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Hydrogeology • Mineral Resources Waste Management • Geological Engineering • Mine Hydrology

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U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

RE: NTS TRIP REPORT

Dear Jeff:

I (Dr. George Bloomsburg) attended the meeting entitled "Development of Tuff Performance Assessment Methodology" on September 21 and 22, 1987. The meeting was held at the Technology Transfer Center, Sandia National Laboratories (SNL), Albuquerque, New Mexico. This letter presents my views of the meeting after lengthy discussions with Dr. Osiensky upon returning to Idaho.

The meeting began with Tito Bonano of SNL presenting a brief review of Sandia's role in development of performance assessment methodology. The four areas of work in which Sandia is involved for the Nuclear Regulatory Commission are: 1) uncertainty and sensitivity, 2) pathways and health effects, 3) groundwater flow and transport, 4) scenario development and screening.

The discussion concluded that the methodology for performance assessment of repositories includes, among other things, the definition of the beginning of the 5 kilometer distance from the site to the accessible environment, and uncertainty in the conceptual model(s). Dr. Bonano concluded that the probability of uncertainty on some of these issues cannot be quantified. The methodology pertaining to tuff includes: 1) water movement in the vapor phase (although aerosol movement is ruled out), 2) flow code categorization (SNL will recommend at least 3 codes to NRC or will recommend starting over) and 3) review of various scenarios, and flow and transport mechanisms.

The methodology for uncertainty/sensitivity analysis will include the groundwater flow inverse problem, stochastic transport models, kriging and co-kriging, and Monte Carlo simulation. The performance measures applicable to unsaturated tuff include fastest groundwater travel time and the cumulative radionuclide discharge in 10,000 years. Development needs include a conceptual model(s), a groundwater flow code for unsaturated fractured media, and new techniques for developing uncertainty estimates.

Dr. Bonano listed the topics that definitely will be pursued in fiscal 1989 and those which probably will be pursued. SNL will conduct the following work in 1989: 1) develop and/or modify groundwater flow codes, 2) work on estimating uncertainty in groundwater travel time estimates, 3) work to improve conceptual models, 4) collect additional data, 5) develop a modeling strategy for radionuclide transport, 6) evaluate uncertainty/sensitivity analysis techniques, and 7) integrate the work areas listed above into a performance assessment technology. Topics which SNL probably will investigate during fiscal 1989 are: 1) experiments in support of model development, and 2) analysis of groundwater travel time. During fiscal 1990, SNL will evaluate conceptual models, radionuclide transport models, uncertainty/sensitivity analysis techniques, development of a performance assessment methodology, and plan for the demonstration of the performance assessment methodology.

Bob Guzowski, a geologist with SNL, presented an introduction of some of the geological aspects of Yucca Mountain including a review of the site characteristics and a discussion of the geologic structure. Evidence of volcanic activity such as calderas and cones also exists. Most of these features are older than 6 million years. Evidence of younger volcanic activity (15 to 20,000 years old) also exists south of Yucca Mountain.

The main part of the presentation by Bob Guzowski dealt with risk(s). The various risks are divided into natural factors, human factors and repository factors. The natural factors consist of such things as surficial erosion processes, glaciation, pluvial climates, earthquakes, volcanic activity and magnetism. The human factors include explosives, drilling, mining, waste disposal, undetected fractures, and hydrologic stresses. The repository factors include shaft or borehole degradation and excavation. Guzowski selected 11 different events and processes which could take place which may affect the movement of water to the accessible environment. These processes are: 1) increases in recharge, 2) a rising water table, 3) development of perched water tables, 4) the occurrence of a volcanic dike perpendicular to the groundwater flow path which dams flow under the repository, 5) the occurrence of a volcanic dike perpendicular to the flow path under the repository which minimizes the length of the ground water flow path, 6) the effect of a dike in developing a perched water table, 7) movement along faults due to formation of a "dam," 8) movement along a fault which raises the water table and minimizes the length of the flow path, 9) movement along a fault which causes a perched water table, 10) withdrawal wells at Fortymile Wash which increase the hydraulic gradient, and 11) irrigation wells which also increase the hydraulic gradient. Various combinations of these events or processes produce 128 possible scenarios. However, when duplications and contradictions are removed, the ultimate list includes only seven possible scenarios and combinations of factors. Guzowski feels that the effects of pluvial climates probably are important. The literature is not consistent on the potential effects of pluvial climates. Several studies in the literature exist which do not necessarily agree.

Washington has conducted and presented a literature review of interfacial phenomena and their influence on water movement into tuff. His presentation was a good review of some of the effects of interfacial phenomena as well as of the movement of isolated pockets of non-wetting fluids such as oil or air. He pointed out that in many cases when water is moving across solid surfaces, the adhesive forces which cause the water to spread are greater than the capillary forces caused by interfaces.

Rafael Bras of the Massachusetts Institute of Technology also presented a literature review. Most of the papers which he discussed are associated with uncertainty in parameter estimation and modeling. The references which he listed were Anderson and Shapiro (Water Resources Research, 1983), Yeh et al. (Water Resources Research, 1985), Mantoglou and Gelhar (Water Resources Research, 1987), Dagan and Bresler (Water Resources Research, 1983), Peters et al. (Sandia Report, 1986), Klavetter and Peters (Sandia Report, 1986), Sinnock et al. (Sandia Report, 1987) and Gelhar and Axness (Water Resources Research, 1983). Evidently some of the work by Gelhar includes the development of a stochastic 3D analysis of unsaturated flow systems. This is work that the USGS has not referenced in any of the reports that have been reviewed by Williams and Associates, Inc.

Doug Smith (with the University of New Mexico?) discussed the experimental characteristics of tuff, the nature of the matrix surface area, porosity, and their effects on the movement of contaminants. Nitrogen absorption, water absorption, helium displacement, mercury displacement, and mercury porosity measurements have been used to characterize tuff properties. Sample cores from Dr. Dan Evans (University of Arizona) are being tested to determine the small and large scale variations along the axis of the boreholes. On a small scale the tuff is very uniform; large scale variations have not been determined yet. In the future Smith expects to determine the characterization history, to determine the range of particle sizes, and to conduct nuclear magnetic resonance studies. Spatial variation is not significant in the material that he has tested.

Paul Davis of SNL discussed the Hydrocoin project in which various mathematical models have been investigated to study uncertainty and to conduct sensitivity analyses to be used in determining the reliability of the performance limits and distribution of groundwater travel time. He discussed the following types of uncertainties: scenario uncertainty (have all possible conceptual models been considered?), model uncertainty (real world, mathematical description and solution), and geologic uncertainty, (field misidentification and misinterpretation of field data, errors in field measurements and incorrect geochemistry). Parameter and data uncertainty exist as well as uncertainty in analytical techniques. Sensitivity analysis must consider the change of output with respect to the input changes. Sensitivity analysis is not required according to regulations, but will be used in site characterization and model development. He also discussed sampling methodologies such as Monte Carlo and Latin Hypercube techniques. The two methods have been compared and the results do not necessarily agree.

An NRC panel chaired by Alan Freeze has been instituted to evaluate uncertainty. The panel divided the uncertainty into 1) model uncertainty, 2) parameter uncertainty, and 3) calibration uncertainty. The interaction of matrix and fractures was selected as the prime concern. The temporary variation of flow at interfaces and the upper boundaries also was of concern.

Peter Wierenga, a soil physicist at New Mexico State University, reported on field work involving a 20-foot deep trench and instrumentation of the soil such that water can be applied and observed moving down through the profile. He also has several deep access tubes (3 ft. diameter) in which water can be applied to the surface and observed moving down through the profile within the cylinder. His experiments show that if no vegetation exists on the surface of these columns recharge will occur, whereas if vegetation exists no recharge will occur. When asked what he had learned from this study, he replied that he had learned that samples of tuff should be brought into the laboratory, and that it is necessary to reinforce a 20-foot deep trench. When water was applied at the surface, the water did not move horizontally into the deep trench as predicted by stochastic models of Gelhar (1983).

John Wilson of New Mexico Tech has studied the movement of water between plastic plates to investigate visually the movement of water through fractures. This study is purely qualitative with nothing being measured. He has produced a film which shows distinctly that the water trickles down fractures in rivelets and does not spread out and flow as film flow. This type of flow is affected by surface tension and interfacial phenomena.

The next discussion concerned the work that should be required for characterization of the Yucca Mountain site. The result of the discussion was a list of research objectives for laboratory studies, and field work at Yucca Mountain. This list includes work on fracture/matrix flow, recharge and gas vapor phase transport. It was suggested that a fracture/matrix flow investigation should be conducted in which large blocks of tuff are brought into the laboratory and various flow parameters measured. It was suggested also that flow visualization projects should be expanded using fractured porous plastic to investigate the movement of water from fractures into the porous matrix. Fracture surface and chemistry experiments should be conducted. The group concluded that it is time to install a weather station or several weather stations on Yucca Mountain. Even one or two years of precipitation data would be better than what is available presently. An extensive inventory of the soil cover and vegetation on Yucca Mountain would be helpful because soils and vegetation would have a large effect on the infiltration into fractures. Peter Wierenga's work has shown that vegetation on the surface in arid climates may prevent recharge. Measurements of unsaturated hydraulic conductivity also should be made in the field. Possible pathways for gas vapor phase transport were discussed.

Problems with modeling a dry soil and the time required for water table rise under certain climatic changes were discussed also.

In summary, I concluded the meeting was productive. However, it is apparent that better communication between the various federal agencies and contractors involved in investigations pertaining to the hydrogeology of Yucca Mountain would be desirable.

Sincerely,

George Bloomsburg

George Bloomsburg

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