UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

February 27, 1998

MEMORANDUM TO: N. King Stablein, Acting Chief
ENGB/DWM/NMSS

THRU: David J. Brooks, Section Leader
Geoscienses/Hydrology Review Section
ENGB/DWM/NMSS

NC for DJB

FROM: Neil Coleman, Hydrogeologist
Geoscienses/Hydrology Review Section
ENGB/DWM/NMSS

NC

SUBJECT: TRIP REPORT - AMERICAN GEOPHYSICAL UNION FALL MEETING
DECEMBER 8-12, 1997, SAN FRANCISCO, CALIFORNIA

During the week of December 7, 1997, I attended the subject meeting in San Francisco, CA, and presented a poster (H51B-13) titled "Issue Resolution Status Report on Methods to Evaluate Climate Change and Associated Effects at Yucca Mountain." The abstract is attached. CNWRA staff (J. Winterle and S. Stothoff) and a CNWRA consultant (D. Woolhiser) also attended and gave poster presentations at the meeting. A number of other papers and posters were presented that are relevant to our Key Technical Issues at Yucca Mountain (YM). Brief summaries of selected papers are provided below.

Poster H42E-9 — Czarnecki, J., et al., "Construction and Calibration of a Preliminary Three-Dimensional Finite-Element Ground-Water Flow Model of the Site Saturated Zone, Yucca Mountain, Nevada"

This poster described details of the U.S. Geological Survey (USGS) 3-D flow model. The finite element model consists of over 50,000 tetrahedral elements representing 16 hydrogeologic units. Calibration of the model is based on 94 observed and simulated values of hydraulic head. Most residuals were less than 5 m. This model has been documented by the USGS as draft milestone report SP23NM3, and our staff has just received it from the U.S. Department of Energy (DOE).

One of the wells used by Czarnecki is located near the Lathrop Wells volcanic cone. I inquired about the source of data for this and other wells and was referred to a report titled "Hydrochemical Database for the Yucca Mountain Area, Nye County, Nevada," by Oliver and Root. This report has been sent to the U.S. Nuclear Regulatory Commission and placed in the Public Document Room. The report provides the best currently available data for groundwater levels and YM hydrochemistry.

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Poster H42E-3 Wu, Y.S., et al., "A Modeling Study of Perched Water Phenomena in the Vadose Zone [at YM]"

This poster illustrated the use of a multiphase flow model to study perched water in the unsaturated zone. The model was calibrated using data on perched water from six boreholes. As described by Wu et al., "steady-state simulation results are in agreement with observed perched water data, including water saturation and potential profiles and perched water elevations, indicating that the model is able to reproduce water-perching conditions as observed in the field." Some of the perched water data that they used is reproduced below:

Borehole	Surface Elev. (m)	Total Well Depth (m)	Top of Perched Zone Elev. (m)	Depth (m)
UZ-1	1349	387	967	381
UZ-14	1349	673	966	383
NRG-7a	1282	461	821	458-461
SD-7	1359	632	880	480
SD-9	1302	678	889	413
SD-12	1324	660	926	398
G-2	1554	1891	1020	534

It should be noted that wells UZ-1 and UZ-14 are located on the same drilling pad and, therefore, detected the same perched zone. Perched water has also been detected in well WT- 24 which is currently being drilled. It is located about 1 mile southeast from well G-2 and is designed to study in detail the so-called large hydraulic gradient. The elevation of the regional potentiometric surface will be determined, and zones of perched water will be characterized.

Poster H51B-7 Marshall, B., K. Futa, and Z. Peterman, "Hydrologic Inferences from Strontium Isotopes in Pore Water from the Unsaturated Zone at Yucca Mountain, Nevada"

Marshall, et al., leached water-soluble salts from crushed core samples taken from borehole SD-7. Near the top of the core, the $d^{87}Sr$ (permil deviation from seawater) is about 3.6, which is similar to values found in perched water and in calcite coatings on near-surface rocks. The $d^{87}Sr$ increases with depth in the Tiva Canyon tuff but increases sharply in the non-welded portions of the Paintbrush Group (PTn). Values within the upper part of the Topopah Spring tuffs are similar to those in thick calcitic soils. Multiple interpretations are possible. If it is assumed that the pore water has reacted with volcanic rocks from the surface to the sampled depths, then the data suggest that most of the variation in pore water compositions could result from dissolution of the rocks, especially the PTn.

Poster H51C-3 V. C. Tidwell, et al., "Visualizing, Quantifying, and Modeling Matrix Diffusion in Heterogeneous Rock Slabs"

Tidwell (Sandia), et al., studied matrix diffusion phenomena using five slabs of Culebra Dolomite from the vicinity of the Waste Isolation Pilot Plant near Carlsbad, New Mexico. A

tracer solution of potassium iodide was used. High-resolution x-ray absorption imaging was used to map out the solute concentration fields. Diffusion rates up to 0.1 cm/day were reported, but were found not to be constant even over relatively small spatial scales. Results suggested a fairly strong correlation between porosity and diffusion rate.

Invited Paper H52E-11 J.S.Y. Wang, et al., "Flow Tests to Quantify Seepage into Drifts"

Wang reports results of flow tests at two tunnel sites within the Topopah Spring tuffs. The first site in Niche 3566 is located in a highly fractured interval between a cooling joint and the Sundance Fault, and is near the occurrence of a zone of elevated Cl-36. Niche 3650 is in a rockmass with relatively low fracture density. Air permeability and liquid tracer tests had been conducted in several boreholes that were dry-drilled, prior to excavation of each niche. Niche 3566 had a higher mean value of air permeability, but a relatively small zone of high air permeability was found in the other niche. In the tracer tests, small amounts of water containing dye were pumped into short test intervals at low rates with virtually no pressure buildup. After testing, the niches were mined out to photograph the distribution of fractures and penetrated dye. The dye migrated along fractures from zero to nearly 3 m below the release points. Wang observed preferential transport along fracture intersections. Imbibition of dye into adjacent rock matrices was limited.

Immediately after Niche 3566 was excavated a large fracture was seen that contained damp, dark fill material, the surface of which was dried out within hours by the tunnel ventilation. This dampness occurred at the far end of the niche, about 9 m from the ESF tunnel. This depth, and the fact that no dye was observed, increases the likelihood that the dampness was caused by natural infiltration rather than tunnel construction activities. A smaller damp feature was seen in Niche 3650, but construction water could not be ruled out as a cause of dampness in this niche.

Paper H52E-12 Whelan, J. F. and R. J. Moscati, "Secondary Mineral Evidence of Large-Scale Water Table Fluctuations at YM, Nye County, Nevada"

At YM, percolation flux has deposited secondary calcite and silica in the unsaturated zone. In the UZ, calcite grows freely into open voids, displays bright white fluorescence and phosphorescence that fades with depth, and typically has $d^{13}C$ values of about -7 per mil. However, in the SZ calcite fills voids with intergrown crystals, has bright orange fluorescence but does not phosphoresce, and has $d^{13}C$ values of about 0 per mil reflecting the Paleozoic marine carbonate source of the altering fluids. Secondary calcite is generally absent from a zone 100- to 150-m thick above the modern-day water table. This zone is consistent with dissolution of calcites during past higher stands of the water table. Secondary minerals in a 300-m thick zone below the WT consist of sparse fracture coatings of calcite that do not fluoresce or phosphoresce and have $d^{13}C$ values ranging from -10 to +4 per mil. These calcites are interpreted to be undissolved remnants of UZ secondary minerals that formed during drier climatic intervals when the WT was much lower than today's. The data suggest that even during drier periods, some percolation flux may have penetrated into the fractured rocks below the Calico Hills tuffs.

Invited Paper U12B-1 Hammer, C. U., "How Rapid is a Rapid Climatic Change?"

Seasonal changes in dust concentrations can be used to obtain greater precision in dating of the GRIP ice core. The Younger Dryas cooling event apparently ended quite abruptly about 11,600 yrs ago. The actual change of climatic mode occurred over a period of less than 20-30 years, as interpreted by the summer part of the cycle. The winter part of the cycle may have shifted in as little as 2 years. One explanation for such a rapid climatic shift would be a major change in ocean circulation patterns. W. Broecker also sees ocean circulation as being a key factor in climate change [for example, see Science, Vol. 278, Nov. 28, 1997, pp. 1582-1588].

Invited Paper U12B-3 Alley, R. B., et al., "Younger Dryas Conditions as Recorded in Greenland Ice Cores"

The Younger Dryas cold oscillation lasted about 1250 years. At the end of this interval, aerosols in Greenland ice cores show a three-fold drop in sea salt and a seven-fold drop in dust in the range of 3-10 microns. Overall conditions after the transition were warmer, wetter, and less windy. The Younger Dryas was a large, rapidly terminated, hemispheric to perhaps global event. A similar though smaller event 8000 years ago has raised the question of possible recurrence.

Poster H21B-4 Levy, S.S., J.T. Fabryka-Martin, and D.S. Sweetkind, "Characterization of Fracture-Matrix Interaction Along Fast Pathways in Welded Tuff, Yucca Mountain, Nevada"

The authors gave a preliminary interpretation of data on apparent pathways. In structural domains where extension dominates and shearing is minor, the cooling joint boundary between wall rock and breccia remained planar and tends to remain as an open fracture during multiple episodes of dilation. Clays deposited in breccia pores and along the boundary between cooling joints and breccia tend to isolate the breccia deposit from reopened fractures because the clay coatings adhere to the breccia. Percolating waters then tend to bypass the breccia matrix and stay in the bounding fracture. The conditions are hypothesized where bomb-pulse Cl-36 is present as higher values in the wall rock containing the fracture surface than in the breccia.

In tectonic domains where shearing dominates over extension, cooling joint boundaries between wall rock and breccia are rough boundaries where the wall rock is in tight contact with the breccia. These breccias may also be less porous than those formed by extension. The absence of a fracture gap between the breccia and wall rock may help to maintain fluid flow within the breccia. These conditions are hypothesized when bomb-pulse Cl-36 is present at higher values in the breccia than in the wall rock that contains the bounding fracture surface.

Attachment: As stated

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RE: AMERICAN GEOPHYSICAL UNION FALL MTG
DECEMBER 8-12, 1998

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ATTACHMENT

Issue Resolution Status Report on Methods to Evaluate Climate Change and Associated Effects at Yucca Mountain

N M Coleman, N K Stablein, D J Brooks (All at U S Nuclear Regulatory Commission, Office of NMSS, Washington, DC, 20555; 301-415-7445; e-mail: nmc@nrc.gov)

The staff of the U.S. Nuclear Regulatory Commission has developed a program for early resolution of technical issues. Climate change was chosen as the pilot topic because (1) it is an important hydrologic subissue that must be addressed to estimate long-term infiltration rates for a potential geologic repository at Yucca Mountain (YM), (2) the Department of Energy's Waste Containment and Isolation Strategy states that seepage into emplacement drifts is the most important factor affecting the ability of a repository to isolate waste, and (3) enough relevant information exists to reach early resolution at the staff level on methods to assess climate variability and related topics. Issue resolution at the staff level during prelicensing is achieved when the staff has no further questions or comments at a given time regarding how the DOE program is addressing an issue. New facts could raise questions about a previously resolved issue.

Based on an independent review of available information, the staff concludes that methods based on paleoclimatic and paleohydrologic data can be used to bound the range of past climates in the YM region and to estimate future precipitation and water-table rise. Current information suggests that the present-day climate at YM will not persist unchanged for 10 kyr or more (1 kyr = 1000 yrs). Accordingly, a pragmatic approach is recommended to address climate change and its hydrologic effects in performance assessments. The staff will presume that an enhanced anthropogenic greenhouse warming will last at most several kyr, and that about 3 kyr in the future the climate at YM will resume or continue the global cooling predicted by the Milankovitch theory of climate. To ensure realism in its safety analysis, staff will postulate that full pluvial (cooler and wetter) conditions will dominate at least several thousand years of the next 10 kyr. At YM, mean annual precipitation increased 2 to 3 times during past pluvials, and the water table rose as much as 120 m (394 ft). A return to such conditions would be reasonably challenging to repository perf rmance because groundwater fluxes in the unsaturated zone would be significantly higher during pluvial episodes. The staff's approach recognizes that unforeseen human effects or the natural recovery of global climate from these effects could cause cooler and wetter conditions at YM than otherwise expected. And finally, any safety analysis that covers periods longer than 10 kyr into the future should simulate climate change using 100-kyr cycles of glacial and interglacial stages, similar to those seen in the paleoclimate record.