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Mr. Donald L. Vieth, Director
Waste Management Project Office
Department of Energy
Nevada Operations Office
P.O. Box 14100
Las Vegas, NV 89114

Dear Mr. Vieth:

Enclosed is a copy of the meeting summary prepared by the U.S. Nuclear Regulatory Commission (NRC) staff following its site visit and meeting with the U.S. Department of Energy (DOE) staff on May 17-19, 1982.

The visit provided the NRC technical staff with an excellent opportunity to review the scope of the siting investigations at the Nevada Test Site. Considerable amounts of technical information were obtained that will be useful in preparing for review of the Site Characterization Report for the Yucca Mountain Site. Hopefully, the observations made in the trip report will prove useful to the DOE staff and its contractors.

As is noted in the meeting summary, the scope of the May meeting was planned to be quite broad even though that resulted in some sacrifice of depth of dicussion. In setting up the May meeting, DOE and NRC agreed that future meetings would be more focused and limited to specific topics and issues so that an opportunity would be provided for detailed discussion and review of data and bases of interpretation. The meeting summary identifies a number of questions to be considered at such follow-up meetings.

Also enclosed is a systematic list of site and design suitability issues prepared by the NRC staff. The list is advanced as a basis for dialogue between DOE and NRC with the objective of reaching convergence of views on the issues at the Yucca Mountain site. Transmittal of the issues list closes one of the action items listed in the meeting summary.

I wish to thank your staff for their time and cooperation in connection with visit. I will contact you regarding follow-up to the May meeting

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and would be pleased to discuss any of the details of the meeting summary or list of issues with you.

Sincerely,

ORIGINAL SIGNED BY

Seth M. Coplan
High-Level Waste Technical
Development Branch
Division of Waste Management

Enclosures:
As stated

cc: C. Newton (DOE)
C. Cooley (DOE)
W. Ballard (DOE)
R. Stein (DOE)
V. Der (DOE)

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SUMMARY OF NRC-DOE MEETING
MAY 17-19 1982
LAS VEGAS, NEVADA

On May 17 through May 19, 1982 NRC staff and consultants met in Las Vegas, NV with U. S. Department of Energy (DOE) staff and contractors. May 17 was devoted to a tour of the Nevada Test Site (NTS) that included stops at the Yucca Mountain Site, G-Tunnel, and the core library. On May 18 and 19, meetings were held at DOE's office. The purpose of the site visit and meetings was to bring NRC up to date on the status of the Nevada Nuclear Waste Storage Investigations (NNWSI), to allow for a technical exchange concerning those investigations, and to discuss questions concerning the scope and level of detail of the Site Characterization Report (SCR).

Included in the NRC group were Lawrence Chase, Seth Coplan, Hubert Miller, Peter Ornstein, Martha Pendleton, Tilak Verma, and Robert Wright of the NRC staff, Clarence Babcock of the U.S. Bureau of Mines, Adrian Brown of Golder Associates, Inc., Robert Cranwell, Robert Guzowski, and Malcolm Siegal of Sandia National Laboratory, Martin Mifflin of the Desert Research Institute, Benjamin Ross of Geotrans, and Daniel Sokol of International Engineering Company, Inc.

Included in the DOE group were Carl Cooley, Victor Der, Mitchell Kunich, Ralph Richards, J. Rinaldi, and Dave Squires of DOE, David Bish, Peter Bussolini, Bruce Crowe, Bruce Erdal, Wes Myers, Allen Ogard, Robert Rundberg, Bryan Travis, and Kurt Wolfsburf of Los Alamos National Laboratory (LANL), J. P. Brauner, L. S. Costin, Keith Johnstone, R. C. Lincoln, James Neal, G. Rudolpho, Leo Scully, Scott Sinnock, Joe Tillerson, and Lynn Tyler of Sandia National Laboratories (Sandia), W. J. Carr, G. L. Dixon, Eugene Rush, Rick Spengler, Peter Stevens, Rick Wadell, and W. E. Wilson of the U.S. Geological Survey (USGS), Laureen Dolan and Zubair Saleem of Ebasco Services Incorporated, M. Glora of ONI, Lawrence Fitch of Rockwell, and L. D. Ramspott of Lawrence Livermore National Laboratory (LLNL).

The May meeting was the most recent in a continuing series of pre-SCR interactions between NRC and DOE regarding the NNWSI. These pre-SCR interactions are intended to assure that all of the significant issues are raised early so that they can be adequately addressed by the DOE program. In February, 1981 an NRC group visited the NTS and met with DOE and its contractors. Again in August, 1981 an NRC group attended the DOE Peer Review Meeting as observers. As a result of these visits and meetings, NRC identified several key questions that would need to be addressed in a license application and started a series of follow-up activities that are intended to keep NRC informed of DOE's progress in preparing for submittal of the SCR.

Because it had been over a year since the last NRC-DOE meeting on the NNWSI, it was planned that the scope of the May meeting would cover the full range of topics of concern to NRC even though depth of discussion might be sacrificed in some instances. It was agreed between DOE and NRC that future meetings would be more focused and limited to specific topics and issues. Such follow-up meetings provide an opportunity for more detailed discussion and review of data and bases of interpretation.

Based on the information presented and the discussions at the May meeting, a number of questions have been identified as subjects for follow-up meetings. The most significant arising from the meeting are the following:

- o What is the groundwater flow system in the tuffs at Yucca Mountain?

Although there is a general understanding of the regional hydrology and the saturated tuffs near the Yucca Mountain site can yield useable amounts of water, there is not a good understanding of the hydrology at Yucca Mountain. In particular, it is not yet clear what the groundwater flow paths and flow rates would be from a repository at the Yucca Mountain site to the accessible environment.

o At repository depth and temperature what is the strength of the tuff and will the strength of the tuff be adequate?

Tuff is by nature a heterogenous rock that exhibits substantial variability in its strength properties. For example, some measured values of strength in one potential host rock (Bullfrog tuff) may be too low to allow construction of a repository with conservative safety factors. Similarly, the Topopah Spring unit (another unit that has been under consideration as a host rock) is, in places, so highly fractured that its rock mass strength may be of concern.

o What physical processes will govern the behavior of a repository in unsaturated, fractured tuff?

What factors should be used in characterizing unsaturated fractured tuff?

The unsaturated zone is under serious consideration for hosting a repository at the Yucca Mountain site. Hydrologic characterization and modeling have been done for unsaturated porous media at several locations off the NTS. However, there has been no similar experience with unsaturated, fractured rock anywhere. Therefore, there is question as to not only the physical processes that could affect release and transport of radionuclides, but also the factors that will be used in modeling of release and transport. The physical processes in question are those that would affect groundwater flow, radionuclide transport, rock strength, and waste package integrity. These questions could become central if a repository horizon were chosen in the unsaturated zone.

Additional and more specific related questions are as follows:

o How do faults and other structural features affect the flow system?

Reconnaissance level information (principally head data) suggests that for the most part lithologic strata are not a primary control of groundwater flow at the Yucca Mountain site. Instead zones of fracturing that cut through the lithologic units may interconnect them and serve as the principal pathways for groundwater flow.

o Does the groundwater flow system in the tuffs at Yucca Mountain communicate with a deeper regional groundwater flow system that could provide a relatively fast pathway to the accessible environment?

In much of the NTS region, a sequence of Paleozoic carbonate rocks underlies the Tertiary tuffs and is a regional aquifer. In places, it has been observed that solutioning has created relatively fast groundwater pathways in the carbonate aquifer. If significant communication exists between the Yucca Mountain tuffs and the carbonate aquifer, a relatively fast pathway could be provided between a repository and the accessible environment.

- What is the discharge area and chemistry for Yucca Mountain groundwater?

  Knowledge of the discharge area and chemistry are needed to provide independent calibrations for the groundwater flow model.

- What is the status of the conceptual repository design?

  10 CFR Part 60 requires that a conceptual repository design be described in the SCR in sufficient detail to allow identification of issues; specifically, what is to be tested for and whether the plans for testing are adequate. As yet, the conceptual design is at the earliest stages of development.

- What is the potential for disruption of a repository at Yucca Mountain by fault movement, earthquakes, or volcanism?

  The Yucca Mountain site is located in a region that has experienced faulting and volcanism in the relatively recent geologic past. Volcanism has occurred near Yucca Mountain in Crater Flat during the Quaternary. A number of faults in and near Yucca Mountain are of undetermined age of last movements. 10 CFR Part 60 requires that quaternary faulting and volcanism be evaluated as they may relate to repository performance.

Structure of Report

This report is structured in terms of three main sections: (A) Progress in the Technical Investigations; (B) Content of the SCR; and (C) Action Items.

A. Progress in the Technical Investigations

Background

Yucca Mountain is composed of a series of north trending and east tilting structural blocks bounded by Jackass Flat on the south and east, by Crater Flat on the west, and by Beatty Wash on the north (Figure 1). Steeply dipping north-south trending faults, estimated as Tertiary in age, bound Yucca Mountain on the east and west flanks. In the vicinity of Yucca Mountain, generalized stratigraphy consists of a basement of folded Precambrian and Paleozoic sedimentary rocks overlain by a thick sequence of Tertiary and Quaternary volcanic rocks which are, in turn, overlain by discontinuous late Tertiary and Quaternary alluvium (Figure 2).

A Paleozoic carbonate aquifer underlies the volcanic rocks in parts of Southern Nevada. This regional aquifer is known to be fractured and to have developed solution channels in places. Borings to a depth of 6000 feet at Yucca Mountain have not encountered this regional aquifer.

In general, there is no apparent spatial correlation of hydraulic conductivity with lithologic units in the tuffs at Yucca Mountain (with the exception of the Topopah Spring). This results in a lack of hydrostratigraphic units complicating the hydrogeology. Preliminary data suggests that fracturing is the principal control of groundwater flow in the tuffs.

Geologic and Hydrogeologic borings for NNWSI in the vicinity of the study area have penetrated up to 6000 feet of thick Tertiary tuffs and Quaternary alluvium (Figure 3). A stratigraphic column is shown in Figure 4 and a generalized stratigraphic cross-section, NW to SE through Yucca Mountain, is shown in Figure 5. Based on limited borings, the tuffs appear to be relatively uniform in thickness and gently dipping (4^{o} to 7^{o}).

A repository horizon has not been selected yet. Tuff units currently being considered as a potential host rock include, in order of increasing depth the Topopah Spring Member of the Paintbrush Tuffs, the Calico Hills, the Bullfrog Member and the Tram unit of the Crater Flat tuff, and the Lithic-Rich tuff. The Topopah Spring Member is unsaturated, densely welded, and devitrified. The Calico Hills is unsaturated, non-welded, and zeolitized. The Bullfrog Member is saturated, partially welded and devitrified. The Tram and Lithic-rich tuffs are saturated, partially welded, and zeolitized. Analyses leading to a choice of repository horizon constitute a major activity in the NNWSI.

The two day technical discussions centered on questions regarding hydrogeology, repository design, geologic stability, and geochemistry. These questions and summaries of the related discussion are presented in the following paragraphs.

1. Saturated Zone Hydrogeology

Although there is a general understanding of the regional hydrology and the tuffs near the Yucca Mountain site can yield useable amounts of water, there is not a good understanding of hydrology at the Yucca Mountain site. In particular, it is not yet clear what the groundwater flow paths and flow rates would be from a repository at the Yucca Mountain site to the accessible environment. In this connection, the following questions are significant:

- What is the flow system in the tuffs?

- How do faults and other structural features affect the flow system?

- Does the flow system in the tuffs communicate with a deeper regional flow system that could provide a relatively fast pathway to the accessible environment?

- What is the discharge area for Yucca Mountain groundwater?

Flow System

The first three questions are related and are, therefore, conveniently discussed together.

Status

The investigations to determine the groundwater flow system in the Yucca Mountain tuffs are being conducted by the USGS. Although the investigations are still at a relatively early stage, a general picture of the saturated zone hydrology has begun to emerge.
The exploratory program is based primarily on boreholes (Table I), of which some are cored (geologic boreholes) and the rest used primarily for hydrologic testing (hydrologic boreholes). So far, all boreholes have been located on the site periphery (Figure 3). All together, there are five hydrologic boreholes and a larger number of geologic boreholes. The well tests and other investigations have provided a data base that now consists of static water levels in open wells at about ten locations (Table I), water level contours, determinations of bulk permeability, measurements of hydraulic head, analyses of water quality samples, and detailed geologic maps and cross sections.

Based on these data, USGS has drawn the following tentative interpretations concerning the site hydrology:

1. there is a small amount of recharge into the tuffs at the Yucca Montain site;

2. with the exception of one borehole (G-2), a regionally uniform position of water levels seems to exist. The one anomalously high observation (approximately 300 m) may be the result of any of several hypothesized conditions. The two considered most likely by USGS are (1) the possibility that the interstitial pore spaces in the rock were partially clogged by the use of mud in drilling the well and (2) a fault that acts as a groundwater barrier is located between the anomalous observation and the remaining observations;

3. groundwater at the site moves in a generally southern direction;

4. groundwater flow may be controlled primarily by structural features . Fractured, welded zones in the tuffs may be hydrostratigraphic units that conform to the geologic units,*

*Well J-13, which is located near the site, in a saturated portion of the fractured Topaph Spring tuff, produces 600 gpm.

but, in general, the geologic units do not appear to be a principal control of groundwater flow. Instead, zones of fracturing that cut through the geologic units may serve to interconnect these units and provide the principal pathways for groundwater flow.

5. the hingeline fault that forms the western boundary of Yucca Mountain may act as a groundwater barrier;

6. Concerning the question of communication between the flow system in the tuffs at Yucca Mountain and the deeper, regional flow system (carbonate aquifer), significant communication appears unlikely. First, wells as deep as 6000 feet have not intercepted the Paleozoic carbonates. Thus, the regional carbonate aquifer may not be present under Yucca Mountain. Second, even if the carbonate aquifer is present under yucca Mountain, significant communication seems improbable. In that case, the carbonate aquifer would be at least 6,000 ft. deep. Also, while the preliminary head measurements from various depths suggest that head decreases with depth, thick sequences of rock that appear to have low permeability occur between the shallow saturated tuffs and the pre-tertiary rocks.

Plans

Investigations that are now planned by USGS are intended to further test these tentative interpretations. To produce more detailed determinations of permeability, measurements of heads, and analyses of water chemistry, USGS plans to retest selected hydrologic boreholes. To determine whether the anamolous fluid potential observation in G-2 is accurate, this borehole will be cleaned out and retested. To further define the effect of the Yucca Mountain hingeline fault on groundwater flow, two new hydrologic boreholes will be drilled to the west of the fault. The planned wells would be used to determine permeabilities and to measure heads and water level.

Two planned investigations would bear on the question of communication between the flow system in the tuffs and the deeper, regional flow system. First multiple completions would be performed in one of the existing hydrologic holes to allow determinations of head as a function of depth. Second, there is a tentative plan to drill and test a well, east of Yucca Mountain, that penetrates the pre-Tertiary rocks.

Observations and Actions

In general, USGS regards the data accumulated so far as too preliminary for distribution because it has not been through full internal review. Consequently, the NRC group was provided only with copies of the water level data and an opportunity for cursory examination of water level contours, detailed geologic maps, and cross sections. Determination of bulk permeability and water chemistry were not made available to the NRC group. Nevertheless, the NRC group did make some specific observations concerning the program of investigations presented. These are discussed in the paragraphs below.

Both the completed and planned investigations have been conducted according to a strategy that includes reconnaissance level testing in boreholes followed by evaluation of data collected to develop an overview to use in planning additional detailed testing. The strategy also allows assimilation and evaluation of data obtained from one well before making a final decision on the location and purpose of the next. The NRC group was favorably impressed by this strategy. Also, the NRC group considered that the completed and planned investigations appear to address the right issues and that the planned investigations seem to follow logically from the tentative interpretations that have been reached by the USGS. This observation, however, is tentative because relatively few data were made available for review by the NRC group.

The distribution of subsurface data on hydraulic parameters and on fracture density and distribution seems too localized in Drill Hole Wash, which may be structurally controlled. Concentrating subsurface data collection within the wash without systematically doing the same in the adjacent areas may bias the fracture occurence data. This is important because the data base developed from pump tests and other hydrologic tests suggests that permeable zones may not correlate directly to stratigraphic units within the tuffs. Therefore, establishing how fracture permeability varies within and beyond the structurally disturbed zones should be an important data collection objective. These fracture data are important for characterization of both the saturated and unsaturated zone.

There was considerable discussion of a methodology to determine the absence or presence of a vertical component of flow in the tuffs of Yucca Mountain. Whether such a component is present bears on the important question of communication between the flow system in the tuffs of Yucca Mountain and a deeper, regional flow system. Three basic approaches (variations of packer and drill stem tests, multiple completion of several zones within one borehole, and more than one borehole) were discussed. Current plans would include multiple well completion with as many as five pipes in a single drilled hole. Although this type of completion has been successful in some situations, the NRC group thought that it may encounter some difficulty at Yucca Mountain because of relatively low permeability, ranging from 10^{-4} cm/s to 10^{-10} cm/s, of the formations. If water levels and water quality were observed to be the same in adjacent zones or aquifers, the results would be uncertain because of the possibility that the cement seal between zones was not effective. In low permeability rocks, the integrity of the seals cannot be verified effectively because the permeability of the seals may he of the same order of magnitude as that of the rocks.

The NRC group favored an approach that would use two separate boreholes closely adjacent to one another, but drilled to significantly different depths into the saturated zone. This would require only one more borehole next to an existing borehole, or for greater confidence, two new boreholes next to two existing boreholes. This approach would also allow for developing evidence as to the local lateral variation in permeability within the common zone of penetrated saturation in the adjacent boreholes and perhaps allow for tests of vertical permeability.

2. Regional Flow System

The remaining question in the area of saturated zone hydrogeology that was addressed at the meeting pertains to the regional flow system and is concerned with the discharge area for Yucca Mountain groundwater.

Status

The current regional investigations are being conducted by USGS and are an extension of more than 20 years of previous work in studying the regional hydrology. A regional model will soon be published by USGS that will provide a basis for understanding the hydrological processes at both a regional and local scale. The conceptual model that will be developed by the USGS will provide input to the performance assessment modeling that will be developed by Sandia.

The USGS interpretation of the regional flow system is based on water level contours developed principally from pre-existing well data According to the regional model, groundwater at the Yucca Mountain site flows in a generally southern direction to a discharge area at Alkali Flats and Furnace Creek Ranch in Death Valley (Figure 1), but several factors lead to a degree of uncertainty in the flow lines. In essence, these factors are that (1) structural features may result in flow lines that are not normal to equipotential lines; (2) the contours are based on water levels that were measured independently and over a period of many years, and (3) if hydrostratigraphic zonation is present, water levels in different zones may inadvertantly have been used to construct the contours.

Plans

USGS plans call for investigations that should define the regional flow system more precisely. Under these plans, the data from older wells would be re-evaluated, new data from exploratory wells at the Yucca Mountain Site would be added to the data base, and some additional wells would be drilled between the Yucca Mountain site and the probable discharge area at Alkali Flats and Furnace Creek Ranch.

Observations and Actions

It was the impression of the NRC group that the USGS seems to have a clear understanding of the limitations inherent in the existing regional flow model and that the additional investigations planned by USGS are appropriate. However, because the data on which the regional model is based were not made available for NRC review, NRC must reserve judgment.

3. Characterization of the Unsaturated Zone

A repository horizon has not yet been established. Included among the formations that are still under consideration are two fractured tuff formations that are in the unsaturated zone. While hydrologic characterization and modeling have been done for unsaturated, porous media, there has been no similiar experience with unsaturated, fractured media anywhere. In this regard two questions are significant that were discussed during the meeting.

- What physical processes will govern the behavior of a repository in unsaturated, fractured tuff?*

- What factors should be used in characterizing unsaturated, fractured tuff?

Status

Groundwater flow provides the most likely vehicle for radionuclide transport to the accessible environment. Thus, a repository constructed in the unsaturated zone would appear to be able to isolate radionuclides more readily than one constructed below the water table. The water table at the Yucca Mountain site is approximately 600 m. below the ground surface, deep enough to permit consideration of a repository in unsaturated rocks.

Interest in the potential for constructing a repository in the unsaturated zone at the Yucca Mountain site has developed only recently and is based on broad, general considerations. Accordingly, detailed,

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*At the meeting, the question was dicussed only in the context of hydrogeology, however, the concern is broader. Specifically, those physical processes that would affect rock strength, radionuclide retardation, and waste package integrity are also of concern.

site specific investigation of the unsaturated zone is still at the planning stage. As yet, no tests have been run in the unsaturated zone and the important hydraulic parameters remain to be identified and measured.

Sandia has the lead responsibility for performance assessment at NTS. Performance assessment modeling of the unsaturated zone is still in the planning stages. Computer codes which could be used in the modeling are in various stages of development. The two codes receiving the most attention are MARIAH (SAT/UNSAT) for groundwater flow outside the repository and TRACR for regional transport. When completed, they will be used to model the unsaturated and saturated portions of the repository block and modal the regional flow and transport.

Plans

USGS is preparing a proposal to DOE for characterization of fractured, unsaturated tuff at the Yucca Mountain site. The proposal would include two types of activity: (1) investigations intended to develop an understanding of potential release mechanisms and radionuclide transport in the unsaturated zone and (2) tests to determine the values of significant hydraulic parameters. Only general plans for performance assessment modeling were discussed during the meeting.

There was considerable discussion of plans and methods for characterizating the unsaturated zone at the Yucca Mountain site. During these discussions, the NRC group described work that NRC is sponsoring at the University of Arizona and an air-drilling technique that has been used sucessfully by one of the NRC consultants in an unsaturated zone study elesewhere.

Observations and Actions

The NRC group agreed to send USGS a copy of the Statement of Work for the University of Arizona project and more information on the air drilling technique.

If a repository horizon were to be selected in the unsaturated zone, the questions discussed in this section could become central. Because of the lack of experience in characterizing and modeling transport in unsaturated, fractured rock, an intensive program is needed to quickly establish and characterize the hydrologic processes that could affect waste isolation in the unsaturated zone.

4. Paleohydrology

The hydrologic conditions at the Yucca Mountain site are, in part, the result of the current arid climate. Since the climate has been less arid at various times in the relatively recent past, similar conditions could occur in the future. Therefore, the following question is of concern:

- o How would hydrologic flow paths and travel times be affected by a potential change to a less arid climate?

Status

USGS has investigated past changes in climate at the NTS on a regional scale. Winograd and Doty (1980) evaluated the Quaternary fluctuations of the water-table in the NTS region using modern and fossil spring deposits. Subsequent unpublished investigations include studies of organic matter found in rat middens that could be related to specific climate conditions at a variety of locations. An unsuccessful study of mineralization in alluvium was also performed in an attempt to identify past climatic conditions. Based on these investigations, USGS has concluded that while the water table might rise, future changes in the groundwater flow system that could significantly affect repository performance are not likely to occur as a result of changes in climate.

Plans

Paleohydrologic studies to date have emphasized regional climatic conditions. To obtain site-specific paleohydrologic data, the USGS plans to attempt a detailed mineralogic study in the tuffs at Yucca Mountain to obtain site-specific paleohydrologic data.

Observations and Actions

The NRC group is concerned that the regional nature of the earlier USGS investigations may limit their applicability to the Yucca Mountain site. The NRC group agrees with USGS that a site-specific paleohydrologic study should be attempted at the Yucca Mountain site. In addition to the planned study, an attempt should be made to identify and examine other site specific data, such as rat middens in forty mile wash, to supplement the regional observations.

5. Conceptual Design

Many of the considerations that would be key to determining whether a repository located at the Yucca Mountain site would be licensable are closely related to the design of the repository.

Status

Sandia is the responsible DOE contractor for repository conceptual design studies. LANL is responsible for development of the conceptual design for an exploratory shaft.

The nature of the design and the rate at which it can be developed are closely linked with the geotechnical testing program, being conducted by Sandia. Testing to date has consisted of laboratory tests performed on core taken from the geologic boreholes and in-situ tests being performed in G-tunnel at Ranier Mesa. Laboratory tests have been performed on core from two wells and have provided preliminary data on strength, creep, and thermal behavior of the Yucca Mountain tuffs. (Results are described under the topic of Rock Mechanics in Section 6 below).

Heater tests are underway in G-tunnel. The tests indicate that the tuff begins to dehydrate at temperatures as low as 100°C. The released water condenses in the cooler places in the emplacement hole and if permeability is low enough, may stay in the hole and "wet" the waste package.

A final conceptual design for an exploratory shaft has not yet been developed by LANL. However, it is expected that the inner diameter of the exploratory shaft will be about 98 inches and that the shaft would be sunk near the center of the repository block to maximize the area that can be characterized from the exploratory shaft. No determination has been made as to whether the shaft will be bored or sunk conventionally.

Because no specific repository horizon has been selected yet and because the geotechnical data base is still somewhat limited, the conceptual design is in the earliest stages of development. In that context, however, Sandia did describe a number of ideas that indicate what design approaches are under consideration.

Two alternative concepts were described for waste emplacement. Under the first concept, waste packages would be emplaced in vertically augered holes in the emplacement room floors. The areal heat density (50-75 KW/Acre) would be such that if retrieval were necessary, repository room temperatures could be reduced to 40°C in about four months.

Under the second concept, parallel pairs of drifts slightly inclined to be self draining and separated by perhaps 600 feet, would be connected by a set of holes drilled normal to the drift direction. Waste packages would be emplaced in a horizontal position in the drilled holes. Because of the spatial isolation of the waste packages from the drifts, drift temperatures would remain at working levels up to 50 years. No decision regarding waste package emplacement concepts has been made.

Plans

The effort directed at development of a conceptual design for a repository at the Yucca Mountain site is expected to remain at a relatively low level until a repository horizon has been selected. Consequently, no specific plans were discussed. Also, no specific plans were discussed regarding further development of a conceptual design for an exploratory shaft.

A series of in-situ tests is tentatively planned for G-tunnel. The test series would include small diameter heater tests in both welded and non-welded tuff. In addition, heated block, unit cell, and other tests would be performed in welded tuff to investigate stresses and thermo-mechanical behavior. Sandia expects that the data from these tests will provide (1) an improved understanding of the coupled thermal, mechanical, and hydrothermal phenomena, (2) at least a partial basis for evaluation of models, and (3) a means to enhance its insturmentation, monitoring, and data collection capabilities. In these three ways, the planned test series would be expected to provide input, in varying degrees, to the selection of a repository horizon, location of an exploratory shaft, waste package design, repository design, and site characterization.

Observations and Actions

The conceptual design effort and the test program appear to be well integrated. However, one consequence of having the design effort move apace with the test program is that it seems doubtful that a full conceptual design will be completed in time for inclusion in the SCR. 10 CFR Part 60 requires that the SCR include a description of the conceptual design in sufficient detail to allow a review of the site characterization investigations. This requirement is intended to allow for identification of the issues; specifically, what has to be tested for and whether the plans for testing are adequate. Thus, it is essential that the NRC and DOE mutually establish what constitutes sufficient scope and level of detail in the sections of the SCR that describe the conceptual design.*

6. Rock Mechanics

Measured strengths of some tuff horizons at the Yucca Mountain site suggest that is may be difficult to construct and maintain stable, mined openings. In this connection, the following questions are significant:

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*A summary of discussion between DOE and NRC on this matter is provided under the heading, "Content of SCR," below.

- At repository depth and temperature, what is the strength of the tuff and will the strength of the tuff be adequate?

- What is the stress field at the Yucca Mountain site?

Status

The question of tuff strength was discussed only briefly. Sandia is responsible for the laboratory test program. Strength tests have been completed on core samples taken from two of the geologic boreholes (G-1 and UE 25 a-1). Samples of the tuff from four of the formations that are under consideration as a potential repository host rock have been tested. In well G-1 samples from Calico Hills, Bullfrog, and Tram tuffs have been tested and in well UE 25a-1 the Topopah Springs, Calico Hills, and Bullfrog tuffs have been tested. Most of the test results have now been published in Sandia reports. Based on these data, Sandia has made a number of observations. Among the more significant are the following:

1. the strength characteristics of the welded tuff are variable. For example, tested samples of Bullfrog tuff from well G-1 have exhibited unconfined compressive strengths that range from 4.63 to 153. MPa. The ultimate strength depends on the porosity of the rock;

2. unwelded, zeolitized tuff has a complex behavior: (a) it contracts when dehydrated, and (b) when partially saturated, 3-4 preliminary scoping tests indicated its strength is strongly temperature dependent (the strength of the tuff tested from G-tunnel decreases by about 30-40% between 23°C and 200°C);

3. the strength of devitrified tuff shows no temperatue dependence (the zeolitized Calico Hills unit is a major exception); and

4. the presence of water is a significant factor in determining the behavior of tuff. Specifically, water can weaken the rock mass under a thermal load because of increases in pore pressure and water may influence the creep behavior of tuff (there 's roughly a 20% increase in strength of devitrified tuff upon dehydration).

Stress measurements are being made by the USGS at the Yucca Mountain site. To date, six hydrofracture tests have been completed at different horizons in one borehole G-1. All six tests were conducted in the saturated zone. The preliminary test results show a consistent trend in agreement with normal faulting in the area (greatest compressive stress N15°E). No stress results have been published yet and the preliminary data were not made available to the NRC group.

A stress-relief test has also been performed in welded tuff in G-tunnel at a depth of 1400 feet. The stresses were found to be less than 1 Mpa in one horizontal direction, 5 Mpa in the other orthogonal direction in the horizontal plans, and 8 Mpa in the vertical direction. The weight of the overburden and the measured stresses are in reasonable agreement.

Plans

Sandia is continuing the program of laboratory strength tests. Samples of the Topopah Springs tuff from the well G-1 are now being tested. In addition, as was described in Section 5 above, the program of in-situ tests in G-tunnel is continuing.

Observations and Actions

This area is one in which NRC has expressed previous concern. Specifically, some measured values of unconfined compressive strength in Bullfrog tuff appeared to be too low to allow construction of stable openings with conservative safety factors. Data that were recently made available to NRC suggest that, in the Bullfrog unit, these low measurements may be confined to the upper part of the unit; however, until NRC has completed a more detailed review of the data, it must reserve judgment. Fewer data are available for other units under consideration as a potential repository host rock, but some low strengths have been measured. In addition, the Topopah Springs unit is extensively fractured in places so that there is some question concerning its rock mass strength. The question of strength of the tuff at the repository horizon remains open.

7. Geologic Stability

The Yucca Mountain site is located in a region that has experienced faulting and volcanism in the relatively recent geologic past. Consequently, a repository located at the Yucca Mountain site may be particularly exposed to a variety of potentially disruptive natural events that could occur after closure. In this context, the following questions are important:

- What is the potential for disruption of a repository at Yucca Mountain by fault movement or earthquakes?

- What is the potential for disruption of a repository at Yucca Mountain by volcanism?

Faulting and Earthquakes

Status

USGS is conducting a program to synthesize the chronology, style, and rates of past tectonism in the vicinity of the Yucca Mountain site. Generally, the program includes geologic mapping, trenching of selected faults, geomorphic studies, seismicity studies, geophysical surveys and plans for a geodetic survey.

Mapping and categorizing of major faults in the NTS region is nearly completed. A regional map of Quaternary faults that will include the NTS is being compiled. USGS is also working on a detailed geologic map of Yucca Mountain. Numerous faults with displacments of less than two meters have been mapped at the southeast end of Yucca Mountain. A few faults have also been mapped in the potential repository block. The mapped faults trend northeast and northwest and have not yet been related to the regional tectonic setting. Preliminary evidence suggests that the northwest trending faults and parallel fracture system may attenuate with depth but this has not yet been established.

To establish the age of last movement of faults in the vicinity of the Yucca Mountain site, USGS has selected several faults having representative trends and old alluvial cover in the vicinity of Yucca Mountain for trenching and is doing geomorphic studies. Observations made in trenches in Crater Flat suggest that the faulting to the east of the Crater Flat cinder cones may be related to past volcanism. Several observations would tend to suggest a lack of recent fault movement. No evidence of Holocene faulting has been found in any of the trenches. In one trench in Crater Flat, a radiometric age of approximately 1 million years before present on volcanic ash indicates that there has been no adjustment on the fault in the last million years. The geomorphic investigations have found that lineaments in the alluvium are uncommon and scarps are generally subdued.

Seismicity studies include the cataloguing of historical earthquakes and interpretation of the seismicity in the context of mapped geologic structure. The historic earthquake activity seems to be concentrated on northeast trending faults.

Plans

Present plans call for continuation of the mapping, trenching, and seismic monitoring. A third program of seismic reflection surveying will continue into this year. As it is now planned the program will use significantly higher energy sources than were used in a previous unsuccessful programs. This program is a last effort to resolve or at least identify the problem in resolving reflectors. If this attempt proves successful, USGS plans to traverse Yucca Mountain. A geodetic survey covering Yucca Mountain and vicinity will also be started this year.

Observations and Actions

The USGS program to synthesize the chronology, style, and rates of past tectonism seems to be generally well conceived. This observation is tentative, however, because most of the data summarized by USGS during the discussions were regarded by USGS as preliminary and not made available for review by the NRC group. Although no recent fault movement has been found in the vicinity of Yucca Mountain by the investigations to date, it has not been established that the faulting is pre-Quaternary. 10 CFR Part 60 requires that if present, Quaternary faulting be evaluated as it relates to repository performance. Continued efforts to resolve the question of Quaternary movement along faults in the site vicinity are essential.

Volcanism

Status

A comprehensive program of investigations by USGS and LANL to determine the nature and extent of volcanic risk at the Yucca Mountain site is nearing completion. The program has included consequence analyses and studies to determine the tectonic and petrologic conrols of the regional volcanism. Details of the investigations appear in a number of publications that have either been published or are now in press.

LANL has completed an analysis of a number of scenarios for disruptive volcanic events at the Yucca Mountain site. The consequences of even such extreme, improbable events as spent fuel rods being ejected from a cinder cone have been considered in these analyses and found to have been minimal.

The geologic studies have resulted in a general understanding of the regional and local volcanic activity. The Nevada Test Site is located in a Plio-Pleistocene belt of basaltic activity, characterized by small dikes feeding cinder cones, that extends from central Nevada south to Death Valley. The rate of activity is low and occurs in discrete pulses. The Plio-Pliestocene basaltic activity may relate to any of three tectonic settings (USGS Open-File Report 80-357): 1) caldera ring fracture zones, 2) NE trending rift zones or areas of relatively young basin and range extension, or 3) right stepping offsets in NW trending right lateral shear zones, or intersections of NE trending faults with these zones. The favored interpretation relates the volcanism to northeast basin and range extension.

Based on these investigations two major conclusions have been drawn by NNWSI investigators regarding the potential for the two general categories of volcanism, basaltic and silicic. These are that (1) silicic volcansim is not a significant hazard at the NTS and (2) there is only a low probability that a repository (one in 10^{-8} to 10^{-10} per year) at the Yucca Mountain site would be disrupted by basaltic volcanism.

Plans

No further field work or analysis is planned. Reports that are now in preparation will be completed and published.

Observations and Actions

Based on the discussions at the meeting, it would appear that DOE considers the volcanism question to have been essentially resolved. The completed investigations do appear to have been well planned; however, until the NRC group has had an opportunity to review the reports, it must reserve comment.

B. Content of the SCR

In addition to the technical discussions during the two day meeting, there was also discussion about the scope and level of detail to be included in the SCR on matters related to both the conceputal design of the repository and NEPA. Summaries of the related discussion are presented in the following paragraphs.

1. Conceptual Design

A conceptual design for a repository at the Yucca Mountain site is only in the earliest stages of development. Consequently a full conceptual design will not be completed in time for inclusion in the SCR (planned submittal is during the third quarter of FY83). Prior to the meeting, DOE and NRC agreed to take up the question of what scope and level of detail are appropriate for the sections of the SCR that are concerned with the conceptual design.

The NRC group described the central purpose of including a description of the conceptual design in the SCR. That purpose is one of allowing identification of the issues, i.e. what has to be tested for and whether the plans for testing are adequate. Based on subsequent discussion, the DOE and NRC groups agreed to meet again to resolve the SCR content question after independently gathering specific examples to illustrate their respective use of design terms and appropriate material for inclusion in the SCR.

<u>NEPA</u>

As outlined in the NRC's draft guide for the standard format and content of SCR's, the SCR would include a description of the process used by DOE to select the Yucca Mountain site for site characterization. Noting that (1) a stated purpose of site characterization is to collect the data needed by NRC to make its NEPA finding and (2) concerns about the planned scope have been voiced by interested states, the NRC group raised a question as to whether the SCR process, as originally envisioned through the procedural rule and the Format and Content Guide for the SCR, would necessarily or appropriately include consideration of broad NEPA issues. The DOE group said that at a broad level of detail these issues would be covered (many have been addressed in the GEIS and other documents), but suggested that the NRC group discuss with their legal division whether more is needed in the SCR and advise DOE of the outcome.

C. Open Items

During the course of the two day meetings, a number of items that were discussed were left unresolved, but with designated actions. In addition, various exchanges of documents and other information were agreed to. Prior to adjourment of the meeting, Mitchell Kunich of DOE and Seth Coplan of NRC compiled the following list of action items:

1. Establish mechanisms for DOE to consult with NRC on operational decisions which may have a potential licensing impact. For example:

   - piezometer installation method
   - drilling in the middle of the repository block
   - miscellaneous drilling problems.

2. NRC will get back to DOE regarding the question of whether instruments must be retrievable from boreholes.*

3. NRC will get back to DOE regarding the question of what can be assumed about the performance of holes drilled during site characterization.*

*Items 2 and 3 may not be resolved until Item 1 has been settled.

4. NRC will provide Mitch Kunich with a copy of the Standard Review Plan for the SCR review.

5. Environmental issues - NRC will consult with its lawyers as to how much coverage is needed in the SCR and get back to Ralph Stein.

6. NRC will get back to DOE with a summary of impressions gained during the site visit and meeting (probably by letter).

7. NRC will send Kunich its NRC issues "rack-up."

8. By late June NRC and DOE will produce examples of conceptual design information that each thinks is appropriate for inclusion in the SCR. Kunich and Coplan will then arrange a meeting to resolve the issue.

9. NRC will get back to DOE with specific data and information requests relative to what was presented at the meeting.

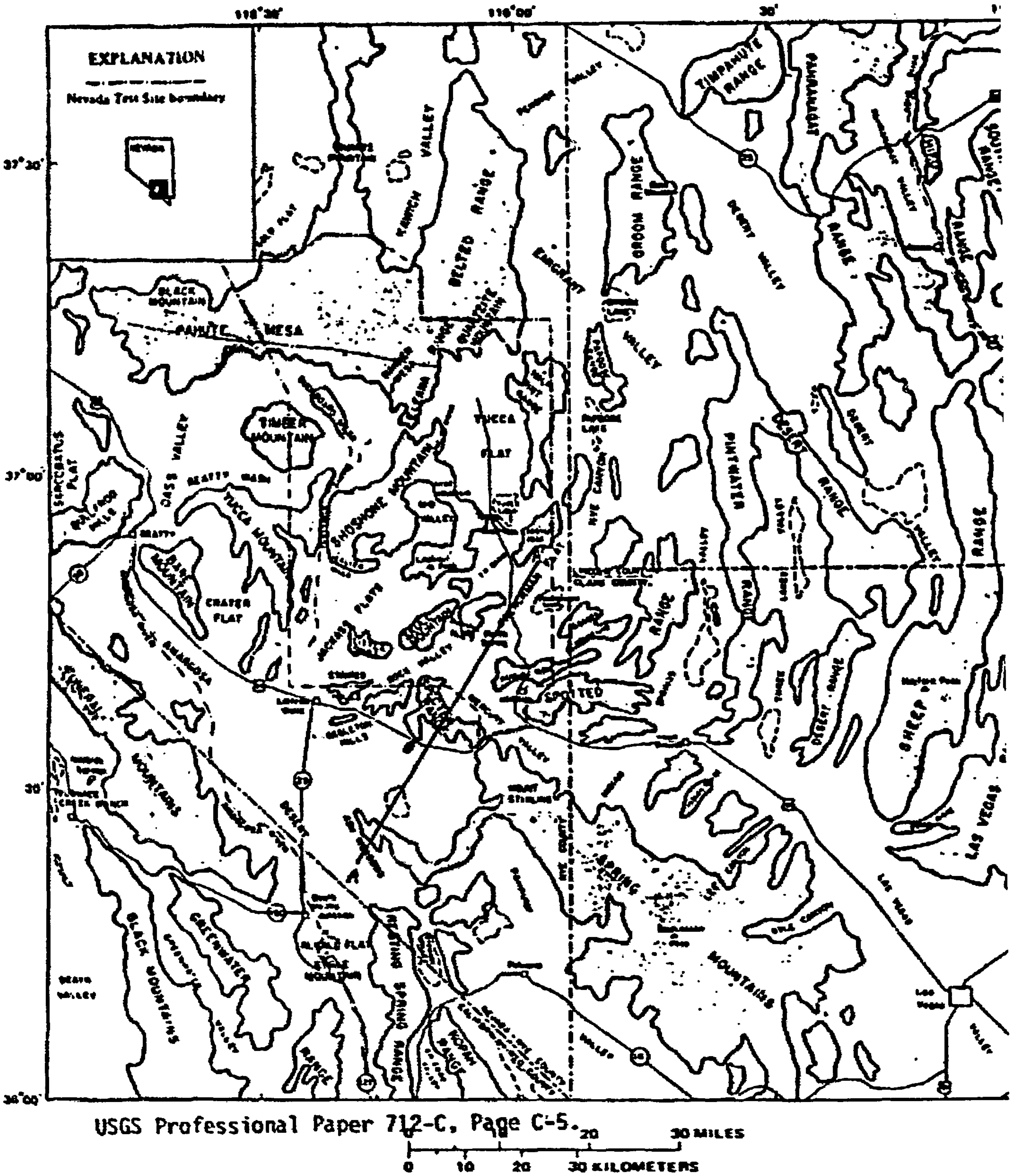
10. Establish ground rules for exchanges of preliminary information. Miller will contact Stein.

TABLE I
Nevada Test Site
Borehole Date

Hole No.	Coordinates	Elevation	Drilled Depth	Static Water Level
UE-25a #1	N 764,900.15' E 566,349.98'	3932.8' Ground	2501'	1542'
UE-25a #2	N 769,200' (Not drilled) E 606,670	-	-	-
UE-25a #3	N 769,350' E 602,925	N/A	2530'	2094'
UE-25a #4	N 767,969.2' E 564,479.2'	4101.1' Ground	500'	-
UE-25a #5	N 766,954.1' E 564,756.3'	4057.1' Ground	487'	-
UE-25a #6	N 765,897.5' E 564,496.0'	4052.7' Ground	500'	-
UE-25a #7	N 766,242.5' E 565,465.5'	4005.1' Ground	500'	
UE-25a #1	N 765,243.62' E 566,416.74'	3938.2' Ground	4002'	1543.37'
UE-29a #1	N 797,728.97' E 585.574.53	3986.7' Ground	215'	110.00'
UE-29a #2	N 797,743.97' E 585,549.53	3986.4' Ground	1383'	110.00'
SW G-1	N 770,500.20' E 561,000.48'	4348.6' Ground	6000'	1877.8 (Still De- clining)

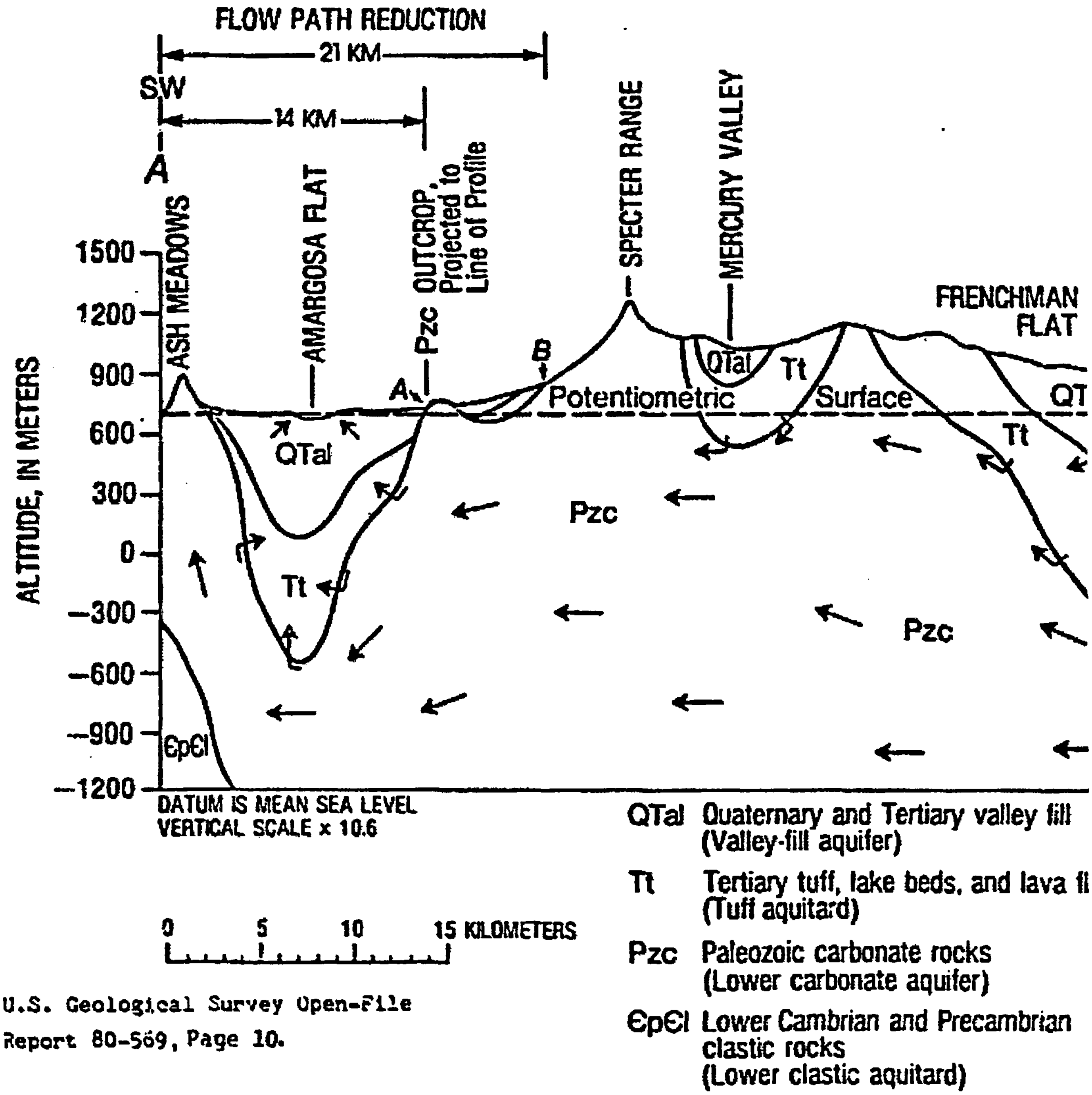
Table I (continued)

Hole No.	Coordinates	Elevation	Drilled Depth	Static Water Level
SW GA-1	N 779.365.42' E 559,246.98'	5186.8' Ground	551'	-
SW G-2	N 787,824.77' E 560.503.42'	5098.0'	6006'	1719.65' (Still De-clining)
SW G-3	N 752,779.84' E 558,483.12'	4856.2' Ground	5031'	2429'
SW GU-3	N 752,690.10' E 558.501.32'	N/A	2640'	Approx.
SW VH-1	N 743,355.81' E 533,624.95'	4131.4' Ground	2501'	610.10'
SW H-1	N 770,254.32' E 562,387.96'	4272.4' Ground	6000'	1877.62'
SW H-3	N 756,542.02' E 558,451.62'	4866.7' Ground	4000'	2439'
SW H-4	N 761,642.58' E 563,911.04'	4097.3'	4000'	1700'
SW H-5	N 766,634' E 558,908' (Relocated)	-	Active	-



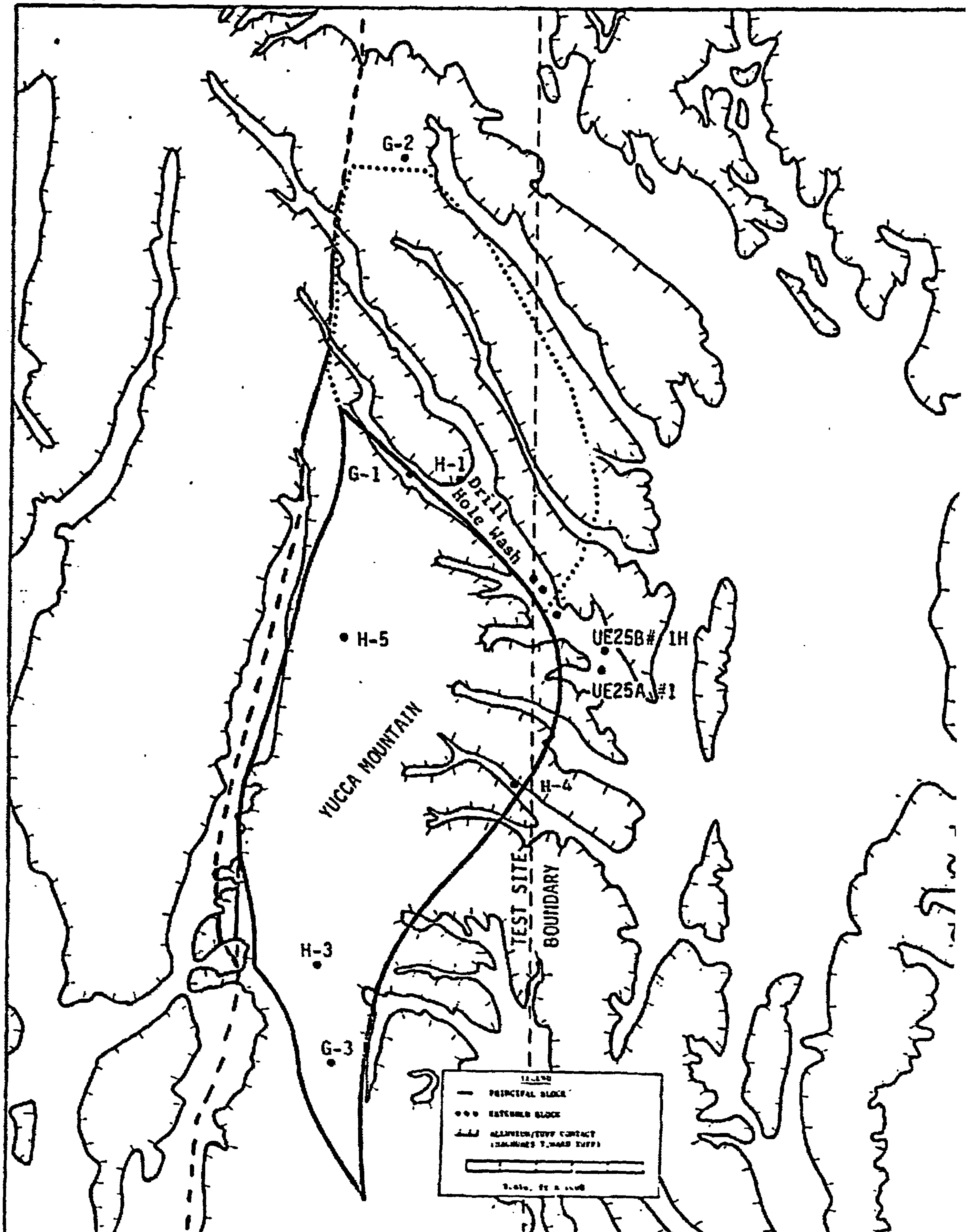
USGS Professional Paper 712-C, Page C-5.

Figure 1.--Index map of the Nevada Test Site and vicinity showing the location of Yucca Mountain.



U.S. Geological Survey Open-File
Report 80-569, Page 10.

Figure 2.--Diagrammatic section illustrating effects of possible past or future pluvial-related water table length of ground-water flow path from Frenchman Flat to points of natural discharge at Ash Meado Amargosa Desert, Nevada (Line of section is shown on figure 1; water level rises of 40 and 150 m initiate disch[illegible] from the lower carbonate aquifer at points A and B, respectively 14 and 21 k[illegible] of modern spri[illegible] neament; arrows depict ground-water flow)


G-2
G-1
H-1
Drill Hole Wash
H-5
UE25B#1H
UE25A#1
YUCCA MOUNTAIN
H-4
TEST SITE BOUNDARY
H-3
G-3

System	Series	Stratigraphic unit	Major lithology	Maximum thickness (feet)	Hydrogeologic unit	Water-bearing characteristics and extent of saturation *
Quaternary and Tertiary	Holocene, Pleistocene, and Pliocene	Valley fill	Alluvial fan, fluvial, fanglomerate, lakebed, and mudflow deposits	2,000	Valley-fill aquifer	Coefficient of transmissibility ranges from [illegible] 35,000 gpd per ft; average coefficient of permeability ranges from 5 to 20 gpd [illegible]; saturated only beneath structurally deep [illegible] Yucca Flat and Frenchman Flat
Tertiary	Pliocene	Basalt of Kiwi Mesa	Basalt flows, dense and vesicular.	250	Lava-flow aquifer	Water movement controlled by primary and secondary fractures and possibly by [illegible] flows; intercrystalline porosity and [illegible] negligible; estimated coefficient of trans[illegible] ranges from 500 to 10,000 gpd per ft; saturated beneath east-central Jackass Flats
		Rhyolite of Shoshone Mountain	Rhyolite flows.	2,000		
		Basalt of Skull Mountain	Basalt flows.	250		
		Paintbrush Tuff (Paintbrush Canyon Group) — Timber Mountain Tuff: Ammonia Tanks Member	Ash-flow tuff, moderately to densely welded; thin ash-fall tuff at base.	250	Welded-tuff aquifer	Water movement controlled by primary and secondary joints in densely welded part of tuff; coefficient of transmissibility ranges [illegible] to 100,000 gpd per ft; intercrystalline porosity and permeability negligible; unwelded part of tuff, where present, has relatively high porosity (15-50 percent) and [illegible] (2 gpd per sq ft) and may act as [illegible]; saturated only beneath structurally deep Yucca, Frenchman, and Jackass Flats
		Timber Mountain Tuff: Rainier Mesa Member	Ash-flow tuff, nonwelded to densely welded; thin ash-fall tuff at base.	600		
		Paintbrush Tuff: Tiva Canyon Member	Ash-flow tuff, nonwelded to densely welded; thin ash-fall tuff near base	100-350		
		Paintbrush Tuff: Topopah Spring Member	Ash-flow tuff, nonwelded to densely welded; thin ash-fall tuff near base	900		
		Paintbrush Tuff: Bedded tuff (informal unit)	Ash-fall tuff and fluvially reworked tuff	1,000	Bedded tuff aquifer	Coefficient of transmissibility ranges [illegible] 1,000 gpd per ft; saturated only beneath locally deepest parts of Yucca Flat, [illegible] Flat, and Jackass Flats. Occurs beneath [illegible] flow tuff members of Paintbrush Tuff [illegible] Canyon Member of Indian Trail [illegible]
	Miocene	Wahmonie Formation	Lava-flow and interflow tuff and breccia; locally hydrothermally altered.	1,500	Lava-flow aquitard	Water movement controlled by poorly connected fractures; interstitial porosity and permeability negligible; coefficient of transmissibility less than 500 gpd per ft; contains minor [illegible] in basalts between Frenchman Flat [illegible] Flats
		Wahmonie Formation	Ash-fall tuff, tuffaceous sandstone, and tuff breccia, all interbedded; matrix commonly clayey or zeolitic.	1,700	Tuff aquitard	Coefficient of transmissibility ranges from [illegible] gpd per ft; interstitial porosity is as high [illegible] cent but interstitial permeability [illegible] (6×10 [illegible] to 5×10 [illegible] gpd per sq ft) [illegible] hydraulic connection of fractures [illegible] permeability probably controls regional water movement; perched minor quantit[illegible] beneath hydrologic flanking valleys; [illegible] only beneath structurally deepest parts [illegible] Flat, Frenchman Flat, and Jackass [illegible] Canyon and Tub Spring Members of In[dian Trail] Formation may locally be aquifers in [illegible] Flat
		Salyer Formation	Breccia flow, lithic breccia, and tuff breccia, interbedded with ash-fall tuff, sandstone, siltstone, claystone; matrix commonly clayey or calcareous	2,000		
		(?)				
		Indian Trail Formation: Grouse Canyon Member	Ash-flow tuff, densely welded	500		
		Indian Trail Formation: Tub Spring Member	Ash-flow tuff, nonwelded to welded.	500		
		Indian Trail Formation: Local informal units	Ash-fall tuff, nonwelded to semiwelded ash-flow tuff, tuffaceous sandstone, siltstone, and claystone; all massively altered to zeolite or clay minerals, locally; minor welded tuff near base; minor rhyolite and basalt	2,000		
		(?)				
		Rhyolite flows and tuffaceous beds of Calico Hills	Rhyolite, nonwelded and welded ash-flow ash-fall tuff, tuff breccia, tuffaceous sandstone, hydrothermally altered at Calico Hills; matrix of tuff and sandstone commonly clayey or zeolitic	>2,000		
	Miocene and Oligocene	Tuff of Crater Flat	Ash-flow tuff, nonwelded to partly welded, interbedded with ash-fall tuff; matrix commonly clayey or zeolitic	700		
		Rocks of Pavits Spring	Tuffaceous sandstone and siltstone, claystone, fresh water limestone and conglomerate, minor gypsum; matrix commonly clayey, zeolitic, or calcareous	1,400		
	Oligocene	Horse Spring Formation	Fresh water limestone, conglomerate, tuff	1,000		

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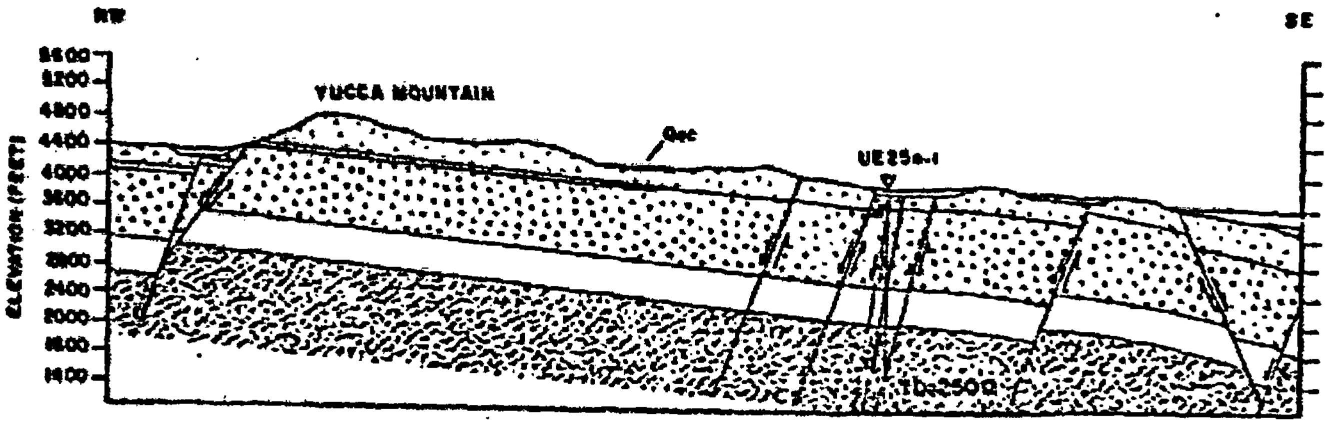
Figure 4--Stratigraphic and hydrogeologic units at Nevada Test Site and vicinity



EXPLANATION

ALLUVIUM AND COLLUVIUM (QUATERNARY) (Qac)

RHYOLITES OF FORTYMILE CANYON (Trf)

TIMBER MOUNTAIN TUFF

RAINIER MESA MEMBER (PLIOCENE) (Tmr)

PAINTBRUSH TUFF

TIVA CANYON MEMBER (MIOCENE) (Tpc)

BEDDED TUFF

YUCCA MOUNTAIN MEMBER (MIOCENE) (Tpy)

PAH CANYON MEMBER (MIOCENE) (Tpp)

TOPOPAH SPRING MEMBER (MIOCENE) (Tpt)

TUFFACEOUS BEDS OF CALICO HILLS (MIOCENE) (Tcb)

CRATER FLAT AND OLDER TUFFS (MIOCENE) (Tcf)

USGS Open-file Report 79-1244, Page 9.

Figure 5--Geologic cross section.