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MEMORANDUM FOR: Hubert J. Miller, Chief  
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Division of Waste Management

FROM: Tilak R. Verma  
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SUBJECT: NOTES ON RHO, DOE AND USGS MEETING IN RICHLAND,  
JUNE 7-10, 1983

Attached are the notes that were taken by Tilak R. Verma and Roy E. Williams, who attended the meeting as NRC observers. The meeting was very useful for the BWIP Hydrogeology Team in evaluating the status of site characterization at Hanford. It should be noted that great deal of data have been collected since the NRC Hydrogeology Team visited the site in July of 1982.

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cc: Robert Wright, WMHT

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Notes on RHO, DOE, USGS Meeting  
Richland, Washington  
June 7-10, 1983  
Tilak Verma and Roy E. Williams, NRC Observers

June 7, 1983

1. Tom Wintczak described the general aspects of RRL2.
2. Steve Strait described the tests performed on RRL2. He described single and bridge plug packer settings procedure using the neutron logs. He described the airlift-flow meter method of identifying the producing zones. He explained that all flow meter analyses were run while pumping by airlift; no flow meter tests were run under non-pumping conditions. He described the existing hydraulic property testing program.
  - a. Tight zones - constant head injection test or over pressure pulse test.
  - b. Permeable zones - airlift pump tests, constant discharge rate.
  - c. He described the higher-than-static water levels in the pumping well after pumping is stopped. He explained that this unusual phenomenon is explained by the release of methane gas. Dr. Dave McWhorter is consulting with them in an effort to explain the phenomenon theoretically.
3. Steve explained the test procedures that are used to ascertain that the effect of drilling fluid on water quality samples is negligible. This procedure includes the use of fluoroscein dye, organic carbon and tritium. Mud loss rate records exist in RRL6, RRL14, DC15, DC16, RRL2 but not by unit.
4. Ron Jackson explained the wells in which mud mass balance data exist. Comments were directed toward impact on hydrochemistry, not impact on hydraulic properties.
5. Steve Strait described the procedures for measuring head. He indicated that water level measurements are made with transducers. USGS personnel asked about equilibration of head with formation prior to measurement. Steve Strait and Ron Jackson explained the equilibration procedure. He explained that waiting periods range from a few days to as long as 4 months (DC16B). He explained that DC16B is being monitored in the Mabton interbed on a semi continuous basis.
6. These presentations took place with complete freedom of exchange between USGS and Steve Strait, Steve Baker and Ron Jackson. USGS personnel asked numerous questions about mud, gas, head, tests, and hydrochemistry.

7. Steve Strait described a planned experiment to test the effect of mud on permeability. It involves testing a hole that was drilled with water, then circulating mud through it, followed by retesting. The "before mud" and "after mud" test results will be compared for purposes of determining the effect of the mud.
8. Steve Strait presented curves from RRL2 tests showing a T value obtained by the Theis recovery method. He also showed a slug test (pulse test) analyzed by the Van der Kamp method. He then described the constant head injection test and showed some results from RRL2 tests. He noted that the data available at present reflect decreasing T with depth except for RRL2 where increases occur in the Umtanum and basal Cohasset.
9. Steve Strait described the content of the borehole interval reports. About 200 interval reports are destined for eventual completion. The interval reports in essence give the results of over pulse tests, constant head injection tests and constant Q airlift pump tests. An interval report for the Composite Umtanum Basalt Flow Tops at Borehole RRL-2 (3568-3781 feet depth below collar). The equivalent K value for this interval according to these tests is  $3.1 \text{ ft/day} = 1.094 \times 10^{-4} \text{ cm/sec}$ . These numbers assume an effective thickness of 157 feet. The interval tested covered 213 feet but the neutron log suggested that only 157 feet yielded water. The T value for the interval is 480 ft/day. This unit constitutes an aquifer of low to moderate permeability.
10. Bob Brice (RHO) presented the highlights of chemical data by depth. An extensive conversation occurred between USGS personnel and Bob Brice. We could not follow the details of the discussion of methane chemistry and its impact on water chemistry due to my limited background in this area. As we understand it the discussion centered around the effect of dissolved gases on the concentrations of a few ions.
11. Ron Jackson presented a lecture on the drilling and testing of well DC15. He discussed the data collected on head, hydrochemistry, and property testing. He pointed out that head variations do occur with depth and that the low heads may be associated with low T zones. If this is consistent, equilibration of head data may be questionable. He presented the results of the interval tests in DC-15 down to the bottom of the Umtanum. The major results presented consisted of airlift withdrawal tests, constant head injection tests, and positive and negative pulse tests (slug tests), depending on whether the unit tested was a flow top or a flow interior. The tests in the interflow zones consisted of airlift development pumping followed by airlift pump tests. Recovery rate was analyzed by the modified Theis recovery method. The data were dated approximately February and March, 1981, and were signed by Frank Spane. Whether or not head data equilibrated was noted in the Spane letters.

June 8, 1983

1. We traveled by bus to the site of the DC-16 cluster of wells (DC16A, 16B, 16C). Steve Strait presented the plans for testing at the cluster. A handout on the cluster plan was made available. DC-16B will be pumped and DC16A and C will be monitored. Test length will be 7 to 20 days. The units testes will be the Mabton, Roza/Frenchman Springs, Rocky Couless flow top and Umtanum flow top. Vertical K will be measured by the ratio test. Anticipated pumping rates by units are in the hundreds of gallons/minute. The results were shown of a Prickett Lonquist non leak model applied to DC16B pumped at 100 gpm with T values obtained from DC16A. The simulated pump test was for the Mabton. Distance va. drawdown indicates that the RRL wells sould experience drawdown within 20 days.
2. Steve Strait presented results of the McGee wells testing. He explained that the McGee well is to investigate the reason for the 500 ft. head loss between the McGee well and the RRL wells (in the Preist Rapids). Prolific questions resulted from the USGS personnel.
3. Steve Strait presented plans for hydrologic testing of the exploratory shaft. They still include borehole testing through the shaft lines.
4. Frank Spane explained the status of the vertical k testing in DC4 and DC5. A testing plan was passed out earlier. A set of view graphs was handed out. The view graphs included the multiple well methods of Hantush (1960), the ratio method, Hsieh and Neuman (1982). The view graphs presented the results of the vertical K test conducted at DC4 and DC5. DC5 was the "pumping" well but "pumping" was by injection. It was constant pressure (132 psi) with variable Q. The Q ranged from 3 gpm at beginning of test to. 113 pgm after 8 weeks when a packer failed. The flow top of the Cohassett was injected and it and the interior of the overlying Rocky Coulee interior were monitored for response. The interior reflected a pressure response when the pump was turned on to the tune of 9 psi. This was interpreted as squeezing of the packer in response of the 132 psi. No other response was detected. Our comments on the test are that we don't understand why such a low T unit was selected for "pumping" at such a low rate. Some thought will have to be given no whether or not this observation is valid. The advisability of the selection of a more permeable section seems obvious at first in order to maximize the probability of detecting a response in the confining layer. But more careful analyis may show that the selection of a more permeable layer for pumping is not absolutely necessary. The pressure applied may be the most critical issue in the success of the experiment. This question could be answer by optimization with a Prickett Lonquist model.
5. Steve Baker presented plans for future groundwater testing. Elements of the plan were presented, as was the scope. Objectives include:

- a. time variant baseline for heads,
- b. validate existing head data and assign uncertainties,
- c. evaluate representativeness of data (such effects and inhomogeneities)

The test includes the installation of 3 clusters of wells with multiple piezometers (clusters 19, 20, 22). The design of each cluster has one well with a piezometer at the top of the basalt; and one piezometer in the Rattle Snake Ridge Interbed (well 19A, for example). Well 19B (2nd well in cluster 19) would be open to the Priest Rapids interflow. Well 19B would be designed for a high capacity pump for pumping the Priest Rapids. Well 19C would have piezometers sealed off to the Mabton Interbed, the Priest Rapids flow top, the Roza flow top, the Upper Frenchman Springs flow top, the Rocky Coulee flow top, the Cohasset flow top and the Umtanum flow top. These three clusters would be baseline piezometers. They would be monitored during shaft sinking with the understanding that shaft sinking may produce a perturbation. These proposals are still in the proposal stage; they have not been approved by RHO or DOE management. Well 19C piezometer will have 6 piezometers (6 tubes) in it. Multiple valued piezometers are being considered. Leo Leonhart is traveling to Canada next week (June 13-17) to observe the installation of multiple valved piezometers in deep wells at a Canadian DOE site. This testing program was designed by Dr. Leland L. Mink, a hydrogeologist with M&K who has been assigned to this site.

June 9, 1983

1. Steve Baker presented an analysis of the work required to conduct an adequate hydrologic characterization of the site. He listed borehole testing, groundwater monitoring, special test development, scale effects and hydrochemistry as items of implementation. He listed as general concerns the lack of data in certain areas, comprehensive evaluation of data, representativeness of data and the overall creditability of the program. He then discussed the status of their programs to address their concerns. His presentation was similar to the one he gave at the ACRS meeting in May in Washington.
2. Subsequent to Steve Baker's presentation, Bill Meyer asked questions about the recharge area for the Grande Ronde. He stated that they must identify and characterize the recharge area for the Grande Ronde. He explained that this is necessary in order to define the regional flow system. Considerable discussion followed. The discussion, in our opinion, revealed that the USGS personnel do not appreciate the difficulty of delineating a valid, defensible unique interpretation of the regional flow system. The fact that several defensible interpretations of regional flow system boundaries (including recharge areas) are inevitable was not brought out properly by RHO and DOE. The discussion punctuated the fact that the USGS personnel are thinking in terms of a regional characterization that is more definitive than that deemed feasible

at least by this NRC consultant. This issue can be expected to constitute an area of disagreement in the future.

3. Bob Price presented a discussion on hydrochemistry. Much discussion followed, most of it was on data uncertainties, including the effect of mud and aquifer mixing.
4. Sue Price made a presentation on geology. She listed the major concerns in terms of what are the characteristics of the host rock and what is the tectonic stability picture at the site. She discussed studies planned or ongoing to improve the status of the understanding of these items of concern. She described plans for outcrop analyses, borehole testing, exploratory shaft, geophysical surveys, seismic surveillance, and geodetic leveling as methods of approaching these two questions.
5. Phil Long made a presentation on geology and rock characteristics. He showed a cross section from DC4 to RRL6. It showed the synclines. He stated that the Rocky Coulee flow has been added to the list of potential repositories. It lies above the Cohasset flow. The McCoy Canyon flow also has been added to the list. It lies between the Umtanum and the Cohasset. He discussed intraflow structures. He presented slides showing fracture densities in the Cohasset, McCoy Canyon and Umtanum. These were obtained from outcrops at Sentinel Gap and at Emerson Nipple. He showed isopachs of these three flows, admitting that the data are sparse. He suggested that geostatistics would be applied to these and other data in the future. USGS personnel asked many questions about the drillhole density required to establish continuity of flow tops so that the validity of these isopachs can be ascertained. The impact of the success of this effort on modeling was discussed also.
6. Kunsoo Kim discussed hydrofracing (hydrofracturing) and in situ stress distribution in down hole straddle packers in RRL2. Injection pressures of 6,000 to 8,000 psi were used to obtain vertical fractures. Stress ratios were obtained and fracture impressions were taken from the tests. The tests show that in situ stresses exist at the site. The major stress direction is roughly north-south. More testing is planned but Kunsoo stated that borehole stress measures should be viewed as near estimates only. He stated that drifts are necessary for more valid measurements.
7. Phil Long returned to the podium. He showed slides of photomicrographs of mineral filled fractures. He showed comparisons of abundances of various minerals and alteration products among the Umtanum, McCoy Canyon and Cohasset. He noted that the Umtanum has fewer alteration products in fracture fillings than do the other flows. Don Thorstenson noted that he would like to see groundwater analyses that facilitate analysis of whether or not the water is equilibrated with the minerals in the fractures.
8. Ann Tallman addressed the investigation of possible structures at the assumed barrier boundary between wells DB1 and RRL8. Gravity,

aero magnetic and ground magnetics show anomalies between wells DB1 and RRL8. Drilling comes next. Two wells will be drilled to basalt along the anomaly. Other wells will follow (or these wells will be deepened) depending on the data obtained from these wells. Additional geophysical data will be obtained also. The objective is to explain the barrier geologically and to define its role on groundwater movement and on modeling of the system.

9. Bob Baca presented his performance assessment (mathematical modeling) lecture. It was essentially the same as the one he gave at the ACRS meeting.
10. Ron Arnett succeeded Bob Baca. He presented the same regional modeling results that were presented at several previous NRC workshops. After completing that presentation he discussed a model with flow going north as we suggested in the SCA. He did not present results.
11. Peter Clifton presented a statistical analysis of  $K_n$  values for composite units. He estimated formation transmissivities in each boreholes from available tests. He obtained the geometric mean of  $K_n$  of transmissive units in each borehole. The geometric mean of  $K_n$  proved to be 11.5 m<sup>2</sup>/day. He then obtained  $K_n$  by dividing by thickness.

Peter then presented an analysis of probability distribution of groundwater travel times. He assumed horizontal flow in basalt flow tops and vertical flow in the dense basalt flow interiors. He used a Monte Carlo technique to develop a probability distribution of travel times in terms of the different head fields that were produced by the different T values. He spoke too rapidly for us to transmit the details. The bottom line is that the median probability travel time values in 13,000 years. He conducted a similar analysis for vertical travel time out of the repository into the overlying flow top. The results indicated that there is a .85 probability or greater that all travel times exceed 10,000 years. The talk went over like a lead balloon. There were a few questions about the basic assumptions.

12. Steve Strait discussed mud loss in RRL2. He explained how the mud balance is measured. He explained that no mud was lost to 2900 feet. Flow tops were then encountered and mud losses began. The ratio of 4 bags of mud to 1,000 gallons was assumed. Bags were counted. Mud loss calculations were based on T values obtained from hydraulic property testing. Total estimated mud loss was 29,668 gallons or 120 bags of mud. Bags of bentonite weigh 100 lbs. Steve also discussed fluorescein dye return as a method of deciding when as mud effect has been eliminated as can be eliminated. He showed data from RRL2. The data demonstrated that total organic carbon (TOC), fluorescein and tritium drops off rapidly during airlift cleanup.

June 10, 1983

1. Everett Jenne, a geochemist with Battelle PNL, has devised a revised geochemistry program for the site. Bob Brice and Everett Jenne discussed the program. Bob discussed the data currently available by source.

Task 1 will consist of adding activity product calculation for site specific nontronite.

Task 2 will model available water analyses including sensitivity analyses and assessment of uncertainty and future data needs.

Task 3 will display saturation indices by boreholes, formation and hydrostratigraphic unit.

Task 4 will related modeling results to hydrology.

Subsequent work will consist of reaction modeling including consideration of chemical reactions required to produce observed hydrochemical changes.

Don Thorstenson suggested that major emphasis be placed on the reaction modeling. He presented a lengthy dissertation on his views of the unknowns, uncertainties, difficulties and problems inherent in hydrochemistry. After listening to his comments, one could easily conclude that RHO ought to consider abandoning their hydrochemistry studies as a utilitarian tool. Bob Brice continued to describe the specific variables to be addressed and the wells.

2. Leo Leonhart explained the measurement of effective porosity with a tracer at wells DC7 and DC8. The tracer was potassium thiocyanate. He discussed the problems. The main problem is too much hole and not enough formation (3,400 ft x 2 = 6,800 ft. compared to 50 ft. of formation). He presented plans which basically consisted of more plans and more testing.
3. Management debriefing session
  - a. Dave Squires asked for USGS comments. Jim Rollo said that they had been bombarded by numbers and would make no comments about them at this time. Jim asked for a flow chart of players. He explained how the USGS "got here in the first place". He explained that at some time in the past DOE requested that USGS put a man on the BWIP site; he explained that USGS declined. He said that six weeks ago DOE requested that USGS go to site and hear numbers. Jim said that the GS would analyze this information obtained at this site visit and draw some conclusions. These conclusions and recommendations will be through the USGS director to Mr. Morgan in a report scheduled for 3 weeks from now. Dinwiddie made similar comments. Dave Squires suggested that the GS contact for future information be made through him or a designee. Raul Deju said he would appreciate input because this is the early stage of the project

and plans can be altered according to input received. Jim stated that they would be in constant communications during the next 3 weeks until the report is turned in to the Director. Jim Rollo stated that he may or may not recommend that a USGS person be assigned to the site. Miscellaneous additional comments that reinforced the above were made. In addition Bill Meyer made a comment "regarding the identification and status of issues related to regional groundwater flow systems". Both RHO and DOE Richland requested continued USGS involvement through future meetings or other contacts