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SUBJECT: "PROBABILITY ENCODING OF HYDROLOGIC PARAMETERS FOR BASALT, ELICITATION OF EXPERT OPINIONS FROM A PANEL OF FIVE CONSULTING HYDROLOGISTS", RHO-BW-CR-146P

I have reviewed the subject document, which describes the procedures for eliciting opinions from a panel of five experts to estimate basalt hydrologic parameter values, and the results of that exercise. My comments are attached. I question the usage of these panel results in performance assessments of the BWIP site for several reasons:

a) The validity of expert panel approaches to parameter estimation has never been demonstrated, to my knowledge.

b) The expert panel approach appears vastly inferior to direct testing when such testing is feasible, as is the case for the parameters evaluated.

c) There appear to have been potential biases and conflicts of interests introduced in the encoding process.

d) Past usage of the panel results for effective porosity by BWIP have misapplied the uncertainty distributions derived in this document to

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represent spatial variabilities. Spatial variability and uncertainty are quite different concepts which must not be mistaken for each other (Delhomme, 1979).

Reference: Delhomme, J., "Spatial Variability and Uncertainty in Groundwater Flow Parameters: A Geostatistical Approach," Water Resources Research, 15(2), 1979.

Original Signed By

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Enclosure:
As stated

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DOCUMENT: "Probability Encoding of Hydrologic Parameters for Basalt, Elicitation of Expert Opinions from a Panel of Five Consulting Hydrologists," RHO-BW-CR-145P, by A. Runchal, M. Merkhofer, E. Olmsted and J. Davis, Rockwell Hanford Operations, Richland, Washington, 1984.

FILE NOS: 3101, 3101.5, 3101.2

REVIEWED BY: Matthew J. Gordon

DATE REVIEW COMPLETED: August 13, 1985

BRIEF SUMMARY OF DOCUMENT:

The document describes the procedures for eliciting opinions from a panel of five experts to estimate the values of basalt flow top and dense interior effective porosities, and the ratio of vertical to horizontal hydraulic conductivity of basalt flow interiors. The results of the exercise are provided in terms of individual and summary probability distributions.

SIGNIFICANCE OF DOCUMENT TO NRC WM PROGRAM:

The document provides a partial basis for the hydraulic parameter values recommended for use in preliminary ground-water travel time assessments of the Hanford site. This report, and a companion report (RHO-BW-CR-146P, same first title, subtitled "Elicitation of Expert Opinions from a Panel of Three Basalt Waste Isolation Project Staff Hydrologists") were utilized by Loo et al. (1984) in choosing the effective porosity distribution assumed for the ground-water travel time assessments contained in the Draft BWIP EA.

LIMITATIONS, PROBLEMS, OR DEFICIENCIES OF REPORT:

Limitations of the expert panel approach

The expert panel analysis method, termed the SRI probability encoding method, is a variant of the better-known "Delphi" analysis method. The main objective of the expert panel approach is to obtain unbiased estimates of parameters for which no or little data exist. The following paragraphs describe potential problems, limitations, and deficiencies that I have identified with the approach and its implementation as described in the subject document.

The expert panel approach is a relatively untried and unproven method for parameter estimation. In the case of effective porosity, a set of direct

measurements using field tracer tests would appear to be readily obtainable at the Hanford site given the existing borehole installations. It is unclear why RHO opted to obtain expert opinions rather than performing direct tests.

Potential panelist bias

There are several aspects of the exercise described which may have resulted in biased estimates by the experts. One of the criteria for panelist selection, as listed on page 7, is the lack of apparent conflict of interest. Conflict of interest was considered to exist if the prospective panelist was currently under active contract to one of the regulatory, supervisory, or advisory agencies that monitor the BWIP project. However, all five of the panelists have been employed on either a sporadic or constant basis by the NRC, DOE, or its contractors over the past three years, and at least two were employed by one of the agencies during their service on the panel. Also, DOE represents a substantial source of potential future funding for expert hydrogeologists such as the panelists selected. The effect that the possibility of future DOE contracts may have had on the experts' opinions is not addressed in the encoding process.

It would seem appropriate, after both the Round 1 and Round 2 panel results, to examine potential correlations between differences in panelists' opinions and the panelists' backgrounds to ensure that no conflicts-of-interest are coming into play. For example experts B and E appear to have similar opinions to each other throughout the document, which are in turn different from experts A and C, who are similar to each other. These groupings should be further investigated. It is interesting to note that in the companion document the three BWIP staff hydrologists tend to estimate the hydraulic parameters consistently more favorably in terms of repository performance. The role of biases in all of the expert opinions cannot be ruled out based on these documents.

Potential introduction of bias in information provided to panelists

Some of the information passed on to the panelists is described in the document, and it appears that this material could have caused a bias in the panel. For example, on page 10 it is noted: "It was explained [to the panelists] that the estimates should be considered to be descriptions of uncertainty about specified parameters, rather than as inputs needed for assessing repository performance." However, the estimates provided by the panel have in fact been used to develop inputs for BWIP repository performance assessments (Loo et al., 1984). This inaccuracy in the information provided could have caused substantial biases in the panelists' opinions, since they were to some extent misled about the purpose of the exercise.

Some of the site-specific information that was provided to the panelists is provided in the document (Appendices C, D, E, and F). The authors of most of the information are not named. If the information was prepared by Rockwell, there may have been some bias in its content due to Rockwell's contractual interest in continuing to investigate the site. It would appear that the information provided to the panelists should have included other relevant information, such as NUREG-0960, and perhaps the comments of the USGS regarding the Hanford site as expressed in their letters to DOE.

In a discussion of the entire basalt stratigraphy provided to the panelists, it is stated that "Saddle Mountains Basalt Flows contain a number of major water-bearing horizons" (page C-5). No similar statement is made for the Grande Ronde or Wanapum formations. Thus, by omission there is an implication that the deeper formations contain no major aquifers. However, at least the Priest Rapids and Frenchman Springs formations are known to be relatively productive within the Wanapum.

The description provided to the panelists of the depths and thicknesses of each of the four candidate repository flows is included in the subject document (page C-8 to C-12). Only the total flow thicknesses and correlations are discussed. This does not seem sufficient, since much more spatial variability occurs in the intraflow thicknesses than in total flow thicknesses. Since the parameters being evaluated were specific to the intraflow structures, this information would have been relevant to the panelists.

There is little information regarding uncertainty in the data included in the material provided to the panelists. The sources of uncertainty mentioned are the short-term nature of the head monitoring, the effects of drilling mud, and the lack of large-scale measurements. No mention is made of other problems, identified by NRC (e.g. Wright (1983), Coleman and Gordon (1984), Gordon (1985a)) including gas overshoot, tubing friction, fluid density variations, results inconsistent with theory, incorrect use of analytical methods, procedures inconsistent with analytical methods, use of pre-test trend as a fitting parameter rather than as an observed parameter, inadequate recovery time for recovery tests, thermal effects, and choice of effective interval.

On page D-18, it is stated that a ratio test to determine vertical conductivity was performed but no discernible formation response was observed. However, the test noted did not have the proper configuration for a ratio test, and it is possible that a response which BWIP attributed to packer compliance may have actually been a formation response (Brown, 1984).

Also on page D-18, it is stated that, "Assuming a contributing zone thickness of 11.3 m and a homogeneous formation, they [Leonhart et al. (1984)] report a

value of 1.6×10^{-4} for n [effective porosity]. The effective porosity is somewhat higher, however, because of the presence of highly conductive zones." This latter sentence is misleading because the value of effective porosity used in performance assessment modeling must be applied to the same interval as the hydraulic conductivity. Since the value of "equivalent conductivity" noted in the document from the results of a transmissivity test in the same hole is calculated based on the 11.3 m thickness, there should be no adjustment of the effective porosity without a corresponding adjustment in the equivalent conductivity.

The document goes on to state, "Some other estimates of porosities for the reference repository location and for various strata within the Columbia River Basalt Group are summarized in Table D-15." However these are apparently total porosity values. In fractured media total porosity and effective porosity can differ by orders of magnitude. The authors do note that "Some of the values reported in Table D-15 are believed by Summers et al. (1978) to be too large due to the fact that they are matrix estimates and not representative of elementary volumes," but no indication of the potential magnitude of the error is provided.

Traceability and quality assurance

The implementation of the method involved the initial usage of a questionnaire defining the parameters and outlining the procedure, and the preparation of information to be provided to the panelists after each round of the two-round encoding process. Only part of the information provided to the panelists is included in the document; of particular interest to this reviewer would have been the material transmitted to the panelists after Round 1, which is not included in the subject document. Because review of the information provided to the panelists is of paramount importance in verifying that no biases were introduced to the panelists, this information is critical to NRC's evaluation of the validity of the panel results. Therefore, this review is handicapped in that a full evaluation of the results is impossible with the information provided in the document.

Additional note

As a side note, Appendix F provides some information on the possible correlation range of log-transmissivity in Grand Ronde flow tops. It is interesting to note that Rockwell concludes that "the correlation range of log-T may be no more than 2.5 km." In the performance assessment modeling included in the draft EA, however, a correlation range of 5 km was assumed, which may have resulted in a higher estimate of groundwater travel time according to the sensitivity studies of Clifton (1985). In fact, the

semi-variogram results in Appendix F show no discernible correlation of log-T values. If any correlation exists, it appears that the log-T values are better correlated at large distances than nearby. This could be due to some periodicity in the spatial variation, according to Peter Clifton (RHO) (based on telephone conversation, early August 1985). In any case, this appendix provides further evidence which calls the results of the draft EA modeling into question.

References

Brown, A., "Review of SD-BWI-TI-136", enclosure to letter #71, NRC contract NRC-02-82-045, NRC Division of Waste Management File No. 3426.1/FIN B7373, February 14, 1984.

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Loo., W., F. Arrett, L. Leonhart, S. Luttrell, W. McSpadden, I. Wang, "Effective Porosities fo Basalt: A Technical Basis for Values and Probability Distributions Used in Preliminary Performance Assessments," SD-BWI-TI-254, Rockwell Hanford Operations, 1984.

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