eakin et al. (1951) for use in Nevada and Utah. For rainfall events, actual infiltration rates depend, of course, heavily on duration and intensity of precipitation, but oxygen-isotope data and much literature on the hydrology of the Great Basin indicate that melting snowpacks are the primary source of recharge. The DOE plans, and has initiated, site-specific studies to determine infiltration rates and rates of percolation through the thick unsaturated zone. These are described in Section 8.3.1.2.2 of the SCP and in greater detail in several study plans.

REFERENCES:

Eakin, T. E., et al., 1951, "Contributions to the Hydrology of Eastern Nevada," USGS Bulletin Number 1018.

COMMENT 13:

It has not been described how flow direction was determined under the site nor whether further delineation of the flow regime will be performed during site investigation and Repository construction. There must be a site-specific investigation undertaken to determine these flows, as regional studies alone do not yield enough information to determine this information accurately.

Response:

Directions of probable ground water flow were inferred from the configuration of the potentiometric surface (approximately the water table), as defined from water level measurements in exploratory drill holes. Site Characterization Plan (SCP) Section 8.3.1.2.3 describes the general nature of studies that will be performed to characterize further the saturated-zone hydrologic system at the site. Consideration currently is being given to more extensive investigation of the possible roles of north-striking fault systems in controlling the directions of flow in the saturated zone.

COMMENT 14:

It is not clear as to why such a large discrepancy exists between the predicted migration rates (9,000 to 80,000 years) through the bedrock to the saturated zone given in the Overview document. All permeability values determined from below the level of the Repository should be determined relative to the suspected leachate that would be produced from the waste.

Response:

The calculations that resulted in a range of unsaturated zone travel times of 9,000 to 80,000 years, with a mean of 43,000 years, are described in Section 3.9.4.1 of the Site Characterization Plan (SCP). The range represents a distribution over the area of the proposed repository, resulting principally from areal variations in the thicknesses of the hydrogeologic units and in their properties such as effective porosity and degree of saturation. Permeability to water in two-phase flow is a variable that depends upon the geometry of interconnected pores, on the degree of saturation, and whether flow is occurring under wetting or drying conditions.

COMMENT 15:

The investigation at the area of the exploratory shafts indicates that sampling of the unsaturated zone will be performed when possible. However, it is not stated how sampling will be performed. It would seem reasonable to install lysimeters to collect this water for continuous monitoring rather than or in addition to a one-time sampling.

Response:

Aqueous-phase chemical investigations of the unsaturated zone are described in Sections 8.3.1.2.2.4.8 (Hydrochemistry tests in the exploratory shaft facility), and 8.3.1.2.2.7.2 (Aqueous-phase chemical investigations), of the Site Characterization Plan (SCP). Lysimeters are not feasible for sampling at depths of hundreds of meters and from rocks having very small permeabilities and water contents. The principal extraction techniques are centrifuging and triaxial compression, although vacuum distillation can provide samples for analyses of hydrogen and oxygen isotopes. The problem of sampling from these rocks is the subject of continuing research and prototype testing.

COMMENT 16:

The Overview document states that pump tests will be conducted in the saturated zone to determine hydrologic parameters. It is not clear which type of well pump tests will be performed nor how long these tests or the infiltration tests will be performed. Slug tests can be used in conjunction with pump tests in the saturated zone to give a larger number of data points. Packer tests should also be used in the unsaturated zone to determine subsurface permeabilities. No boreholes drilled for the determination of hydrologic parameters should have drilling fluids introduced downhole. In many cases, air can be used for the purpose of lifting the cuttings (and for cleaning blast holes). If fluids must be introduced, they should be kept at a minimum and the resultant mud cake scraped from the walls of the borehole.

Response:

Drilling methods: There has been considerable experimentation and evolution in drilling methods for both unsaturated zone and saturated zone testing. For example, prototype drilling as part of Site Characterization Plan (SCP) Activity 8.3.1.2.2.4.9 (Multipurpose Borehole Testing of the Unsaturated Zone) is currently being performed at Apache Leap, Arizona. The ODEX dry drilling system has been successful to depths of about 100 meters at Yucca Mountain, and the current testing is designed to extend the feasible depth. Reverse-circulation air-vacuum drilling has been accomplished to depths of several hundred meters, whereas air-mist and air-foam methods may be required for deeper drilling as they have been in the past. Mud cake is not a significant problem with these methods, but it may disturb in situ moisture conditions in the unsaturated zone. Saturated zone drilling with air foam, water, or water and detergent has proved satisfactory for hydrologic purposes and most coring for geologic studies. Because the greatest permeability in the saturated zone is associated with fractures and faults, natural permeability can be restored during development by pumping.

Saturated zone testing: The type and duration of pumping tests varies according to the objectives of specific tests and the results of the testing itself. The commentor is referred to SCP Study Plan 8.3.1.2.3.1 (Characterization of the site saturated zone groundwater flow system) for a preliminary description of the planned testing program, which is subject to change as the results of characterization studies become available. Slug tests have been used extensively in the past and will probably be applied to a more limited extent in future studies. In practice, the slug test technique is limited to zones having transmissivities less than about 2 m^2/day. Many of the fracture and fault zones encountered below the water table have larger transmissivities. However, packers will still be used (1) to obtain potentiometric levels in isolated zones at various depths; (2) to sample water from various zones for hydrochemical analysis; and (3) possibly to test the sensitivity of apparent permeability to applied hydraulic stresses as an indication of the effect of in situ mechanical stress on permeability. The experience from past hydraulic testing indicates that for overall hydraulic characterization, pumping tests combined with borehole flow and temperature surveys provide the most useful data set.

Unsaturated zone testing: As described in SCP Study Plan 8.3.1.2.2.3 (Characterization of Percolation in the Unsaturated Zone -- Surface-Based Study) and 8.3.1.2.2.4 (Characterization of Yucca Mountain Percolation in the Unsaturated Zone -- Exploratory Shaft Facility Study), extensive pneumatic testing with packers is planned for both the surface-based borehole testing and testing in the Exploratory Shaft Facility.

COMMENT 17:

No mention is made of water quality or quantity sampling of Ghost Dance fault nor of the imbricate faults identified on Figures 2 and 3. Test holes should be drilled, fluids sampled, and aquifer tests performed in these areas to further identify local hydraulic characteristics. These faulted areas would seem to be capable of carrying the most fluids subsurface.

Response:

The Site Characterization Plan (SCP) does not contain extensive plans for characterizing the saturated zone near the Ghost Dance Fault nor the imbricate fault zone to the east. The possibility of adding such plans to the testing program is being evaluated, although the decision as to whether to supplement current plans or design a more extensive testing program will occur at a later time. Tests at the Solitario Canyon Fault zone and at the UE-25c multiple-well complex, as described in SCP Section 8.3.1.2.3.1 (Characterization of the Site Saturated Zone Groundwater Flow System) may provide hydraulic information about the faults, which will be useful to both the decision and the design. Other factors include the results of the unsaturated zone studies to be performed and scoping and sensitivity analyses of the hydrologic effects of possible future climate change and tectonic processes. DOE agrees that the fault zones probably are much more transmissive than the rocks in unfaulted volumes. The uncertainty is in the degree to which the behavior of the saturated zone will influence the determination of site suitability.

COMMENT 18:

The presence of much faulting in the area (32 faults of unknown activities within 6 km, Dudley, USGS, GEOTIMES, January 1989) increases the permeabilities and porosities of the natural geologic materials. This secondary permeability and porosity precludes the predictability of the variable porosities and permeabilities of the Repository site. The Overview states that investigators believe fracture flow to be a minor component of flow in the area. The rationale for believing that fracture flow is minor compared to matrix flow should be explained.

Response:

The reference to GEOTIMES, should be to Brocoum, et al. (1989) who stated, "Within a 2,600-square-km area that encompasses Yucca Mountain, 32 Quaternary faults have been recognized, 5 located within 8 km of the repository block." The DOE agrees that faults probably provide permeable pathways (though minor additional porosity) in the saturated zone. Project investigators believe, however, that matrix flow is more important than fracture flow in the unsaturated zone. The fundamental concept is that fluid (air and water) pressure in fractures is approximately atmospheric, whereas water in the interstices of the rock matrix is under capillary tension. Unless the rock matrix closely approaches complete saturation, a large hydraulic gradient exists from the fracture into the matrix. This is discussed in some detail in Site Characterization Plan (SCP) Section 3.9.2.1.

REFERENCES:

Brocoum, S., et al., 1989. "Yucca Mountain: Geoscientists Help Make 10,000-year Ddecision Siting a Nuclear Waste Repository" GEOTIMES V. 34 n. 1.

COMMENT 19:

No mention is made in the report of the methodology for sealing boreholes, shafts, or ramps after abandonment. Normal methods of sealing (as used today in the drilling industry) are not suitable for long-term isolation. The water content of the seals (grouts) will lessen over time and the grout mixture will crack, especially with the added heat that radioactive decay within the Repository will produce. Unless a better method of sealing is agreed upon, it might be better to rely upon diversion instead of, on in conjunction with, sealing. This would require the placement of diversionary dams and/or checks at various subsurface locations to divert flow from these boreholes. They must be designed to compensate for an elevated water table if this area experiences a wetter climate in the future.

Response:

The technical basis for performance goals, design requirements, and material recommendations for the sealing program are described in Fernandez et al., (1987). This report presents a broad range of sealing design options that are intended to satisfy the seal performance goals even if unanticipated hydrologic conditions are encountered. This report also discusses the process that will be involved to elect candidate materials for the sealing program. The overall strategy for the sealing program includes a combination of sealing (diverting or reducing flow) and drainage that diverts water in a controlled manner. The sealing program for a repository at Yucca Mountain is discussed in considerable detail in Site Characterization Plan (SCP) Section 8.3.3.2 (Seal Characteristics).

REFERENCES:

Fernandez, J.A., P.C. Kelsall, J.B. Case, and D. Meyer, 1987. Technical Basis for Performance Goals, Design Requirements, and Material Recommendations for the NNWSI Repository Sealing Program, SAND84-1895, Sandia National Laboratories, Albuquerque, NM.

COMMENT 20:

The surface expression of these boreholes would require the same types of devices to stop the introduction of fluids below ground. All of the openings sealed after closure of the site should also have a method of diversion designed accordingly.

Response:

Fernandez et al., (1987) describes the types of materials being considered for the sealing program and the associated properties for these candidate materials. The material selection process that has been used to determine candidate seal materials includes the development of a logic for the initial selection and subsequent refinements in the selection of materials. Each refinement examines whether candidate seal materials possess several physical and chemical properties that are determined from seal design requirements. Each refinement provides a basis for materials performance, testing, and analysis. The first material evaluation identified broad materials groups (such as cementitious and earthen materials) and explained why other materials (such as ceramics and metals) are not being evaluated in current testing. The second material evaluation considered the hydraulic conductivity, strength, emplacement considerations, groundwater chemistry and emplacement environment of specific seal components. The second material evaluation resulted in the identification of specific material types, such as "high- temperature concrete" or "low-permeability crushed rock/clay," for each of the seal components that may be included in the design. The sealing program for a repository at Yucca Mountain is discussed in considerable detail in Site Characterization Plan (SCP) Section 8.3.3.2 (Seal Characteristics).

REFERENCES:

Fernandez, J.A., P.C. Kelsall, J.B. Case, and D. Meyer, 1987. Technical Basis for Performance Goals, Design Requirements, and Material Recommendations for the NNWSI Repository Sealing Program, SAND84-1895, Sandia National Laboratories, Albuquerque, NM.

COMMENT 21:

Roof bolts, such as those proposed to be used to stabilize the roof of the Repository, can not be expected to remain in place for 10,000 years. The excavation of the Repository should make use of the surrounding consolidated tuff formation to insure long-term stability in the Repository gallery. By proper design and excavation of the gallery, it may be possible to distribute the loads upon existing, in-place bedrock, as either pillars or by utilizing the surrounding enclosure itself. This would be a more realistic alternative as the usefulness of roof bolts diminishes greatly over a relatively short period of time (depending on ambient conditions).

Response:

Roof bolts are used for support during the repository waste emplacement operations to protect personnel and equipment. They do not need to remain in place for 10,000 years, but only on the order of 50-80 years. The proposed repository design will make use of the surrounding consolidated tuff formation to ensure stability in the repository gallery.

COMMENT 22:

The Overview document states that waste-emplacement boreholes will be only partially lined and grouted in the effort to contain waste within the boreholes. All vertical and horizontal waste-emplacement boreholes should be fully lined and grouted to prevent, to the greatest possible extent, migration of fluids either into or out of the holes.

Response:

As indicated at the beginning of Chapter 3 of the Overview, this Site Characterization Plan (SCP) Conceptual Design of the waste package borehole is the first of four engineering design steps. The design will change as data from site characterization are collected and analyzed and more detailed designs are developed.

COMMENT 23:

Air gaps between the waste-emplacement cylinders and the borehole walls have been designed to keep ground water away from the waste-emplacement cylinders. The air gaps will not have adequate capacity if ground water encroaches upon the facility. Thus, these air gaps should not be relied upon to demonstrate isolation of the wastes from saturated or unsaturated underground flow.

Response:

The air gap discussed in this comment is intended to serve as a capillary barrier to movement of moisture into the borehole. Because of the high matrix potential, water in the rock pores will not be able to migrate into a large void (including fractures). By providing an air gap between the waste package containers, liquid water in the pores will not be able to enter the emplacement boreholes and contact the containers. The U.S. Department of Energy (DOE) does not intend to rely on the volume of this air gap to provide capacity to handle water entering into the borehole. In theory the air gap could be very small; however, it will be large enough to provide for some uncertainties, such as wall dimensions. The purpose of the air gap is to minimize the possibility of contact between container and borehole wall since any contact could allow water to wick onto the container.

This capillary barrier is intended to function under unsaturated conditions and would not be effective in a saturated environment. As stated above, it is not intended to provide volumetric capacity to accommodate substantial quantities of liquid water. DOE will not rely on the air gap to demonstrate isolation when carrying out saturated-zone performance assessments.

COMMENT 24:

A number of drains are to be installed in the Repository (exact number is unknown). All drains are likely to clog over time. A procedure should be developed to test for clogging and a design implemented to allow for remediation should clogging occur.

Response:

The design requirements for the sealing program are described in Fernandez et al. 1987. The evaluation of various types of drain designs will be conducted so that specific requirements for drains can be identified and appropriate actions taken to remediate or mitigate clogging. See also the response to Comments 19 and 20.

REFERENCES:

Fernandez, J.A., P.C. Kelsall, J.B. Case, and D. Meyer, 1987. Technical Basis for Performance Goals, Design Requirements, and Material Recommendations for the NNWSI Repository Sealing Program, SAND84-1895, Sandia National Laboratories, Albuquerque, NM.

COMMENT 25:

The term "lithophysae" is used in conjunction with the thermal and mechanical response of rock within the Repository. Staff have not been able to find a definition for "lithophysae" and are thus unable to determine the accuracy of the investigation of the breakout.

Response:

The glossary for the Site Characterization Plan (Overview, p. 139) defines lithophysae as "Bubble-like structures in rocks, generally hollow, composed of concentric shells of finely crystalline alkali feldspar, quartz, and other materials." Section 2.2.3 of the Overview, The origin and formation of tuff" (p. 15), describes the geologic context for lithophysae.

COMMENT 26:

It is not clear for what length of time this repository is designed to retard the flow of radionuclides. Staff assumes the report is referring to complete containment for 300 years and partial containment for 10,000 years. If this assumption is correct, partial containment should be defined.

Response:

Limitations on the release of radionuclides are contained in the regulations of the U.S. Environmental Protection Agency [10 CFR 60 (1987)] and the U.S. Nuclear Regulatory Commission [40 CFR 191 (1986)]. These regulations and the U.S. Department of Energy interpretations of substantially complete containment and controlled release of radionuclides are described in Sections 8.3.5.9 and 8.3.5.10 of the Site Characterization Plan (SCP).

COMMENT 27:

The SCP is not intended to provide a final description of the site's environmental characteristics. At this time, many site parameters, which are critical to the final site selection process, need verification. The purpose of the SCP is to summarize 1) the relevant data currently assembled from preliminary studies, 2) the definite conclusions which can be drawn from the data, 3) the significant questions which remain or have surfaced, and 4) the proposals for further investigation. To this end, the SCP should address the range of possible interpretations of the data, and the program of future study necessary to produce and verify an accurate final site characterization.

The determination of appropriate future studies should proceed as the results of current studies are developed. DMG recommends that DOE inform all interested and qualified agencies of the Site Characterization progress, and solicit feedback from interested agencies on a regular basis.

Response:

An Environmental Monitoring and Mitigation Plan (EMMP) has been developed to monitor for and to mitigate significant adverse environmental impacts that might occur during the U.S. Department of Energy (DOE) Site Characterization program.

DOE will release progress reports semiannually. These reports give the status of completed, ongoing and future studies of the Site Characterization program. See also the response to Comment 2.

REFERENCES:

DOE (U.S. Department of Energy), 1988. Environmental Monitoring and Mitigation Plan (EMMP), DOE/RW-0208, Oak Ridge, TN.

COMMENT 28:

The most important geologic issue relevant to California is groundwater contamination. The potential for migration of radionuclide contaminants into eastern California aquifers (i.e., into the Death Valley regional groundwater basin) is a legitimate concern. Preliminary site studies conclude that Death Valley is hydraulically connected to, and down-gradient of, the aquifer beneath the Yucca Mountain site (Waddell et al., 1984).

DMG defers to the California Water Resources Control Board, or other governing agencies dealing with groundwater quality, on more precise comments regarding 1) specific aspects of aquifer characterization, 2) the potential for contaminant release at the site, 3) the potential for subsequent migration into eastern California, and 4) the adequacy of the SCP in addressing those issues.

The premise for all contamination issues is the potential for accidental radionuclide release at the site. It may be impossible to absolutely assure that radionuclide release will not occur over the 10,000 year post-closure period. Therefore, future site studies should include complete regional, as well as local, aquifer characterization, with emphasis on qualifying and quantifying the potential aquifer characteristics down-gradient of the site.

Investigation techniques and practices should be carefully planned to produce reliable data, while avoiding degradation of desirable aquifer characteristics. For example, exploratory boreholes and shafts should be designed to prevent radionuclide migration in otherwise low permeability (desirable) materials. Since boreholes may act as connections between the site and the underlying aquifer, their location, depth, drilling method, testing method, and closure should be carefully planned and conducted. Furthermore, final site characterization should evaluate the impact, over the post-closure time frame, of the total subsurface exploration conducted on the site.

Response:

As was discussed in the response to Comment 1, satisfaction of the licensing criteria would preclude any reasonable likelihood of ground water contamination at a perimeter not more than 5 km from the repository. Therefore, a very high level of confidence that contamination will not occur at many times this distance will exist if the site is judged by the U.S. Department of Energy (DOE) to be suitable and if the necessary permits and licenses are granted by the U.S. Nuclear Regulatory Commission after intensive review of the site characterization program results.

Although it appears highly probable that flow in the saturated zone beneath the proposed position for a repository at Yucca Mountain ultimately discharges in eastern California at Alkali Flat, also known as Franklin Lake, it is quite uncertain as to whether spring discharge in Death Valley is derived from water in the Amargosa Desert basin fill. Recent potentiometric data, obtained from commercial mineral-exploration drilling, indicate the possibility of a ground-water divide in the Greenwater Range between the southern Amargosa Desert and Death Valley (Czarnecki, 1987, 1989). DOE is currently considering, within the context of broader planning, whether the

potentiometric high should be further investigated, particularly northward in the southern Funeral Mountains. If it does exist in the southern Funeral Mountains (which the current sparse data do not indicate), then underflow in Paleozoic carbonate rocks deep beneath the Amargosa Desert is the more likely source for the principal springs in Death Valley; the probable recharge area for such flow would be far to the east, possibly in the Spring Mountains. Hydrochemical reconnaissance will be the primary method to delineate flow paths from the Yucca Mountain area and those approaching Death Valley. Because the significance of the source of Death Valley springs to site suitability lies mainly in the saturated zone flux from Yucca Mountain southward, there is no apparent necessity for thorough hydraulic characterization of regional aquifers distant from the proposed site.

The impacts of site characterization activities on the integrity of the site is an important consideration in the design of the characterization program, as is discussed in Site Characterization Plan (SCP) Section 8.4.3. The plans for sealing boreholes, shafts, and drifts also constitute an important element of the current program, SCP Section 8.3.3.2.

REFERENCES:

Czarnecki, J.B., 1987. "Should the Furnace Creek Ranch - Franklin Lake Playa Ground-Water Subbasin Simply Be the Franklin Lake Playa Ground-Water Subbasin? [abs.]," EOS, Transactions, American Geophysical Union, Vol. 68, No. 44, p. 1292.

Czarnecki, J.B., 1990. Hydrologic, Meteorological, and Unsaturated-Zone Moisture-Content Data, Franklin Lake Playa, Inyo County, California, USGS-OFR-89-595, Open-File Report, U.S. Geological Survey.

COMMENT 29:

The SCP Overview describes the site's hydrogeologic regime in terms of a relatively simple conceptual model, assuming steady-state conditions similar to those which exist today (p. 26-30). Future studies outlined in the Overview (p. 104-107) emphasize refinement of the knowledge of existing hydrogeologic characteristics of the "saturated" and "unsaturated" zones underlying the site, to develop precise models to predict the conditions that would be expected over the post-closure period. Important aspects of the hydrogeologic regime include the relative importance of liquid and gas flow through rock fractures and the rock matrix.

A revised conceptual hydrogeologic model, incorporating "dynamic" processes, has been proposed (Szymanski, 1987). This model suggests that significant, periodic changes occur in the hydrogeologic environment, which could increase the potential for the escape of radionuclide contaminants into the surrounding environment. Future studies should concentrate on developing an accurate local and regional hydrogeologic model, with consideration of factors of the hydrogeologic regime that are dynamic over the post-closure time frame. These studies should have a high priority, as the conditions predicted by the alternative conceptual model may result in the disqualification of the Yucca Mountain site (Szymanski, 1987).

Response:

The Site Characterization Plan (SCP) Overview was necessarily quite brief. The commentor is referred to SCP Sections 8.3.1.1 (Overview of the Site Program) and 8.3.1.2 (Overview of the Geohydrology Program) to obtain a better understanding of the range of alternatives that are being considered in the design of the characterization program. More specific consideration of the effects of tectonism on the hydrologic system is found in SCP Section 8.3.1.8.3, within the postclosure tectonics program. See the following response to Comment 30 for further discussion of the Szymanski hypothesis and its impact on the characterization program.

COMMENT 30:

Szymanski's (1987) alternative conceptual model applies to the hydrogeologic regime of the Yucca Mountain subbasin, and to the greater Death Valley groundwater basin, of which the subbasin is a part. This conceptual model incorporates a "two phase, heat-field coupled, flow field developed in a deforming fractured medium." It is dynamic, in the sense that it allows for "evolutionary loops" in the hydrogeologic regime resulting from deformational cycles in the region. In this model, the characteristics, and relative importance, of rock matrix and fracture flow could change significantly.

The dynamic model incorporates post-closure regional geologic/tectonic factors more comprehensively than the existing (steady-state) conceptual model. Therefore, the "dynamic" model would seem appropriate for site characterization over the post-closure period.

The significant deformational cycles may be associated with episodes of volcanic activity nearby. The current knowledge about the age and character of a) the adjacent Crater Flat volcanic field, and b) local faulting, together with the history of past caldera formation in the area, suggest that future periodic volcanic activity and regional deformation episodes can be expected. The SCP should evaluate the association of deformational cycles and volcanic episodes, with emphasis on the timing and character of both such episodes. The possibility of renewed local volcanic activity during the post-closure period, and the resulting possible impacts to local hydrogeologic conditions should be fully addressed. Other studies should address the effects of heat and water chemistry induced by such volcanism on the repository performance.

Szymanski (1987) suggested a study, among others, that would compare interstitial and fracture porewater at the site to test the validity of his conceptual model. Such a test may or may not prove conclusive. The comparison apparently would assume that the effects of the most recent deformational episode were not overprinted by a past wetter climatic cycle. Whether a wet climatic cycle, such as the last (Wisconsinian) ice-age, could have overprinted the hydrogeologic effects of a cyclic deformational event should be ascertained. The potential for climatic overprinting becomes more substantial if the timing of the last significant deformational cycle pre-dates the end of the Wisconsinian ice-age.

Response:

In its present form, Szymanski's hypothesis (1987 and updated in 1989) is not developed to the extent of a testable model, because it lacks both theoretical rigor and quantification. However, in its report on the technical review of Szymanski's 1987 manuscript, a team of Yucca Mountain Project (YMP) scientists concluded that some of the processes proposed to be acting in the Yucca Mountain area are credible, though with unknown magnitudes and durations of effect. The YMP team found little merit in the field evidence that was proposed to support the position that the processes have strongly influenced the hydrologic system in the past.

Briefly, Szymanski's hypothesis is that the water table under Yucca Mountain could undergo large variations in elevation over time periods of thousands of

years or less in response to changes in stress in the rocks caused by earthquake activity. The principal evidence cited for this hypothesis is the presence of calcite-silica veins in fracture zones at Yucca Mountain, which Szymanski believes were deposited by rising, hot ground water from deep in the earth. The weight of current evidence strongly indicates that these deposits are pedogenic (soil-formed) caliches.

Caliche is a hard, white soil material that forms as rainwater leaches minerals out of upper soil layers and deposits them in lower soil layers as downward-percolating water evaporates. Pedogenic calcrete (caliche) is very common in deserts because most rainwater that soaks into the soil evaporates there before reaching the water table. Since water often percolates downward through fractures in bedrock, caliche commonly forms in veins. Veins formed by mineral-rich water upwelling through fractures sometimes are similar in chemical composition to caliche, but are nearly always different in other characteristics. Although rather improbable, it is still possible that the calcite-silica deposits at Yucca Mountain may have been deposited by upwelling hot water (rather than downward percolating rainwater). Site characterization activities in the Site Characterization Plan (SCP) that would provide evidence that would bear upon the Szymanski hypothesis are described in Study 8.3.1.5.2.1 (Quaternary regional hydrology).

Currently, two panels are evaluating Szymanski's hypothesis and reports. The first is composed of five scientists who are not associated with the U.S. Department of Energy (DOE) or the Yucca Mountain Project; the report of this panel is expected to be completed before the end of 1990. The second panel, also independent of DOE and the YMP, has been formed by the National Academy of Science to examine the broader question of the coupling of hydrologic, tectonic, and hydrothermal systems; a preliminary assessment of Szymanski's hypothesis is expected within a few months as an intermediate product. Both panels have been asked to give particular attention to identifying studies that are relevant to assessing the effects of tectonics and volcanism on the hydrology of the site.

Concurrently, the Project is developing a preliminary plan that will be re-evaluated as the recommendations of these panels and others are formulated and expressed. Phenomenological modeling to investigate the sensitivity of the hydrologic system to stress, rock deformation, faulting, and thermal sources is an obvious early activity, as is a review of the historical record of hydraulic responses to tectonic and volcanic events. The evaluation will also be highly dependent on the results of YMPSC studies of tectonic models, structural controls on volcanism, the geothermal regime, saturated zone hydrology, and the origin of geologic features such as the calcite-silica deposits.

REFERENCES:

Szymanski, J. S., 1989. "Conceptual Considerations of the Yucca Mountain Groundwater System with Special Emphasis on the Adequacy of this System to Accomodate a High-level Nuclear Waste Repository." Internal report, Yucca Mountain Project Office, U.S. Department of Energy, Las Vegas NV.

COMMENT 31:

Paleoclimatic factors are crucial to the assessment of the repository site over the post-closure time frame.

The SCP Overview indicates that the proposed Yucca Mountain "Repository Site has existed in an arid to semi-arid climate during the Quaternary period (p. 31). To put that in perspective, most of the Central Valley in California has a semi-arid climate. The combination of cumulative precipitation and evaporation determines the aridity. Obviously, long-term changes in temperature, as well as precipitation, are important factors. However, additional factors need to be considered for a hydrogeologic evaluation. For example, the amount of groundwater originating from adjacent geographical regions may be significant, and should be evaluated. Groundwater from outside sources may include runoff from nearby mountainous watersheds, percolation from neighboring aquifers, and surface flows originating from wetter regions.

Long-term climatic change is an important consideration for site hydrogeologic characterization over the post-closure period. The response of the groundwater elevation to changes in climatological factors would depend to a large degree on the relative importance of fracture vs. matrix (interstitial granular) flow and permeability. Appropriate investigations and monitoring should be conducted to address potential climatic change factors, and resulting aquifer response. In addition, potential changes in local and regional aquifer characteristics (permeabilities, flow paths, etc.), resulting from groundwater elevation adjustments, should be fully evaluated.

Response:

The U.S. Department of Energy agrees that the parameters and phenomena noted by the California Energy Commission are important, and note that these factors are being considered in the Yucca Mountain Project program for long-term performance assessment.

Section 8.3.1.5 of the Site Characterization Plan (SCP) addresses both the nature and rates of change of future climates (Investigation 8.3.1.5.1, Studies to provide the information required on nature and rates of change in climatic conditions to predict future climates,) and the effects of these conditions on hydrologic characteristics (Investigation 8.3.1.5.2, Studies to provide the information required on potential effects of future climatic conditions on hydrologic characteristics). Studies of geologic evidence for hydrologic conditions associated with Pleistocene climates in the southern Great Basin are included and are ongoing.

COMMENT 32:

Seismic hazards in the vicinity of the proposed Yucca Mountain Repository Site are of concern to California, given that such hazards could release radionuclides to the environment.

The SCP Overview describes numerous normal faults at, or in the vicinity of, the site. According to the Overview, the Ghost Dance fault crosses the repository area and has a significant amount of vertical offset. Although the Ghost Dance fault is not identified as having evidence of Quaternary-age movement, other similar faults nearby display such evidence (SCP Overview, p. 22). Apparently, all of these faults formed in response to the same tectonic environment. Therefore, the Ghost Dance fault should be assumed to be potentially active until evidence can be produced that precludes its activity.

Response:

The Ghost Dance fault will be investigated in detail to determine if it is currently active and therefore a potential seismic hazard. The character of the Ghost Dance Fault within the repository will be investigated directly by geologically mapping the northwest drift from the exploratory shaft facility, which is designed to intersect the fault at depth as outlined in the Site Characterization Plan (SCP) (Activity 8.3.1.4.2.2.4, Geologic Mapping of the Exploratory Shaft and Drifts). Surface trenching of the Ghost Dance Fault will be designed to evaluate offset of Quaternary datum. These procedures will provide the best information available for determining timing, recency, slip rates and recurrent intervals for Quaternary faulting (Activity 8.3.1.17.4.6.2, Evaluate Age and Recurrence of Movement on Suspected and Known Quaternary Faults). A geodetic quadrilateral established across the surface trace of the Ghost Dance Fault will be systematically resurveyed to test contemporary displacement (Activity 8.3.1.17.4.10.1, Relevel Base-Station Network, Yucca Mountain and Vicinity).

COMMENT 33:

The SCP Overview states that "geologic field evidence suggests that in terms of major tectonic activity Yucca Mountain has been relatively stable for the past 11 million years" (p. 22). However, the Overview should clarify this statement with respect to the activity of specific site faults. Faults with a potentially active status should be included in assessments of rupture and strong motion hazards.

Response:

The Site Characterization Plan (SCP) Overview presents summaries of selected topics covered in depth in the SCP; it is not a substitute for the SCP. The Overview is intended primarily for those persons who want to understand the general scope and basis of the U.S. Department of Energy's site characterization program, the activities to be conducted, and the type of facilities that would comprise a hypothetical repository at Yucca Mountain, without spending the time necessary to become familiar with all of the technical details in the SCP. Chapter 8 of the SCP has numerous activities planned to study the faults at and near the site with an objective to establish whether they are potentially active. See also the response to comment 4.

COMMENT 34:

The SCP Overview states that estimated seismic strong ground motion for the preliminary design of the proposed facility is 0.4g, based on a M6.8 event on the Bare Mountain fault, 11 miles away (p. 22). While this estimate seems conservative for the preclosure time frame, the context in which it is given suggests that deterministic methods were used in its derivation. A probabilistic assessment is a more appropriate method for estimating the design-basis strong ground motion. A probabilistic analysis would consider the potential size and number of events from all seismic sources in the vicinity, and the uncertainty of strong motion estimation, given an assumed level of risk. The Overview should clarify whether their strong motion estimate is derived by probabilistic or deterministic methods, and whether it, or some other value, applies to the post-closure time frame. If probabilistic seismic hazard methods are utilized, the Overview should describe the assumptions and input parameters assumed in the ground motion assessment.

Response:

The U.S. Department of Energy agrees with this comment regarding the derivation of the ground motion estimate. The preliminary estimate for design ground motion was deterministically derived. Section 8.3.1.17 (preclosure tectonics) describes additional planned work to refine potential ground motion both by deterministic and by probabilistic methods.
As stated in the response to Comment #33, the Overview is little more than a very short summary of the Site Characterization Plan and, therefore, cannot contain the type of detail requested in the comment.

COMMENT 35:

The SCP should also fully address disturbance associated with strong ground motion from continued nuclear weapon detonations at the Nevada Test Site.

Response:

The U.S. Department of Energy believes the Site Characterization Plan fully addresses disturbance associated with strong ground motion from continued nuclear weapon detonations at the Nevada Test Site. Section 8.3.1.17 (preclosure tectonics) contains three planned activities, 8.3.1.17.3.2.1 (Determine the range of UNE sources), 8.3.1.17.3.2.2 (Determine Maximum Underground Nuclear Explosion Source(s)), and 8.3.1.17.3.3.2 (Select or Develop Empirical Models for Ground Motion from Underground Nuclear Explosions).

COMMENT 36:

DMG is interested in any geological/seismological studies conducted in California that the U.S. Geological Survey, the Department of Energy, or any other agency involved with site characterization studies may perform in conjunction with further evaluation of the Yucca Mountain site. The USGS. has proposed seismic refraction exploration, as part of the Yucca Mountain Repository Site studies, in Death Valley National Monument. Furthermore, other California regions may provide useful analogies to test conceptual models of groundwater flow behavior theorized for the site and its vicinity. Such information may prove to have scientific and economic importance outside the realm of the site selection, and, therefore, be valuable to the State. DMG would like to be informed of planning for geologic and seismologic investigations planned in California, and would appreciate the opportunity to provide input for such studies. The information exchanged could be useful and valuable to all concerned.

Response:

See the U.S. Department of Energy's response to Comment #2.

COMMENT 37:

Potential slope mass-movement hazards, such as rockslides and avalanches, may be significant along nuclear waste transportation routes in California as well as Nevada. Slope raveling, erosion, sedimentation, flooding, and other geologic factors, may temporarily close routes and necessitate continual route maintenance. These problematic factors could limit the timing of waste transportation opportunities, or require temporary alternate routing, which are not in the best interest of waste transportation operations. Route selection will depend heavily on security factors. Nonetheless, DMG encourages the consideration of geologic hazards and problematic conditions in transportation route selection.

Response:

The U.S. Department of Energy recognizes there are many problematic factors that will limit the high level waste transportation system, including the ones mentioned. Appropriate contingency scenarios will be developed to properly respond to these factors. These include alternate routes to accommodate highway closures for whatever reason, e.g. weather, accidents, or construction. The driver of the high-level waste transporter is required to use only approved routes and alternates so that the alternate routes will be determined ahead of time.

COMMENT 38:

The Department of Fish and Game has reviewed the US Department of Energy's Site Characterization Plan (SCP) for the proposed Yucca Mountain, Nevada, high-level nuclear waste repository. The SCP describes the detailed studies that will be performed to determine the suitability of the site for nuclear waste disposal, and the potential environmental impacts of construction and operation of the repository. The Department is interested in the SCP because of potential impacts the waste repository could have on water supplies for California fish and wildlife populations in and near Death Valley National Monument.

The Death Valley area is one of the most arid regions in North America. Perennial water supplies in the region are available only where groundwater surfaces in the springs or short reaches of streams. Many fish and wildlife species are totally dependent on the unique habitats that these isolated water supplies provide. Some of these species occur nowhere else on earth. The Department is particularly interested in the following species:

Amargosa pupfish	Cyprinodon nevadensis amargosae
Saratoga Springs pupfish	Cyprinodon nevadensis nevadensis
Salt Creek pupfish	Cyprinodon nevadensis salinus
Cottonball Marsh pupfish	Cyprinodon nevadensis milleri
Shoshone pupfish	Cyprinodon nevadensis shoshone
Amargosa vole	Microtus californicus scirpensis
Saratoga Springs Belostoman bug	Belostoma saratogae

In addition, two as yet unclassified forms of Amargosa speckled dace (Rhinichthys osculus ssp.) occur in the area, and some endemic snail species have recently been discovered in the area as well. Of these species, the Amargosa vole is both State- and Federally-listed as endangered, and the Cottonball Marsh pupfish is listed by the State as threatened. Other species may well qualify for listing in the future, when more is known about them.

Because these species are totally dependent on surfacing groundwater, the Department is concerned about any effects the waste repository may have on groundwater flows and groundwater supplies. The SCP indicates that the groundwater that supplies the springs and streams in California originates from recharge areas in Nevada. These ground waters flow underground, past the Yucca Mountain disposal site, and then to California in a slow, complicated underground path that the SCP indicates is not well understood. If the construction or operation of the waste repository interrupts or depletes these groundwater flows, water supplies for the many fish and wildlife species listed above, and other plan and animal species as well, could be reduced or cut off. Because some of these species occur nowhere else on earth, this could cause the extinction of several fish and wildlife species.

The Department believes that the U.S. Department of Energy should perform the necessary studies to determine if the project will reduce or cut off groundwater flows to California. The Department notes that the SCP describes several planned studies that relate to groundwater. However, the SCP does not include a study element specifically aimed at addressing potential project effects on fish and wildlife populations dependent on groundwater supplies. The Department recommends that such a study element be added to

the SCP as a separate and significant part of the overall study plan. Furthermore, the Department recommends that if this study determines that impacts on California's fish and wildlife populations could occur, the U.S. Department of Energy should implement alternative project features or modifications, or develop adequate mitigation measures, so that these impacts do not occur.

Response:

The Yucca Mountain Environmental Assessment (DOE, 1986) found that the regional effects of withdrawing groundwater for a repository at Yucca Mountain are expected to be negligible. It has been estimated that the relatively minor water requirements for site characterization will not cause a significant drawdown because the aquifers underlying Yucca Mountain can produce an abundant quantity of ground water for long periods of time without lowering the regional ground-water table.

However, there is the possibility that the site characterization activities planned at the Yucca Mountain site may create significant adverse impacts to the water resources of the area due to some uncertainty in the duration and extent of those activities. To address these concerns, the U.S. Department of Energy (DOE) has prepared an Environmental Field Activity Plan (EFAP) for Water Resources (DOE, 1989). This plan presents monitoring programs for water quantity and quality at Yucca Mountain and downgradient in the Amargosa Desert, Ash Meadows, and applicable Death Valley National Monument (including Devils Hole) areas. As a subset to the overall EFAP, a monitoring plan for water levels and springflows in the above-mentioned downgradient areas is being prepared to expressly address the National Park Service concerns regarding water resources in the Ash Meadows area and Furnace Creek portion of the monument. The National Park Service (NPS) was consulted during the preparation of the EFAP, (DOE, 1989) and this consultation is continuing in the development of specific plans for monitoring water quantity and quality. If monitoring identifies a significant adverse situation developing, either to the water resources or the threatened and endangered biological resources in the downgradient areas of the Yucca Mountain Project, DOE will implement mitigation measures to alleviate the problem.

The only ground water withdrawals associated with the repository project are those for site characterization and, if the site is found to be suitable, for construction and operation. In the site characterization phase, emphasis is being placed only on the impacts of site characterization activities. Section 8.7.3 of the Site Characterization Plan (SCP) briefly explains that the environmental assessment for Yucca Mountain presented a preliminary determination that adverse impacts were not expected, but that an environmental monitoring and mitigation plan would be developed.

Based on analyses of information that was available to support preparation of the Environmental Assessment and the SCP, and on currently available information, no adverse effects on existing springs or seeps can credibly be predicted to result either from site characterization or possible future water use at Yucca Mountain. Nonetheless, implementation of the EFAP is accepted by DOE as an environmental responsibility.

REFERENCES:

DOE (U.S. Department of Energy), 1989. Yucca Mountain Project Environmental Field Activity Plan for Water Resources, DOE/NR-10576-19, Yucca Mountain Project Office, Las Vegas, NV.

DOE (U. S. Department of Energy), 1986. Environmental Assessment, Yucca Mountain Site, Nevada Research and Development Area, Nevada, DOE/RW-0073, 3 vols. U. S. Department of Energy, Washington, D.C.