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December 2, 1985
Contract No. NRC-02-85-008
Fin No. D-1020
Communication No. 9

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

Re: BWIP

Dear Jeff:

We have enclosed two copies of our review of the new test plan document for BWIP. This BWIP document is entitled "Test Plan for Multiple-Well Hydraulic Testing of Selected Hydrogeologic Units at the RRL-2 Site, Basalt Waste Isolation Project, Reference Repository Location" (comment copy-11/85, SD-BWI-TP-040). Please call if you have any questions concerning our review.

Sincerely,

Roy E. Williams

Roy E. Williams

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WMGT DOCUMENT REVIEW SHEET

ROCKWELL DOCUMENT #: SD-BWI-TP-040

DOCUMENT: Test Plan for Multiple-well Hydraulic Testing of Selected Hydrogeologic Units at the RRL-2 Site, Basalt Waste Isolation Project, Reference Repository Location. Authors: Stone, R., Lu, A.H., Rogers, P.H., and Bryce, R.W. November 1985.

REVIEWER: Williams and Associates, Inc.

DATE REVIEW COMPLETED: November 1985

BRIEF SUMMARY OF DOCUMENT: DATE APPROVED:

The document under review describes the test plan for the first large-scale, multiple well hydraulic test that will be conducted in the basalts at the Hanford site. The report under review describes the testing that will be conducted in the Rocky Coulee flow top of the Grande Ronde Basalt; the testing of the Rocky Coulee flow top is the principal test described. The document under review also describes in lesser detail the test plans for the large-scale tests that will be conducted on the Grande Ronde #5 flow top and the Umtanum flow top. The test plan also describes the small scale testing planned for the Cohassett flow top. Rockwell Hanford Operations believes that the Cohassett flow top cannot be tested with a large scale test as will the other three flow tops. The smaller scale pulse type test will be conducted on the Cohassett flow top.

"The purposes of this test are to obtain characteristic hydraulic parameter value estimates averaged over a large area, discrete point values of selected hydraulic parameters near the pumping well, and hydrochemical samples" (page 3a). The plan describes the detailed objectives of the test, the relationship of the test to other characterization activities, the test design, a description of the test facilities and equipment, a synopsis of test analysis methods, and the test schedule. The facilities at the site consist of several components. The pumping well designated as RRL-2B is one of the major components. One observation well for this first large-scale test is the original core hole at the site which now is designated RRL-2A. The second observation well at the site is a multilevel piezometer designated RRL-2C. Observation well RRL-2C is approximately 250 ft east of the pumping well designated as RRL-2B. Observation well RRL-2A is approximately 500 ft south of the pumping well (RRL-2B). The exploratory shaft is located 300 ft west of observation well RRL-2A. Distances given are presumed to be surface distances between the wells; they are not necessarily representative of distances between the wells at depth.

The pumping well (RRL-2B) will be deepened and cased after conducting each flow top test. Only the Umtanum flow top will remain open to the borehole at the completion of testing. A positive displacement pump will be used for the Rocky Coulee flow top test. The pump will be installed so as to eliminate well bore storage in the well. The pump fits into a seating nipple with a water-tight seal near the top of the unit tested.

Observation wells to be used during the large scale test at RRL-2B include the previously mentioned observation wells, plus RRL-6, RRL-14, DC-22, DC-20, DC-4, DC-19, and McGee well. These wells range in distance from 250 ft to 23,200 ft from the pumping well (RRL-2B). Observation well RRL-2A is approximately 500 ft from the pumping well as noted previously. The next closest observation wells are RRL-6 and RRL-14 which are 7,400 ft from the pumping well (RRL-2B).

Observation well RRL-2C will provide data from three flow tops in the Grande Ronde Formation. These flow tops are the Rocky Coulee, Cohassett, and Grande Ronde #5. In addition, observation well RRL-2C will provide data from three flow interiors (Rocky Coulee, Cohassett, Grande Ronde #5). This well is the only multi-level piezometer that currently is completed in basalt interiors and basalt flow tops. The transducers will measure shut-in pressures in the basalt flow interiors. A wire line packer will be set above the screen in the piezometer completed in the flow interiors. A transducer will monitor the pressure in this packed off interval which minimizes casing storage effects.

Borehole RRL-2A is the original 2.98 inch diameter core hole. This borehole will contain bridge plug packers to isolate selected flow tops for the hydraulic test of the Rocky Coulee flow top. The flow tops isolated in borehole RRL-2A via bridge plug packers are the Umtanum flow top, McCoy Canyon flow top, Grande Ronde #5 flow top and Cohassett flow top. A straddle packer will be used to isolate the Rocky Coulee flow top during its hydraulic test. Brief hydraulic tests have been conducted in the hydrofractured zones in the Cohassett flow interior. These tests apparently indicate no measurable change in the hydraulic conductivity due to hydrofracturing. The Rocky Coulee flow top was cemented in borehole RRL-2A to control drilling fluid loss. A dynamic fluid temperature logging procedure indicates that this flow top is not completely sealed in the borehole. The pressure in the flow top will be monitored in borehole RRL-2A as a consequence of the logging information. The measurement of pressures in the Cohassett flow top and in the lower units will require the alteration of the current bridge plug packer arrangement. Some trade-offs are evident if this procedure is initiated. RRL-2A is the only nearby observation point in the Umtanum flow top. Observation well RRL-2C does not have a piezometer completed in the Umtanum flow top.

The observation well clusters at DC-19, DC-20 and DC-22 provide multi-level water level and pressure data for several flow tops. These cluster sites are providing the long-term (baseline) water level and pressure data for the site. Borehole RRL-6 was completed as a 2.98 inch diameter core hole. Bridge plugs have been installed in the flow interiors to prevent vertical hydraulic interconnection of the flow tops in the borehole. The Rocky Coulee flow top will be isolated via a packer during the test of the Rocky Coulee flow top. Borehole RRL-14 was completed as a 3.98 inch diameter borehole. A Westbay multiple port monitoring system has been installed in this borehole. Ports in the Westbay tubing are equipped with check valves. These ports are located between double packers located opposite the Rocky Coulee, Cohassett, Grande Ronde #5, and the Umtanum flow tops. A port also has been located opposite the vesicular zone in the Cohassett flow interior. A Westbay system requires the use of a traveling pressure probe. The probe is positioned opposite a port to obtain a pressure measurement. Borehole DC-4 was completed as a 3.03 inch diameter core hole. This borehole has been completed with bridge plugs set in flow interiors to prevent vertical hydraulic interconnection of the flow tops. The Rocky Coulee flow top is isolated by a straddle packer. Borehole DC-5 (near DC-4) is cased and cemented to the top of the Grande Ronde Basalt. Bridge plugs have been set in the open hole in the Grande Ronde Formation. The bridge plugs separate the Umtanum, Grande Ronde #5, Cohassett, and Rocky Coulee flow tops. The McGee Well was originally an irrigation water supply well. The well was deepened to a depth of 3,123 ft. Bridge plugs have been set in the flow interiors to prevent vertical hydraulic interconnection of flow tops. The Rocky Coulee flow top is isolated by a straddle packer assembly. The report under review notes that pressure monitoring in units below the Grande Ronde #4 flow top will require that bridge plugs be removed from the well and that a straddle packer be repositioned. Boreholes DC-16A and -16C contain bridge plugs to prevent interconnection. The bridge plugs prevent interconnection of the Wanapum and Grande Ronde hydrostratigraphic units that are monitored at piezometer clusters DC-19C, DC-20C, and DC-22C. The report under review states that borehole DC-16A and possibly boreholes DC-4, RRL-2A, RRL-6, and the McGee Well may be equipped with multiple port monitoring systems. This plan is dependent on the performance of the system installed at borehole RRL-14.

A hydraulic test planned for the RRL-2 series wells was evaluated using a psuedo three-dimensional flow model and an axisymetric flow model. The three-dimensional flow model was used to approximate the areal response in the stressed flow tops. The axisymetric model was used to estimate the required positions for monitoring completions in the basalt flow interiors. The psuedo three-dimensional model used boundary conditions that incorporated no flow boundaries to the north, south and west of the RRL-2 site. The boundary to the east of the RRL-2 site was assumed to be infinite. The three-dimensional model study used an interaquifer transfer coefficient (TCF). This coefficient allows for the creation of vertical flow based on the vertical hydraulic conductivity of the confining unit and the thickness of the confining unit. The coefficient does not take into account storativity in the confining unit. The model was used to project drawdowns at the respective observation wells noted earlier in this review. Figures are included in the report under review that illustrate the areal extent of the cone of depression and the simulated drawdown in the Rocky Coulee flow top while pumping the Rocky Coulee flow top in well RRL-2B.

The axisymetric model was used to locate the basalt flow interior monitoring locations. A series of figures is included in the report under review that illustrate the results of the study conducted by Golder Associates for Rockwell Hanford Operation. The report under review states that "hydraulic head response in flow interiors of at least 2 ft in a period of 30 days or less is required for positive identification and measurement of head transients in the flow interiors" (p. 58). The report under review also notes that the transducers are known to drift downward by approximately 1 ft per month.

A tracer test is planned for the wells that are used for the hydraulic stress test. The tracer test will consist of a two-well convergent pulse technique. Separate tracers will be injected into the pumped flow top in RRL-2C and RRL-2A. The injection will occur after it is deemed that the flow conditions have approximated steady state. Ammonium thiocyanate solution will be injected into the Rocky Coulee flow top in well RRL-2C. Lithium bromide solution and deuterium will be injected into the Rocky Coulee flow top in borehole RRL-2A. Future tracer tests will use pentafluorobenzoate (PFB) solution and metatrifluoromethylbenzoate (MTFMB) solution. Deuterium may be used in later tracer tests depending on the results of its use in the Rocky Coulee flow top test. One hundred thirty liters of tracer solution will be injected at borehole RRL-2A. The tracer solution will be followed by 60 liters of Rocky Coulee water.

One hundred liters of tracer solution will be injected into borehole RRL-2C. This tracer solution will be followed by 400 liters of Rocky Coulee water. The tracer solutions and chase waters will be injected into the Rocky Coulee flow top under 250 m of pressure head. The tracer solutions are expected to flow into the flow top in 4 minutes in RRL-2A and 3 minutes in RRL-2C.

Ground water samples will be collected throughout the pumping period for each flow top tested in RRL-2B. In addition, gas samples will be collected at the surface. Downhole samples also will be collected for dissolved gas analysis.

The test will continue until tracer recovery is reasonably complete. The report under review also states that the pump test may continue if there is an indication that the head transient is reaching or may reach hydraulic boundaries. The possibility exists that steady flow conditions may occur due to vertical leakage. The report under review states that the test could be terminated if the ratio and tracer tests are complete. The report states that a certain amount of "consultation" will take place.

Pressure data will be obtained via downhole pressure transducers. The data will be passed through a Seling signal conditioner to a Hewlett-Packard frequency counter. The data will be stored on paper and floppy disk or magnetic tape. Water levels will be monitored using chalked steel tapes, electrical water level indicators, or chart recorders (Stevens). Water level measurements made by manual methods will be stored on magnetic tape or disk. Barometric pressure will be measured using a transducer located at borehole RRL-2C. The pressure data will be recorded as noted for the transducers used downhole. The report under review states that redundant flow totalizing water meters will be used during the test of the Rocky Coulee flow top. Subsequent constant rate discharge tests will use "electronic flow rate meters".

The data analysis procedures are described in the report under review. Analysis procedures will include analytic and numeric schemes. Both forms of analysis will be applied to the hydraulic test data and the tracer test data. A general discussion is presented regarding the criteria which will be used to apply the numeric as opposed to analytic analyses.

The water produced during testing of RRL-2B will be disposed of in a furrowed surface disposal area west of the RRL-2 site. The area will be used to infiltrate the water into the alluvial materials at the surface.

The work schedule in the report under review predicts that the first test will begin in January of 1986. Testing will be completed in the Grande Ronde #5 flow top prior to the exploratory shaft reaching the Grande Ronde Basalt. Testing is projected to be completed in January of 1987.

SIGNIFICANCE TO NRC WASTE MANAGEMENT PROGRAM:

The test plans are very important to the program because this is the first large-scale test that will be conducted at any site. Large-scale tests are important to the program because such tests allow the measurement of hydrogeologic parameters on the basis of a much larger volume of material than that which was previously tested by the single well tests that were applied at all sites to date. Large-scale tests provide information regarding hydraulic continuity, vertical hydraulic conductivity of confining layers, and hydrogeologic boundary conditions.

PROBLEMS, DEFICIENCIES OR LIMITATIONS OF REPORT:

The Executive Summary states (p. 3b) that "The discharge rate may have to be adjusted at an early stage of the test (the first 2 hours) to match actual field conditions." The discharge rate should not be altered during the early stages of the test. Preferably the discharge rate should not be changed during any period of the test. The alteration of the discharge rate can adversely affect early time drawdown data which may be critical for calculating transmissivity and for the detection of boundaries.

The report under review states (p. 8) that the primary observation wells for the test using RRL-2B are the piezometer clusters DC-19, DC-20, and DC-22. This statement is contrary to the presentation made during the May 1985 workshop held in Silver Spring, Maryland. The approach presented in the report under review is more appropriate, particularly in light of the understandings achieved between the NRC and DOE in earlier meetings.

The logic diagram for the BWIP hydrologic test strategy (Figure 2, page 9) does not include NRC consultation or review after the completion of testing in RRL-2B and associated observation wells. We believe that the NRC should be involved in a review session involving the test data prior to Stage 3 of the logic diagram.

The report under review states (p. 17) that a positive displacement pump will be used in pumping well RRL-2B for the test of the Rocky Coulee flow top. The positive displacement pump does not produce a continuous constant rate of discharge during the test. A positive displacement type pump causes a pulse of water to move up the column followed by a downstroke of the pump which does not produce water. Pressure data will be obtained from the pumping well (RRL-2B) using a Seling triple pressure probe (pages 21 and 22). The usefulness of data from the pumping well will be compromised severely because of the use of a positive displacement pump. We would prefer to see a submersible pump which could be throttled back to produce the desired 8 gpm discharge rate. Such a pump should be able to produce a continuous, constant rate of discharge. A continuous, constant rate discharge will facilitate the analysis of the data produced from this test.

Table 1 (p. 20) has an error in the dimension statements. The feet and meters are transposed on the table. The table illustrates the disparity between the distances from the pumping well to observation wells. Observation wells RRL-2A and RRL-2C are 500 and 250 ft from the pumping well (RRL-2B) respectively. The next closest observation wells are RRL-6 and RRL-14 which are 7,400 ft from the pumping well. A large gap exists in the observation well network as evidenced from these figures. The test data will verify whether or not additional observation points are required at intermediate distances for the proper determination of hydrogeologic parameters and boundary conditions.

Figure 8 (p. 22) illustrates the pumping test equipment configuration in RRL-2B for the pump test of the Rocky Coulee flow top. The sucker rod pump will be installed on a seating nipple near the top of the test zone. The test zone will have minimal borehole storage effects due to the use of a packer and the aforementioned seating nipple. This procedure offers a definite design advantage for testing low transmissivity units.

The basalt flow interior piezometer completions in borehole RRL-2C are illustrated on Figure 9. The basalt interior completions in the Rocky Coulee and Grande Ronde #5 flows are located approximately in the middle of the flow interiors. The basalt interior piezometer completion in the Cohassett flow is below the mid point of the flow interior. We will comment further on the use of modeling techniques to determine the placement of these piezometers later in this review.

Page 27 of the report under review states that brief hydraulic tests have been conducted in the zones in the Cohassett flow interior that were hydraulically fractured for measuring in-situ stress. The report states further that the results indicate "no measurable change in hydraulic conductivity." The report does not state when these tests were conducted nor does the report under review present quantitative data to substantiate the statement.

The report under review states (page 27) that the Rocky Coulee flow top in borehole RRL-2A was cemented during construction to minimize fluid loss. The report further states that the flow top was not completely sealed. We believe that every effort should be made to ensure the validity of the test data obtained from this flow top. The sole evidence presented in the report under review is a statement regarding a dynamic temperature log that was run in this borehole. Borehole RRL-2C is the only other close observation well for testing in RRL-2B.

Page 27 of the report under review states that bridge plugs may have to be removed in borehole RRL-2A to facilitate the measurement of the pressure response in the Grande Ronde #5 flow top. Bridge plugs will have to be removed and the straddle packer assembly repositioned to allow measurement of the pressure response in the Umtanum flow top. There is a definite trade-off between monitoring pressures in the lower intervals as opposed to the interconnection of flow tops that would be created by the removal of the bridge plug packers. We do not wish to state a position on this point at this time. The results of the first test in RRL-2B will help provide a basis for determining whether or not such actions should be taken. The report under review states on page 28 that such actions may be initiated because well RRL-2C does not have a piezometer completed in the Umtanum flow top. Therefore, well RRL-2A is the only well which would be able to monitor the Umtanum flow top in close proximity to the pumping well.

Page 28 of the report under review states that the Rocky Coulee flow top was cemented during the drilling of borehole RRL-6. Our comments regarding the cementing of Rocky Coulee flow top in borehole RRL-2A are applicable to this well also.

Figure 16 (page 32) illustrates the configuration of borehole RRL-6 for the hydraulic tests of the Rocky Coulee flow top. The figure illustrates the position of the inflatable straddle packers; the figure depicts the inflatable straddle packers as having an approximate separation of nearly 200 ft. The figure states that bridge plugs and packers are not to vertical scale. It is not clear whether the length of the packers is not shown to scale or whether the separation between the packers is not to scale or both. It would be desirable to have the packers closer together if they can be adequately seated in the basalt flow interiors. This would minimize any potential cross connection for measurement purposes.

Borehole DC-4 and the McGee Well will reflect the same trade-off between allowing the interconnection of flow tops from the removal of bridge plugs or monitoring the deeper flow tops for pressure responses during the testing of those lower flow tops.

We believe that the benefits of the trade-off can be determined better after evaluating the initial test at RRL-2B.

Figure 20 (p. 37) illustrates the configuration for borehole DC-4 for the hydraulic tests of the Rocky Coulee flow top. The bridge plug placement in this borehole has allowed the interconnection of the Grande Ronde #7 and the Umtanum flow tops. It is also possible that the Grande Ronde #6 flow top is interconnected with the previously noted two flow tops. This interconnection should be considered in evaluation of data from DC-4 during the tests of these deeper basalt flow tops.

The report under review states on page 41 that "The real focus of the large-scale hydraulic testing in the Grande Ronde Basalt at the RRL-2 site is the Cohassett flow interior." We believe that this may be the real focus of the testing, but the quantification of hydrogeologic parameters for the Cohassett flow interior are not of primary importance if DOE does not plan to take travel time credit through the Cohassett flow interior. This statement may be misleading; however, the statement may accurately reflect the desires of DOE with respect to testing the Cohassett flow interior.

The report under review states on page 41 that the large-scale hydraulic test of units in the Grande Ronde Basalt will be initiated once the time series head values from the observation wells and boreholes can be projected reliably beyond the planned test lengths. We concur with this statement with respect to the generation of an adequate potentiometric baseline for testing purposes.

The report under review states (page 42) that the "hydraulic test design is relatively insensitive to the likely range of boundary conditions." We would like to see this statement clarified or explained in greater detail by Rockwell.

The report under review states on page 43 that heterogeneities cannot be expressed as regions within the conceptual model at this time. Such regions cannot be designated because the existing knowledge base will not support such decisions. We concur with this assessment by Rockwell.

The areal extent of the cone of depression from the pump tests was evaluated using a psuedo three-dimensional ground water model developed by the U.S. Geological Survey. The model was used in a mode in which storativity of the confining units is not considered. We are not sure that such a procedure is significant with respect to the output desired by Rockwell. The lack of consideration of storativity in the confining units is certainly an appropriate question with respect to early time drawdown data and the movement of pressure transients through the basalt flow interiors. The report under review contains several figures and tables which illustrate projected drawdowns at various distances from the pumping well (RRL-2B). Table 4 on page 49 indicates that drawdowns at RRL-2C could range between 26 and 64 m for cases 1, 2, and 3. Drawdowns at borehole DC-16 could range from 0.003 to 6.9 m for the same 50-day pumping period of RRL-2B. Drawdowns in borehole DC-19 for the same cases and equivalent pumping period range from 0.0006 to 2.6 m. We believe the drawdowns contained in Table 4 illustrate the potential problem that may occur due to the lack of observation wells between 500 ft from the pumping well and 7,400 ft from the pumping well.

An axisymetric model was used to simulate pump test responses. The model was used by Golder Associates under the direction of Rockwell. The cases that were simulated included storativity in the confining units. The storativity was not altered between runs although the hydraulic conductivity of the flow interiors was altered. Several figures are included in the report under review that illustrate the propagation of pressure transients through the flow interiors and adjacent flow tops. These figures were used for the placement of the basalt flow interior piezometers in borehole RRL-2C. The criterion that seemed to have been used for the placement of the flow interior piezometers was that a hydraulic head response in the flow interior had to reach 2 ft in a pumping period time of 30 days or less. The report under review also acknowledges that the transducers had a known drift downward of approximately 1 ft per month. Figure 31 (page 60) is one of the figures produced by Golder Associates for Rockwell. The contour S' = 50 on this figure appears to be in error. The contour crosses the Cohassett flow top at the same angle as the contour crosses the Rocky Coulee interior and the upper portion of the Cohassett interior. We do not believe that the contour would follow the same angle based on the difference in hydraulic conductivies used in modeling the response to pumping RRL-2B.

A potential problem exists with the plans for conducting concurrent in-situ tracer tests with the large-scale hydraulic stress test. The report under review (page 76) describes the process for injecting the tracers into the observation well. The report under review states that 130 liters of tracer solution will be injected at borehole RRL-2A into the Rocky Coulee flow top. The tracer solution will be followed by the injection of 60 liters of Rocky Coulee water. The tracer solution and chase water will be injected under 250 m of pressure head. The report under review also states that 100 liters of tracer solution will be injected in the well RRL-2C which will be followed by approximately 400 liters of Rocky Coulee water. Again, the tracer solution and the chase water will be injected into the

Rocky Coulee flow top using 250 m of pressure head. The report under review states that injection will be completed in approximately 4 minutes in borehole RRL-2A; the injection will be completed in borehole RRL-2C in approximately 3 minutes. We are concerned that the tracer solution volumes and chase water volumes will adversely affect the water level measurements in these two observation wells. In addition, the injection under 250 m of pressure head will definitely alter the hydrogeologic regime around these two wells in the Rocky Coulee flow top. The head that will be used to inject the tracer and chase water will definitely affect the ability to use water level data or pressure data from these wells to detect hydrogeologic boundary conditions during the pump test. The period and magnitude of the injection pulses should be investigated to ensure that the injection testing does not adversely affect the data obtained from the large scale stress test. We recommend that the tracer tests be altered to minimize water level impacts.

The report under review states (page 78) that ground water samples will be taken from the well every 12 minutes for laboratory tracer analysis. A rationale for the time interval is not presented.

The report under review (page 78) lists the laboratory analyses which will be conducted on ground water samples collected at the surface during the pump test. Table 13 outlines the variables that will be analyzed for content in the ground water samples. Carbonate and bicarbonate are absent from the list of major ions which will be analyzed. We believe that the concentrations of carbonate and bicarbonate should be determined in the ground water samples obtained during the pump test. These two ions are necessary for the calculation of an ion balance.

The report under review states that a pulse test will precede the pumping test in each flow top that will be pump tested. It is not clear in the report under review that an adequate recovery period will occur prior to starting the pumping test. This point should be clarified.

The report under review (page 83) states that the tests will not begin until the head values from the observations wells and boreholes can be projected reliably beyond the planned test length. We wish to point out that the planned test length should also include the recovery period for the projected large-scale stress tests.

The report under review states (page 83) that the tracer solution will be injected into the Rocky Coulee flow top once quasi-steady state flow conditions have been reached in the vicinity of the RRL-2 site. Criteria for determining quasi-steady state flow conditions are not stated in the report under review. The determination of quasi-steady state conditions appears to be judgemental. We do not object necessarily to the judgemental aspect of the determination of quasi-steady state flow conditions but some criteria should be developed.

The criteria for determining the termination of the hydraulic property test are described on page 84. Basically, the test will be terminated once the tracer recovery is reasonably complete or steady state conditions have been reached due to vertical leakage. The test will continue if there appears to be a chance that the head transient will reach a hydrogeologic boundary. We find no objections with the criteria as stated in the report under review. The report futher states that a "certain amount of consultation will take place" for determination of the course of the pumping test after the completion of the tracer test. The report under review does not state who will be involved in the consultation.

The report under review states (page 88) the criteria that will be used for analysis of the data by either analytical and/or numerical techniques. The criteria as stated in the report under review are fairly open and present no problems that we see with respect to the analysis of the data. The use of numerical models for inverse modeling is described further on subsequent pages. The report under review states (page 91) that a smaller scale model which is suitable for near field modeling will permit the detailed consideration of small-scale phenomena. They refer to small-scale phenomena such as wellbore storage and effects of storage in the aquitards or basalt flow interiors. We question whether this will be practical with respect to the fact that numerical models typically are inaccurate during early times of the simulation. Early time data generated by numerical models usually do not fit the theory very well. The report under review further states (page 92) that the tracer test may be analyzed by analytical models as well as numerical transport models. The models that are noted in the report under review are the random walk model by Prickett, Naymik, and Lonnquist (1982) and the finite element model used by Golder Associates. The third model was developed by Sun and Yeh (1983). We do not know whether these models have been used in an inverse modeling technique at this time. A significant amount of work will have to be conducted with these models to verify their use as a valid tool for the inverse modeling technique.

The report under review states (page 93) that a furrowed surface disposal area has been prepared west of the RRL-2 site. This surface disposal area has been prepared for the disposal of ground water produced during the pumping tests. The report under review does not state how far the disposal area is from the test site. We would have preferred to have seen the disposal area to be in a direction east or southeast of the test site. A possible conflict with the disposal area and the detection of hydrogeologic boundary conditions to the west or northwest is evident. We are not saying that there will be a conflict but we believe this represents an inadequate consideration of potential affects on the hydrologic test results.

The report under review (Figure 40, page 97) indicates that the tracer tests will begin after only a few days of pumping during the large scale tests. We believe that the tracer injection should be scheduled to occur later in the pumping test schedule. This will minimize potential problems with the interpretation of the pump test data.

REFERENCES CITED:

Prickett, T.A., Naymik, T.G., and Lonnquist, C.G., 1982, A "Random-Walk" Solute Transport Model for Selected Ground Water Quality Evaluations: Bulletin 65, Illinois State Water Survey.

Sun, N.Z. and Yeh, W.W.G., 1983, A Proposed Upstream Weight Numerical Method for Simulating Pollutant Transport in Groundwater: Water Resources Research, Vol. 19, No. 6, p. 1489-1500.

Golder Associates, Inc., 1983. Ground Water Computer Package User's Manual Hydraulic Solution, FPM Computer Program: Bellevue, Washington.

McDonald, M.G., and Harbaugh, A.W., 1984, A Modular Three-Dimensional Finite-Difference Ground Water Flow Model: Open-file Report, U.S. Geological Survey, Reston, VA.