REVIEW OF "STOCHASTIC ANALYSIS OF GROUNDWATER TRAVEL TIME FOR LONG-TERM REPOSITORY PERFORMANCE ASSESSMENT," RHO-BW-SA-323-P

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The Rockwell/BWIP document "Stochastic Analysis of Groundwater Travel Time for Long-Term Repository Performance Assessment," RHO-BW-SA-323P, by P. M. Clifton, R. G. Baca, and R. C. Arnett, is referred to in the preliminary draft BWIP Environmental Assessment in support of BWIP's contention that groundwater travel times from the disturbed zone to the accessible environment are likely to substantially exceed 1,000 years. The Clifton et. al. document presents a cumulative distribution function of groundwater travel times in a "representative" Grande Ronde Basalt Flow Top over a distance of 10 km. It concludes that "the probability of pre-waste-emplacement groundwater travel time exceeding 1,000 years is greater than 0.95", and that "the median travel time is 17,000 years" (p. 8). However, because of the non-conservative assumptions and other limitations of the Clifton et. al. analysis, use of these conclusions in the manner applied in the preliminary draft Environmental Assessment (p. 6-59) is unsupportable. Because of the likely importance of these conclusions to potential future demonstrations of compliance with the 1,000 year minimum groundwater travel time criterion for licensing review, the following concerns regarding the Clifton et. al. analysis are presented:

1) The distribution of transmissivities within the "representative" flow top was assumed in the Clifton, et. al. analysis to be log-normal with a geometric mean of 0.153 m^2/day, and a standard deviation of log-transmissivity of 1.83. (The data to support these statistics was not presented.) It is acknowledged by Clifton et. al. that there is insufficient data available to develop reliable statistics of transmissivities within individual candidate horizon flow tops. The distribution chosen is "the same as the distribution governing the ensemble of transmissivities from Grande Ronde Basalt flow tops."

   There is no basis for the assumption that the statistical variation within a flow top is the same as the statistical variation among flow tops. Therefore, we consider that it may be inappropriate to use the ensemble distribution of flow top transmissivities to describe the statistics of an individual flow top. Within an individual flow top, the variance of transmissivity may not be as large as the variance between flow tops. Given the same geometric mean value of transmissivity, a decreased variance could cause a <u>decrease</u> in calculated groundwater travel times. This is because the groundwater travel time across an inhomogeneous system is dominated by the lowest values of transmissivity along the flow path.

BWIP should further justify their use of the ensemble statistics in this study.

2) The effective thickness (effective porosity * mean thickness) within the "representative" flow top was assumed to be $4 * 10^{-2}$ m, based on an assumed effective porosity of $5 * 10^{-3}$, and an assumed thickness of 8 meters. However, as noted on p. 6, only one field-determined effective thickness is currently available for a Grande Ronde Flow Top. The report claims that the range of effective porosities suggested by this test "includes" the effective porosity assumed by Clifton et. al.

The only field-determined effective thickness value of which the NRC is aware is that described in Gelhar (1982). Gelhar (1982) estimated an effective thickness of 0.0103 ft. (p. 14) for a mean thickness 49.8 ft (p. E-3). This implies an effective porosity of $2 * 10^{-4}$. Therefore, the assumed effective porosity is greater than the single measured value available by a factor of 25. Since groundwater travel time is directly proportional to effective porosity, the cumulative distribution of travel times shown on page 9 of Clifton et. al. would be shifted by over an order of magnitude towards the shorter travel times if the single measured value of effective porosity were chosen rather than Clifton et. al.'s assumed value. In other words, the median travel time would be 680 years (rather than 17,000 years) and there would be a > 0.95 probability that the groundwater travel time would be greater than 40 years (rather than 1,000 years).

3) On page 7, it is stated that "longer correlation ranges cause greater uncertainty in parameter estimates and, subsequently, in predictions". This statement should either be supported through a theoretical development, through a sensitivity analysis or by reference to more detailed documents. In any case, the assumption of a 5 km correlation range for flow top transmissivity requires further justification.

4) The generation of the "covariance matrix of the unconditional estimator", and the product of the generation exercise, is not described in sufficient detail in the document to allow proper review of this aspect of the study.

5) The section, "Limitations of Analysis", provides a useful summary of many of the model's limitations. We consider that these limitations have significant negative impact on the reliability of the numerical results of the analysis.

We consider that the limitations and non-conservative assumptions noted above preclude the use of the Clifton et. al. numerical results to support, based on

current data, BWIP's assertion of great confidence that pre-emplacement travel times are likely to substantially exceed 1,000 years.

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REFERENCE

Gelhar, Lynn W., "Analysis of Two-Well Tracer Tests With a Pulse Input", RHO-BW-CR-131-P, Rockwell Hanford Operations, April 1982.