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MEMORANDUM FOR: Myron H. Fliegel
Geotechnical Branch
Division of Waste Management, NMSS

FROM: Matthew Gordon
Geotechnical Branch
Division of Waste Management, NMSS

SUBJECT: REVIEW OF SAGAR & RUNCHAL (1982), "PERMEABILITY OF FRACTURED ROCK"

Attached please find a review of the subject document, which appeared in Water Resources Research, April, 1983. The document appears to be referenced in the preliminary draft BWIP EA in support of BWIP's contention of low vertical conductivity of basalt flow interiors at the BWIP site. My review of the document suggests that use of the document in this fashion is inappropriate since the assumed fracture parameter distributions are, for the most part, fictional and non-conservative for the BWIP basalts.

/s/

Matthew Gordon
Geotechnical Branch
Division of Waste Management, NMSS

Attachment:
As Stated

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WMGT DOCUMENT REVIEW SHEET

FILE: 3101.2

DOCUMENT: "Permeability of Fractured Rock," B. Sagar and A. Runchal, Water Resources Research, 18 (2), April 1982.

REVIEWER: Matthew J. Gordon

DATE REVIEW COMPLETED: 10/22/84

BRIEF SUMMARY OF DOCUMENT:

DATE APPROVED:

The authors present a "second-order" statistical analysis of the effects of field data uncertainties on estimates of equivalent permeability of fractured rocks. The authors use data from BWIP as an example of this analytical method.

SIGNIFICANCE TO NRC WASTE MANAGEMENT PROGRAM:

This document appears to be referenced in the BWIP preliminary draft EA, although the complete citation is not listed in the EA references section. It appears that the document was used to support a statistical estimate of a 3.5 to 1 anisotropy ratio for hydraulic conductivity (vertical to horizontal) of basalt flow interiors at BWIP. If the reference in the EA is in fact the document under review herein, which seems to be the case, the document is being used in an entirely inappropriate fashion in the preliminary draft EA. This is important because accurate estimates of vertical conductivity are critical to determinations of the degree of vertical confinement and thus isolation of waste from the accessible environment.

PROBLEMS, DEFICIENCIES, OR LIMITATIONS OF THE REPORT:

The statistical distributions of many of the fracture properties, including the means, are arbitrarily assumed by Sagar and Runchal (S&R) in this document. These arbitrary assumptions are applied to the most important variables, including fracture frequency, aperture, and length. In fact, it appears that the only real data on which the S&R study is based is the data collected by Hocking et. al. (1980a, 1980b) on orientation of fracture sets.

It is not known whether the draft Dames and Moore document (Hocking et. al. 1980a) referred to in the reviewed document is the same as the BWIP document in the Division files with the same title and authors (Hocking et. al., 1980b). In the reviewed document, it is stated that "the frequency of fracture is not mentioned in the Hocking et. al. report (1980a). We assumed a total of 8 fractures in the elemental cube [5 meters by 5 meters by 5 meters]." In the BWIP document (Hocking et. al., 1980b) on page 34, it is stated that "the

average fracture frequency observed in the two heater tests is approximately 14 joints/meter." While the units of measure (joints/meter; joints/125 cubic meters) can not be directly related without a full statistical and geometric analysis, it is obvious that the frequency of fractures used in S&R's study is much less than the frequency noted in Hocking et. al. (1980b), especially since S&R's assumed fractures are not extensive through the elemental volume (maximum length dimension of fracture is assumed 2 meters, compared to 5 meter length of block in each direction). Even neglecting this point regarding S&R's assumed extensiveness of the fractures, the 14 joints/meter noted by Hocking et. al. could indicate a fracture frequency of up to 210 fractures within the elemental block (14 joints/meter in each of three principal directions, times five meters length in each direction, times three principal directions).

The assumed fracture apertures of 0.0002 meters, fracture length in one principal fracture direction of 2 meters, and fracture length in other direction of 1.5 meters, are apparently entirely arbitrary. The chosen values have no relation to actual BWIP field data and are non-conservative for this purpose.

S&R note that the data that appears in Hocking et. al. (1980a) is based on a sample obtained from 45 meters below the surface of Gable Mountain, in the Pomona entablature of the Saddle Mountains basalt. It is highly questionable whether these observed properties can be extrapolated to repository depths.

It also appears that the anisotropy ratio which could be inferred from the hydraulic conductivity tensor calculated by S&R is not 3.5 to 1, but closer to 3.5 to 2.5 (based on the Mohr Circle coordinate transformation method to principal directions described in Bear (1972)). Use of the lower ratio would be even more favorable in terms of BWIP's contention of low vertical conductivity of dense interiors; however, as noted above, the numbers used by S&R to calculate the tensor are for the most part fictional, and very non-conservative for BWIP.

The S&R (1982) document, on its own, is a good and valid piece of work, with appropriate cautionary words used about the report limitations which BWIP appears to have ignored in the preliminary draft EA. Though limited in its application, the sensitivity study provides some interesting results. S&R do note that the conclusions of the sensitivity study are "data-dependent" and "other results would be obtained in different situations." Therefore, even the results of the sensitivity study should not be extrapolated by BWIP or anybody else to apply to any real site.

ACTION TAKEN:

1. This review has been placed on file for future reference;

2. The S&R document has been sent on to the technical assistance contractor (Williams & Associates);

3. I have asked Bob Cook (NRC BWIP site rep) to identify the exact "Sagar and Runchal (1982)" document referenced in the preliminary draft EA in order to determine whether the reviewed document is the same as the referenced document.

FOLLOW-UP ACTIVITY:

1. Call Sagar to determine if the two S&R documents are the same or identical documents, and if the Hocking et. al. (1980a) and (1980b) documents are also identical.

2. If the answer to either question is negative, I will try to obtain copies of the appropriate documents from Sagar.

REFERENCES:

Bear, Jacob, Dynamics of Fluids in Porous Media,American Elsevier Publishing Co., New York, N.Y., 1972.

Hocking, G., J. Williams, P. Boonlualohr, I. Mathews, and G. Mustoe, "Numerical Prediction of Basalt Response for NSTF Heater Tests #1 and #2," draft report, Dames and Moore, Burlington, Mass., 1980a.

Hocking, G., J. Williams, P. Boonlualohr, I. Mathews, and G. Mustoe, "Numerical Prediction of Basalt Response for NSTF Heater Tests #1 and #2," RHO-BWI-C-86, Rockwell Hanford Operations, November, 1980b.