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Mr. Jeff Pohle
Division of Waste Management
Mail Stop 623-SS
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

RE: BWIP

Dear Jeff:

A copy of the review of the following document is enclosed.

1. LeGore, T., and Arnett, R.C., February 1986, Ground Water Drawdown As a Factor in Long-Term Repository Performance Assessment. Rockwell Hanford Operations, Richland, WA, BWI-TA-202, 22 p.

Please contact me if you have any questions concerning this review.

Sincerely,

Gerry Winter

Gerry V. Winter

GVW:sl

WM-RES
WM Record File
D1020
W&A

WM Project 10, 11, 16
Docket No.
PDR ✓
XLPDR ✓ (B,N,S)

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WMGT DOCUMENT REVIEW SHEET

FILE #:

DOCUMENT #: BWI-TA-020

DOCUMENT: LeGore, T., and Arnett, R.C., February 1986, Ground Water Drawdown As a Factor in Long-Term Repository Performance Assessment. Rockwell Hanford Operations, Richland, WA, BWI-TA-020, 22 p.

REVIEWER: Williams & Associates, Inc., Jerry A Slatter

DATE REVIEW COMPLETED: March 23, 1987

ABSTRACT OF REVIEW: APPROVED BY: Roy E Williams

The report under review describes a groundwater modeling effort that uses the MAGNUM-3D computer code. This code was used to predict groundwater levels during and after repository construction and repository development. The report concludes, based on the modeling efforts, that the hydraulic sink caused by the repository would last for a period of 60 to less than 600 years depending upon the nature of hydrogeologic boundary conditions surrounding the reference repository location (RRL). The report states that the results "do not support a conclusion that a practical, large-scale hydraulic sink would provide significant delay in movement of radionuclides away from a repository."

The report states that regional gradients direct groundwater flow toward the southeast. This flow direction is contradicted by flow directions calculated by our three-point solutions of water levels measured in the multipiezometer completions at boreholes DC-19, DC-20, and DC-22. The report does not state why a southeasterly direction is preferred over a southwesterly flow direction.

The values of horizontal and vertical hydraulic conductivity for individual basalt flow tops were determined based on the probability distributions governing the ensemble of transmissivities from the Grande Ronde Basalt flow tops. The ratios of vertical hydraulic conductivity to horizontal hydraulic conductivity were assumed for the basalt flow tops and flow interiors. The values of hydraulic conductivity that were assigned to the basalt flow interiors were arbitrarily increased two orders of magnitude to reflect uncertainty in the data base.

BRIEF SUMMARY OF DOCUMENT:

The report explains that this effort constitutes an exploratory groundwater modeling analysis. The analysis evaluates the hydraulic sink that will be created around the repository; it does so by simulating a well field designed for lowering groundwater levels. The report estimates the approximate duration of the hydraulic sink created around the repository. The report acknowledges that prior to completion of site characterizations, substantial uncertainties will continue to exist. We assume they mean in the hydrogeologic data base. The stated purpose of the report is to explore the general impact of the hydraulic sink. The report acknowledges that a potential cost savings and enhancement of various safety factors could occur by lowering the groundwater levels but that the scope of the analysis is limited to potential long-term performance impacts (p. 6).

The report states that a series of alternative conceptual hydrogeologic models have been defined. The conceptual model used in this particular report is judged to maximize the duration of the hypothetical sink. The authors of the report reasoned that if the predicted duration of the sink is not significant with the conceptual model used, then it would be less likely that the other conceptual models would predict a longer duration for the hydraulic sink.

The report states that enough preliminary transmissivity data exist for the basalt beneath the Hanford site to develop some statistics. The report states that it is not possible to develop viable statistics of transmissivity for individual flow tops based on available data. The report assumes that the probability distribution for the measured transmissivities for all the Grande Ronde Basalt flow tops is the same as the distribution for the individual Grande Ronde flow tops. The geometric mean of the existing transmissivity measurements is 0.153 m^2/day; the standard deviation of the base 10 logarithm of transmissivity is 1.83. A nominal value of 10^{-13} m/sec was selected for the horizontal hydraulic conductivity of the basalt flow interior. The vertical hydraulic conductivity of the basalt flow interior is assumed to be three times the horizontal value or 3×10^{-13} m/sec (p. 10). The report acknowledges that substantial uncertainties exist in the value of vertical hydraulic conductivity. The authors have acknowledged the uncertainty and consequently arbitrarily increased the vertical hydraulic conductivity of the interiors to a higher value of 10^{-11} m/sec. The Grande Ronde basalt flow tops are assumed to be isotropic; they were assigned a hydraulic conductivity of 2×10^{-7} m/sec. Table I lists the hydraulic conductivities and layer thicknesses used in the model.

The report notes that the Cohassett flow within the Grande Ronde Basalt Formation is the preferred candidate horizon (p. 11). The report assumes that 100 percent drawdown should be achieved for the Cohassett flow top. The pumping period is established at 6 years.

The northern boundary of the model extends to the flanks of the Umtanum-Gable Mountain Anticline. The southern boundary extends to the flanks of the Rattlesnake Hills. The eastern boundary of the model is along a line near boreholes DC-7/8; the line connects the northern and southern boundaries near boreholes DC-7/8.

Ten layers are used in the model. Table I lists the hydraulic conductivities and layer thicknesses used in the model.

Modeling was conducted using MAGNUM-3D. The MAGNUM-3D computer code is a fully three-dimensional finite element groundwater flow model.

The report acknowledges that uncertainties exist regarding the nature of suspected hydrogeologic boundary conditions surrounding the modeled area. The Rattlesnake Hills to the south of the modeled area may be an impediment to groundwater flow. The report states that there are indications that the Umtanum-Gable Mountain Anticline to the north also may be an impediment to groundwater flow. An initial condition of 1,000 m of head was assumed for the modeling. The analyses assume no flow conditions at the top and bottom surfaces of the model (p. 14).

Because of the uncertainties noted, the report analyzed two scenarios. The first scenario assumes a constant head boundary condition on the northern and southern boundaries of the Cold Creek Syncline. The second scenario assumes that these same boundaries are no flow boundaries (p. 14).

The evaluation criteria are based on the time required to achieve groundwater recovery to within 10 m of the prepumped values. The criteria are applied to simulated water levels within the flow tops and flow bottoms directly above and below the repository.

The two scenarios for boundary conditions were executed by three methods. The first method assumed that a well field exists around the RRL site. The second method simulated recovery after pumping stopped. The third method replaced the well field with a zero head boundary condition around the RRL site.

The well field design consists of twelve wells located on a radius of 2,300 m from the RRL-2 well; the total pumping rate from the wells was 240 gpm (p. 14). Pumping rates were constant during the drawdown portion of the analysis.

The third method used in the model assumed a zero head boundary; the boundary roughly coincides with the edges of the RRL site. This boundary condition creates variable inflow rate to the repository. The inflow rate is dependent upon the capacity of the aquifers to supply water to the modeled repository.

The results of the analyses were presented in the form of simulated head data for the Cohassett flow top. The report states that the boundary conditions have a strong effect on the results. The most favorable (no flow) boundary conditions result in a recovery time of approximately 500 years. The report explains (correctly) that this time period is small compared to the 10,000 year postclosure period (p. 15). The time required to achieve 800 m of drawdown in the hypothetical flow tops above and below the repository horizon is derived by assigning instantaneously a zero head boundary condition at the edges of the RRL. The zero head boundary provides a basis for assessing the effectiveness of the well field. The zero head boundary also provides the most efficient means for lowering water levels; the use of this boundary condition results in the prediction of the minimum time required to achieve the desired drawdown.Approximately 8 to 10 years is required to achieve 800 m of drawdown. The report concludes that the long-term benefits that would be gained by creating a hydraulic sink around the RRL do not appear to be great. The sink would not last long enough to constitute a significant percentage of the 10,000 year postclosure period. The report emphasizes that "this analysis is not intended to support site characterization or license application. Further action on this subject is not recommended" (p. 19).

SIGNIFICANCE TO NRC WASTE MANAGEMENT PROGRAM:

This document is important to the Waste Management Program because it outlines an attempt to assess the role of the hydraulic sink that would be created by the repository. The repository will create the sink because the groundwater which will flow into the repository will have to be pumped out to prevent flooding of the repository. The consequent cone of depression around the RRL will affect the transport of radionuclides away from the repository for some period of time.

The report evaluates this time period using what appears to be conservative assumptions and values of hydraulic conductivity. The authors of the report conclude that the longevity of the hydrogeologic sink is not long enough to warrant its inclusion in future considerations of retardation of radionuclide movement.

PROBLEMS, DEFICIENCIES OR LIMITATIONS OF REPORT:

One of the major concerns that we have noted in reviewing this document is that the authors assumed a southeasterly groundwater flow direction in the Columbia River Basalts. Three-point solutions of water levels from the piezometer clusters at DC-19, DC-20, and DC-22 indicate a southwesterly groundwater flow direction. The inconsistency between the flow direction assumed in the report (southeast) and the flow direction (southwest) indicated by data from the aforementioned piezometer clusters is not addressed in the report under review. This point should be addressed.

This is the first report in which we note that Rockwell Hanford Operations may consider the Rattlesnake Hills to be an impediment to groundwater flow. This point is significant because the Rattlesnake Hills would act as a hydrogeologic barrier boundary to groundwater flow in a southwesterly direction. The southeasterly flow direction assumed in the report is compatible with the boundary conditions assumed in this report.

A second major concern exists regarding the manner in which hydraulic conductivities were assigned to the basalt flow tops and flow interiors. The report acknowledges that "it is not possible at present to develop reliable statistics of transmissivities for individual flow tops based on data only from those flow tops" (p.. 10). The authors of the report were forced to assume that the probability distributions governing the ensemble of transmissivities from the Grande Ronde Basalt flow tops are appropriate for individual flow tops. In addition, the vertical hydraulic conductivity of the flow interiors was assumed to be three times the selected horizontal hydraulic conductivity for the flow interiors. The authors acknowledge the uncertainty regarding these values of hydraulic conductivity. The authors arbitrarily increased the values of vertical and horizontal hydraulic conductivity of the flow interiors by two orders of magnitude. Layers 1 and 10 were assigned horizontal hydraulic conductivities of 5×10^{-6} m/s. The rationale for the assignment of this value for hydraulic conductivity for these two layers is not provided. The rationale for the selection of this value should be provided.

The values of hydraulic conductivity discussed in the text of the report (p. 10) are not entirely consistent with the values shown in Table I (p. 13). The text states that a vertical hydraulic conductivity of 10^{-11} m/s was used for the flow interiors; Table I shows a value of $3x10^{-11}$ m/s for the vertical hydraulic conductivity. The text states that the flow tops are assumed to be isotropic; the flow tops were assigned a value of $2x10^{-7}$ m/s. Table I indicates that a value of 10^{-7} m/s was used for the horizontal and vertical hydraulic conductivities of the flow tops. These inconsistencies should be corrected.

TABLE I
MODEL CONDUCTIVITIES AND LAYER THICKNESSES

Layer	Nominal Thickness m	+ Unit	K_h m/s	K_v m/s
1	2300	G.R. COMP.	5×10^{-6}	10^{-11}
2	15	* G.R.-5 F.I.	10^{-11}	3×10^{-11}
3	23	G.R.-5 F.T.	10^{-7}	10^{-7}
4	68	Coh. F.I.	10^{-11}	3×10^{-11}
5	8	Coh. F.T.	10^{-7}	10^{-7}
6	41	R.C. F.I.	10^{-11}	3×10^{-11}
7	12	R.C. F.T.	10^{-7}	10^{-7}
8	19	S.B. F.I.	10^{-11}	3×10^{-11}
9	7	S.B. F.T.	10^{-7}	10^{-7}
10	180	S.B. COMP.	5×10^{-6}	10^{-11}
WESTERN FLOW BOUNDARY ALL LAYERS (see Fig. 3.1)			10^{-9}	10^{-9}

GR - Grande Ronde
FI - Flow Interior
FT - Flow Top
Coh - Cohassett
COMP - Composite
SB - Sentinal Bluffs
RC - Rocky Coulee

* The Grande Ronde -5 flow has recently been named the Birkett flow. The un-named flow between the Cohassett and the Birkett does not exist in the Cold Creek Syncline model area.