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March 8, 2001
Contract No. NRC–02–97–009
Account No. 20.01402.861

U.S. Nuclear Regulatory Commission
ATTN: Mrs. Deborah A. DeMarco
Two White Flint North
11545 Rockville Pike
Mail Stop T8A23
Washington, DC 20555

Subject: Programmatic Review of Abstract

Dear Mrs. DeMarco:

The enclosed abstract is being submitted for programmatic review. This abstract will be submitted for presentation at the American Geophysical Union Spring Meeting to be held May 29–June 2, 2001, in Boston, Massachusetts. The title of this abstract is:

> "Numerical Modeling of Unsaturated Flow in Thick Vadose Zones of Fractured Rocks" by W. Illman and D. Hughson

Please advise me of the results of your programmatic review. Your cooperation in this matter is appreciated.

Sincerely,

Budhi Sagar
Technical Director

/ph
Enclosures
cc: J. Linehan, B. Meehan, E. Whitt, J. Greeves, J. Holonich, W. Reamer, T. Essig, K. Stablein, D. Brooks, B. Leslie, N. Coleman, W. Patrick, CNWRA Directors, CNWRA Element Mgrs, T. Nagy (SwRI Contracts), P. Maldonado, W. Illman, D. Hughson

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Numerical Modeling of Unsaturated Flow in Thick Vadose Zones of Fractured Rocks

Walter A. Illman and Debra L. Hughson
Center for Nuclear Waste Regulatory Analyses, San Antonio, TX, 78238-5166, USA

Unsaturated flow through fractured rocks is a concern in the siting and performance of waste facilities such as the proposed geological repository at Yucca Mountain. Unsaturated flow in fractured rocks is uncertain primarily due to the highly heterogeneous properties of fractured media, interactions between the matrix and fractures, and the effect of boundary conditions such as episodic pulses of infiltration from storm events. We conducted a modeling study of flow in unsaturated fractured rocks using a two-phase, non-isothermal, flow simulator. In this simulator the fractured rock is idealized as a dual-continuum porous media, in which the matrix and fracture constitute two distinct continua represented by two overlapping, interacting numerical grids. The exchange of fluids between the two continua is governed by Darcy's law and the area of the matrix-fracture interface open to flow. To investigate the applicability of the dual-continuum approach for modeling unsaturated flow in a thick vadose zone of fractured rocks, we applied the model to site data collected from Yucca Mountain. A two-dimensional numerical model was constructed using uniform formation properties to investigate the effects of geologic layering on flow diversion. These model results showed agreement between modeled saturation and ambient saturation data obtained from deep boreholes at Yucca Mountain. However, heterogeneity of rock properties is a primary source of uncertainty in the spatial and temporal distribution of unsaturated flow through fractured rock. We investigated the consequences of simplifying fracture continua permeability on unsaturated flow by comparing the model results using uniform formation properties to a stochastic model, that represents spatial variability of the fracture continua permeability within the layers as a random multivariate normal field. In both models, the water flux boundary condition was varied spatially to simulate localized infiltration. Monte Carlo simulations revealed the development of preferential pathways and focusing of flow, both of which can have significant consequences on the performance of waste facilities constructed in unsaturated, fractured rocks.