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PROJECT WM-10

MEMORANDUM FOR: O. L. Olson, DOE, Richland, Washington

FROM: Robert J. Wright, NRC, Washington, DC

SUBJECT: TRANSMITTAL OF SECTIONS 4-6 AND APPENDIX A OF DRAFT SITE TECHNICAL POSITION ON HYDROGEOLOGIC TESTING STRATEGY FOR BWIP

Attached is a copy of Sections 4-6 and Appendix A of the NRC's Draft Site Technical Position on Hydrogeologic Testing Strategy for BWIP. Sections 1-3, which cover introductory and background material, are under revision at this time.

The attached sections comprise the proposed testing strategy that we will present and discuss at the workshop in Richland, July 11-15, 1983. The NRC is transmitting this information for background information in preparation for the workshop.

ORIGINAL SIGNED BY

Robert J. Wright, NRC, Washington, DC

Attachment:
Sections 4-6 and Appendix A

cc: Mark Frei, DOE, HQ (2 copy)

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DRAFT SITE TECHNICAL POSITION

ON ~~HYDROLOGIC~~ HYDROGEOLOGIC TESTING STRATEGY

FOR THE BWIP SITE

July, 1983

~~JUNE 1983~~

Division of Waste Management

U.S. Nuclear Regulatory Commission

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a small-scale, single well test often can be detected by large-scale tests.

## 4.0 A TESTING STRATEGY FOR THE GROUNDWATER FLOW SYSTEM AT THE BWIP SITE

### 4.1 Constraints

The strategy presented in this site technical position has been developed within the following constraints:

1. The existing work must be utilized to the fullest extent possible, both with respect to the available data, and to the available facilities (mainly boreholes open in the Grande Ronde).

2. The strategy must be flexible so that it can be adjusted in response to the results of on-going testing and modeling at any time during the program.

3. The strategy proposed must use conventional techniques and proven equipment, where possible.

4. The time schedule of NWPA must be adhered to, if possible.

5. The cost of the proposed strategy must be acceptable within the context of the funding of the current BWIP program.

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In addition, the proposed testing strategy has been developed by the NRC staff on the assumption that the repository horizon will be within the Grande Ronde Formation. If the final selection of the repository horizon is outside the Grande Ronde, then changes to the details of this strategy would be necessary. However, the NRC staff considers that the philosophical framework and the logic of the method of approach presented in this site technical position can be adapted readily to any potential repository horizon in the basalts at the Hanford site.

## 4.2 Approach

The approach to investigation proposed in this site technical position paper depends essentially on the following steps:

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1. Preliminary activities

- installation of a trial piezometer string in hole DC-16A;
- installation of continuous water-level-monitoring recorders in all deep, open boreholes at the BWIP site;
- performance of an initial multiple-well pump test in DC-16C;
- analysis of the initial pump-test data from in DC-16C
- Installation of a piezometric and hydrochemical monitoring network in existing and some new holes;

- performance of a head and hydrochemistry survey of the site.

2. Final Pump Test of DC-16

- design, installation and performance of large-scale, long-term pump test at DC-16C;

- evaluation of need for further testing using appropriate performance assessment methodology (see Figure 5 and discussion in Appendix A).

3. Additional Large Scale Testing (if needed)

- design, installation of well, and performance of long-term pump tests adjacent to some or all of DC-4/5, DC-3, RRL-2, and possibly the McGee well cluster;

- evaluation of the need for further testing using performance assessment methodology.



4. Additional Local Scale Testing (if needed)

- design, installation of test well, and performance of local-scale tests (pump tests, dual-well tests) at some or all of RRL-4, RRL-6, RRL-14, DC-1/2, DC-X (a new hole southwest of the repository), DC-18 (to be drilled) and the McGee cluster.

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In each case, the length of the test and the rate of pumping of the well should be the largest possible within the constraints of equipment and aquifer performance (e.g., achieve maximum draw down and maximum cone of depression) in the host rock.

Details of the testing program are given in Appendix A; graphical representations of the logic of the program are given in Figures 2 to 5. The program generally uses boreholes open in the Grande Ronde Formation for observation of hydraulic head in the Grande Ronde. New wells are anticipated for most of the pumping locations and for most of the head-monitoring locations in units above the Grande Ronde Formation (Figure 2). The NRC staff considers that all new boreholes should be drilled using air-rotary technology.

At several points in the flow diagram of Figure 4, there is a notation of need for consultation between NRC and DOE. These are critical programmatic decision points, and the NRC staff considers that further NRC guidance will be necessary at these points in the implementation of the testing program.

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### 4.3 Schedule and Cost

One of the criteria for this site technical position on hydraulic testing at Hanford is that the cost and schedule for any revised program be acceptable within the relevant constraints (Section 4.1.5). Rough estimates, based on quotes for drilling, equipment, and testing, suggest that the cost of the revised program should fall within the range of $3 million to $10 million, exclusive of administrative overhead. ~~(Golder, 1983)~~. The elapsed time for completion of the program by a reasonably efficient organization is estimated at between one and two years, depending on the outcome of the large-scale tests and on the time required to demonstrate the existence of steady-state or long-term trending hydraulic conditions.

## 5.0 RELATIONSHIP OF THIS PROGRAM TO OTHER HYDROGEOLOGIC FIELD INVESTIGATIONS

This site technical position addresses only the investigations of the hydraulics of the groundwater system at the Hanford site. However, the DSCA identified other areas in the BWIP program for hydrogeologic characterization of the site that require additional testing to address remaining key issues. These areas include evaluation of solute transport parameters (dispersivity, retardation, and effective porosity), long-term hydraulic head conditions, and long-term hydrochemical conditions. Many of the facilities which would be installed under the program described in this site technical position also are appropriate for testing required to address these areas.

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### 5.1 Solute Transport Parameters

The standard method of evaluating solute transport parameters is to perform tracer tests between boreholes spaced a relatively short distance apart (e.g., DC 7/8). In addition to the paired holes already in place, the program described in this site technical position, if carried out to stages 3 or 4, ~~will~~ would provide a considerable number of such pairs of boreholes in each horizon of potential interest. If hydraulic testing is completed after stage 2, then boreholes for tracer testing may have to be drilled at critical locations. The number and exact location of additional paired boreholes for tracer testing should be determined after analyzing results of the hydraulic testing.

### 5.2 Long-Term Measurements of Hydraulic Heads

An essential aspect of this hydraulic test program is that a detailed three-dimensional, temporal record of hydraulic head over the controlled ~~zone~~ area would be obtained. This record would provide ~~an excellent~~ a baseline for pre-development piezometric conditions and ~~an excellent~~ a record of the hydraulic effects of all subsequent drilling, testing, and subsurface exploration. In addition, the head-monitoring system would be in place for ~~long-term~~ monitoring of long-term activities at the site.

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### 5.3 Long-Term Data on Hydrochemistry

The extensive network of depth-specific sampling points proposed in this program would allow periodic sampling of groundwater from each geologic unit. Such a sampling program would allow evaluation of the true nature of groundwater chemistry by providng repeated collection of pressurized samples and by preventing mixing of waters from different elevations within each borehole.

## 6.0 CONCLUSION

This site technical position gives a broad summary of the approach which the NRC staff has developed in the process of evaluating the results of the hydrogeolgic investigation program at the BWIP site to date. The proposed approach takes advantage of the existing facilities at Hanford, including the excellent geological characterization of the site and the existence of open holes at the depths of prime interest. In addition, the physical installations needed to implement this program also can be used in the testing that will be needed to address the areas of solute transport, long-term measurements of hydraulic head, and hydrochemistry.

It must be recognized that the testing strategy which is set out in this document is not necessarily the only approach which would lead to an acceptable hydraulic data base and performance assessment. However, the method of arriving at a philosophically sound site characterization strategy is intended as representative of the type of strategy expected prior to licensing application. Because of the dynamic nature of this kind of testing program, the NRC staff considers that continuing interactions between NRC and DOE will be required over the full period of site characterization. Finally, the strategy set out here is not intended to be a blueprint for the DOE or its contractors but is a guide to the reasons that reviewers have found the current testing proposals unsatisfactory for defensible licensing decisions.

APPPENDIX A - DETAILS OF APPROACH

A1 STAGE 1. PRELIMINARY ACTIVITIES

1A. Complete one hole (DC-16A) in the Grande Ronde Formation.

This completion would serve to test the reliability of the selected completion technique. The completion proposed includes a temporary piezometer string with multiple ports completed in the Grande Ronde in order to obtain data on each flow top and each dense interior of the formation. Each completion interval would be equipped to allow the water pressure to be read using a down-hole tool and also to allow a water sample to be taken under pressure. At least one commercially available piezometer system is currently available for this purpose, and it has been used successfully at the depths contemplated at the BWIP site.

1B. Install continuous water level recorders

In order to monitor water levels in all boreholes other than the DC-16 cluster on a continuous basis, water-level recorders would be installed in all other boreholes open to the Wanapum or Grande Ronde units. These boreholes currently include the following: DC-1, DC-2, DC-3, DC-4, DC-5, DC-6, DC-7, DC-8, DC-12, RRL-4, RRL-6, RRL-14, and all of the wells in the McGee cluster. These monitor wells would record the temporal variation of the composite water levels in the entire deep basalt rock mass ~~and~~ would be capable of recording the effects of any testing on any part of the site. (Note that as the rest of this program progresses, it will be necessary to remove some of the recorders to allow completion of some holes). There are a variety of commercially available recorders which are capable of being used for this purpose, the best-known of which is the "Stevens" line of recorders.

1C. Perform a preliminary pump test in DC-16C

After the water levels have been monitored in all the deep drill holes for a reasonable period to establish the background variation, well DC-16C would be pumped at a high rate for a period ranging from a week to twelve weeks. Water would be drawn from the entire open portion of the Grande Ronde unit. During the pumping period a flow-velocity profile would be performed to identify the water-yielding zones of the well. Heads in the adjacent multiple-completion piezometers would be monitored, as well as heads in all other open boreholes (which would be automatically recorded). The test should be continued until an approximately steady state is reached.

1D. Analyze the preliminary pump test in DC-16C

The pump test results would be analyzed with the following objective.

- To establish the distance in the Grande Rone at which head changes created by this test can be measured.



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- To identify the primary producing units of the Grande Ronde at this location to help design th e final DC-16 test.

- To evaluate the effectivenss of the multiple piezometers installed in DC-16A for monitoring a pump test.

- To provide a data base for the design and planning of the final pump test at DC-16B.

1E. Install head and hydrochemistry monitoring system

As soon as the preliminary pump test is completed, the installation of the area-wide piezometer and hydrochemistry monitoring network should begin. The network, which is considered necessary for licensing purposes, is shown in Figure 2.

A total of six new holes are proposed for this activity, of which two are to be drilled to below the Umtanum Unit (DC-18, DC-X) and four are to be drilled to the base of the Wanapum unit (at the locations of DC-4/5, DC-3, DC-16, and RRL-2). Each of the new and existing holes is then to be completed with piezometers using the technology proven in DC-16A. It is considered that the arrangement shown would provide adequate investigation of the currently proposed controlled area ~~zone~~ and depths to below the Umtanum unit.

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1F. Perform head and hydrochemistry survey of site.

A full suite of head and water quality readings would be taken from the installations described above after the completion of drilling and the decay of the major transients caused by the closure of the existing vertical flow conduits. This survey would produce the first time-coincident head and water quality survey of the site; it also would provide needed information on the pre-emplacement head gradients and water quality. After the inital survey, a regular (e.g., monthly) monitoring survey of heads would be maintained through the remainder of the characterization program.

A2. STAGE 2. FINAL PUMP TEST OF DC-16C

2A. Design and pre-analyses of the final DC-16C test

Based on the results of the previous test, the final test of DC-16C can be designed, and a pre-analysis performed in order to ensure that appropriate measurements are taken. At this point, decisions can be made on which portion or portions of DC-16C should be pumped, whether additional piezometers are needed above the Vantage interbed at this location, which piezometer(s) in each string should be monitored frequently, how long the test should run, and what the pumping rate should be.

In addition, the pre-analysis should address the question of whether substantial additional data will be obtained by this re-test of DC-16B. If not, then it should be omitted and the process should re-start with Step-2D below.

2B Prepare and perform the final DC-16C test~~(s)~~

This test would be a repeat of the inital test at DC-16C, but during this test the monitoring would be in isolated units of the Grande Ronde and Wanapam ~~separately~~. The pumping would be either from the entire Grande Ronde unit or from a portion of it, depending on the relation between pumping and drawdown discovered in the initial pump test. Pump testing in units above the Grande Ronde also may be required to characterize potential pathways. In this case, DC-16B could be completed to allow testing in units above the Grande Ronde. Each test would run for as long as it takes for conditions to approach the steady state; if the effects are extensive, the test might continue in excess of three months; if the effects are local, a few weeks may suffice. Monitoring would be conducted in all piezometers on site, as part of the regular monitoring program initiated in Step 1F, ~~and~~ augmented by more frequent monitoring of selected piezometers.

2C. Analyze test and evaluate results

The analysis of the test would be performed using both appropriate closed-form analytical solutions and numerical paramater-matching methods. The results of the testing would provide two, fundamentally different sets of information:

1. A perturbation/response data set for use in validation of computer modeling and direct demonstration of the flow systems.

2. A parameter data set relating to the behavior of the material involved at the scale of the testing, for use in future modeling.

Both sets are needed for site characterization, performance assessment, and preparation for the licensing process.

2D. Decision on the need for additional information

Once all the results of the analysis of the DC-16C testing and the testing of head and hydrochemistry are complete, a new data base will exist for performance assessment. The decision upon whether to continue with hydraulic testing must be made at this point, based upon the results of performance analyses. The process is described below:

1. Perform sensitivity studies of performance using the existing data base with existing uncertainties.

2. Establish the sensitivity of performance to key hydrologic parameters.

3. Is performance clearly acceptable under the EPA/10 CFR 60 regulations? If so, cease testing for hydrologic parameters. If not, go to the next step.

4. Is performance clearly unacceptable under EPA/10 CFR 60 regulations? If so, cease testing for all purposes. If not, go to the next step.

5. Will further testing reduce uncertainties sufficiently to allow performance to be defined to required limits for decision making? If so, proceed to next test level. If not, cease testing for hydrologic parameters.

This process is shown schematically in Figure 3.

A3. Stage 3. Additional Large-Scale Pump Testing

If the testing at DC-16C perturbs only a small volume of basalt, it ~~is~~ likely that additional testing may be needed. The next stage of testing would then be implemented. This stage would involve large-scale tests at up to four locations on or close to the RRL; these locations are the same as the locations of DC-4/5, DC-3, RRL-2, and possibly the McGee wells.

The test design would be similar to that used at DC-16C. A large-diameter well open to the entire Grande Ronde Formation would be drilled adjacent to the already-completed piezometer string at each site; this well would be pumped in order to stress the surrounding rock-mass. The response (if any) to this pumping would be mesaured in all piezometers on the site. In addition, a flow velocity profile would be taken during pumping to define where the water was being produced in the well. Test duration would be until steady-state conditions were approached, which is expected to be between one week and several months.

For each of these tests, the process of design, pre-analysis, preparation performance, analysis and evaluation would be identical to the process described for DC-16 (Stage 2). At the end of this stage, DC-16, DC-4/5, DG-3, RRL-2 and possibly the McGee cluster would have been tested to the same level using large-scale technology.

Additional testing of the overlying units, particularly the Wanapum, may be required for site characterization if a clear hydraulic connection were established during the testing of the Grande Ronde. In this case, a second test, pumping from a new well open to all or part of the Wanapum, would be designed, performed and evaluated using the same procedures proposed for the testing of the Grande Ronde. Note that many of the piezometers needed for such a test would be in place already.

A4. Stage 4 - Additional Local Tests

It is possible that the testing performed to this point will have characterized only a small volume of rock surrounding the test wells, such that the data collected represent values of hydraulic properties only in the vicinity of the test locations. If this occurs, then the decision process will probably show that further values of the key parameters are needed. In order to obtain these values, the fourth stage of the testing program would be implemented. Local-scale tests would be conducted at up to a further seven sites, namely RRL-4, RRL-6, RRL-14, DC-1/2, DC-12, DC-X, DC-18, and the McGee wells, if not tested previously. (Note that tests at DC-16, DC-4/5, DC-3, RRL-2, and possibly the McGee wells will have already been conducted.)

These tests would involve the drilling of a pumping well adjacent to the existing piezometer strings at these locations and pumping from it in a manner similar to that used for previous tests (e.g., at DC-16B). If this level of testing is needed, the head effects created by this pumping will be localized, so it is likely that monitoring will only be effective at the adjacent piezometer well. The tests will therefore be of short duration (1-4 weeks), and it may be advantageous to perform additional detailed ~~cross~~ two-hole tests to determine detailed parameter values in key locations (see for example Hsieh et al., 1982) using the existing well and piezometer hole pairs).

Again, the general process of design, pre-analysis, preparation, preformance, analysis and evaluation for these tests would be similar to that used in previous tests. Testing would cease when adequate definition was obtained, as defined by the logic of Figure 3.

A5. Stage 5 - Single Hole Testing

In the event that no response to well-pumping could be felt in piezometers as little as 50 meters away, then the only viable exploratory technique available would be single-hole testing. Single-well technology has been used extensively on the site already, and it would appear that little more could be learned about the site by further testing of this sort. If site characterization depended upon this type of testing alone, then heavy dependence would have to be placed upon model validation using the accurate temporal head and the geochemical data collected from the multiple piezometer strings in the deep holes. Even in this case, the installation of piezometer strings and the hydraulic heads and hydrochemical data monitored in them would be an integral part of the test strategy.

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Hsieh, P.A., S.P. Neuman and E.S. Simpson, "Pressure Testing of Fractured Rocks - A Methodology Employing Three-Dimensional Cross-Hole Tests," Draft NUREG/CR-3213, 1983.

Lester, Barry, S.D. Thomas and C.R. Faust, "Analysis of BWIP Site Modeling - Final Report," ~~Prepared for U.S. N.R.C. by~~ GeoTrans, Inc., 80 p., March 9, 1983.

NRC, "Draft Site Characterization Analysis of the Site Characterization Report for the Basalt Waste Isolation Project - Hanford, Washington, Site," NUREG-0960, 1983.

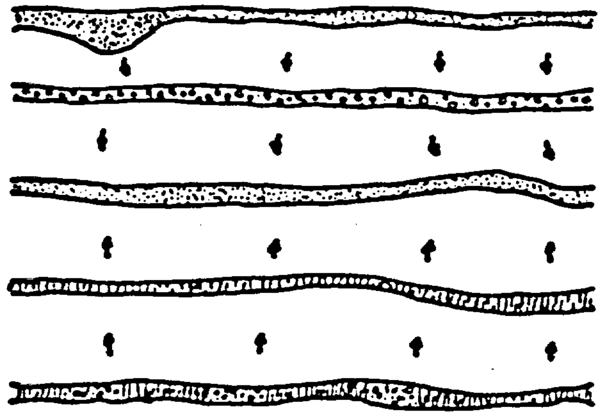
RHO, "Hydrologic Studies with the Columbia Plateau, Washington: An Integration of Current Knowledge," RHO-BWI-ST-5, 1979.

U.S. Geological Survey, "Review Comments by the U.S. Geological Survey on 'Site Characterization Report for the Basalt Waste Isolation Project'," 1983.

Letter of J.B. Robertson (U.S.G.S.) to O.L. Olson (BWIP), May 6,

## ALTERNATIVE CONCEPTUAL MODELS

Figure 1



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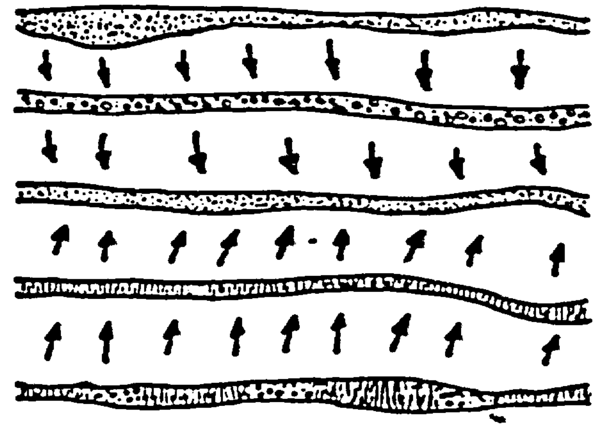

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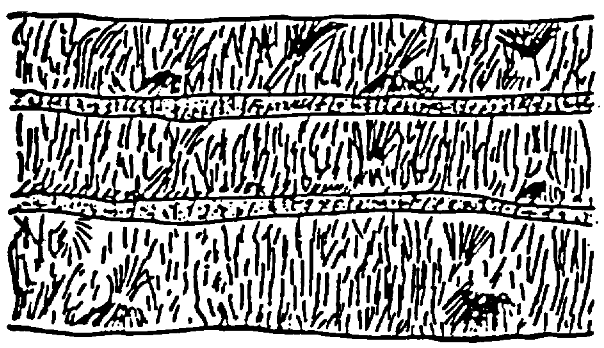

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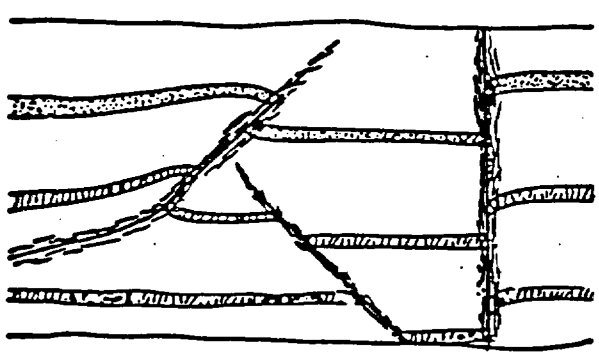
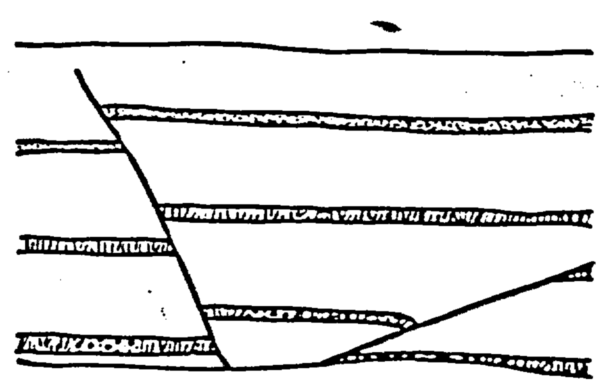


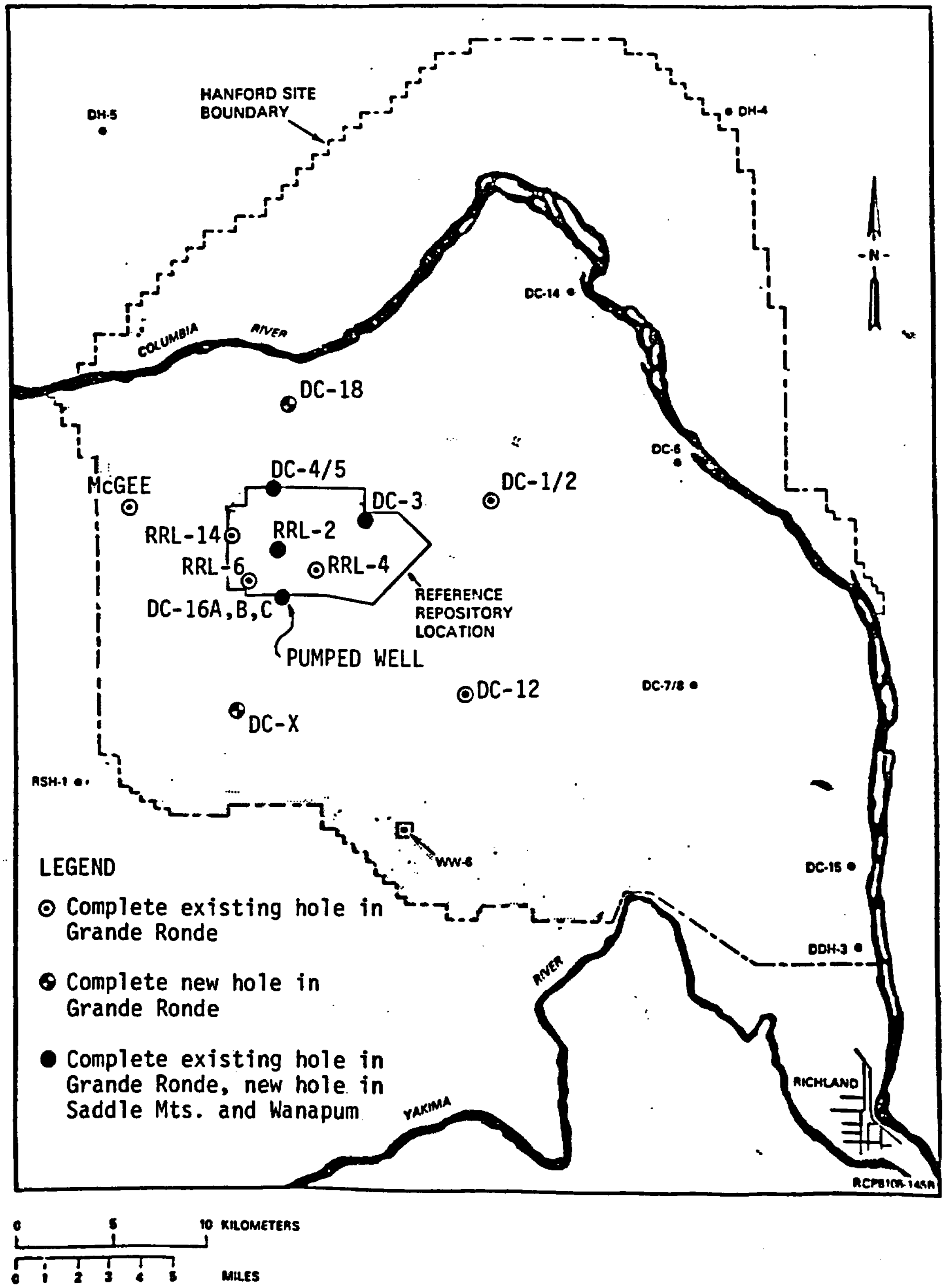
HIGH PERMEABILITY DISCONTINUITIES



LOW PERMEABILITY DISCONTINUITIES

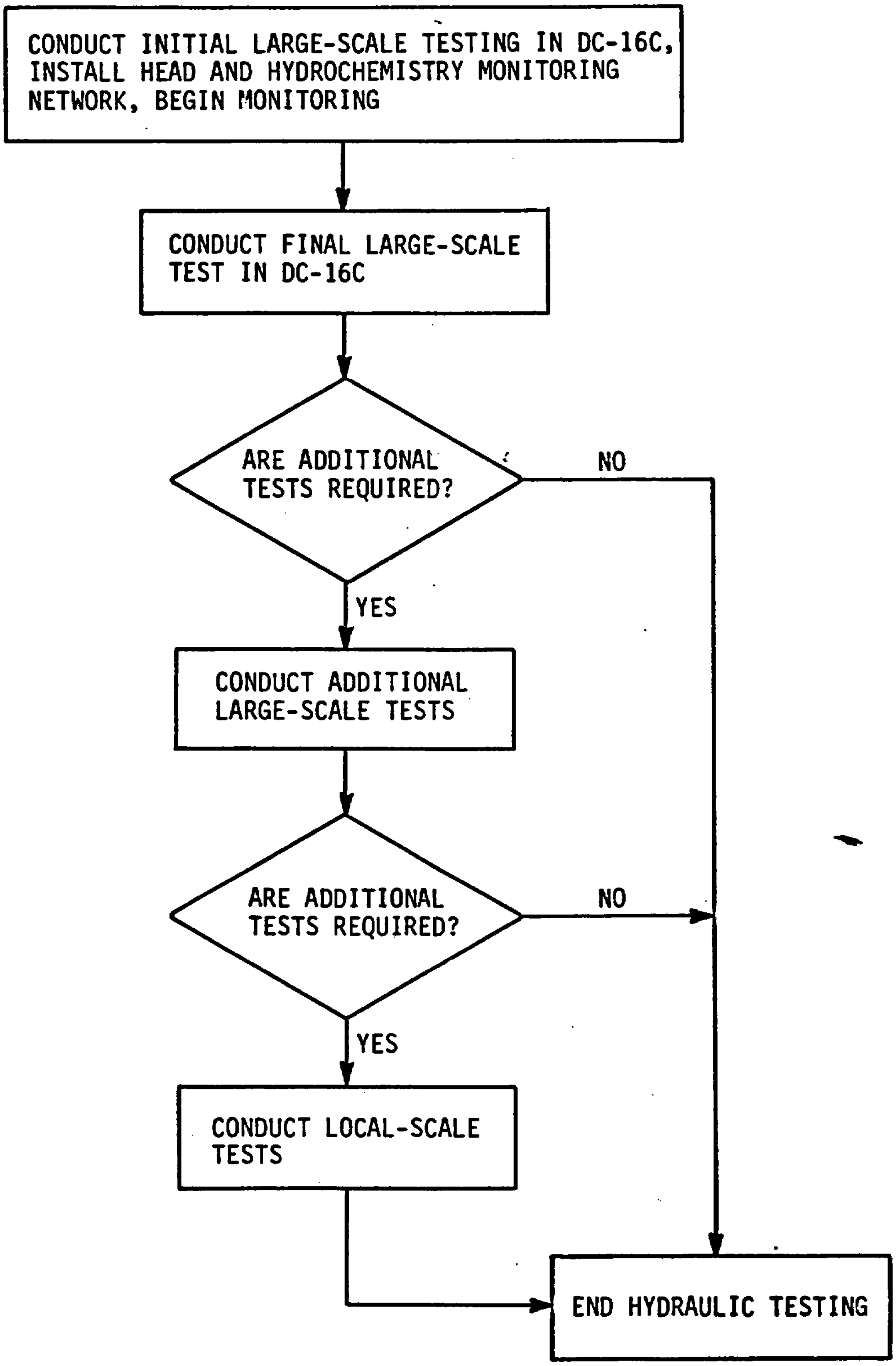
## BOREHOLE LOCATIONS

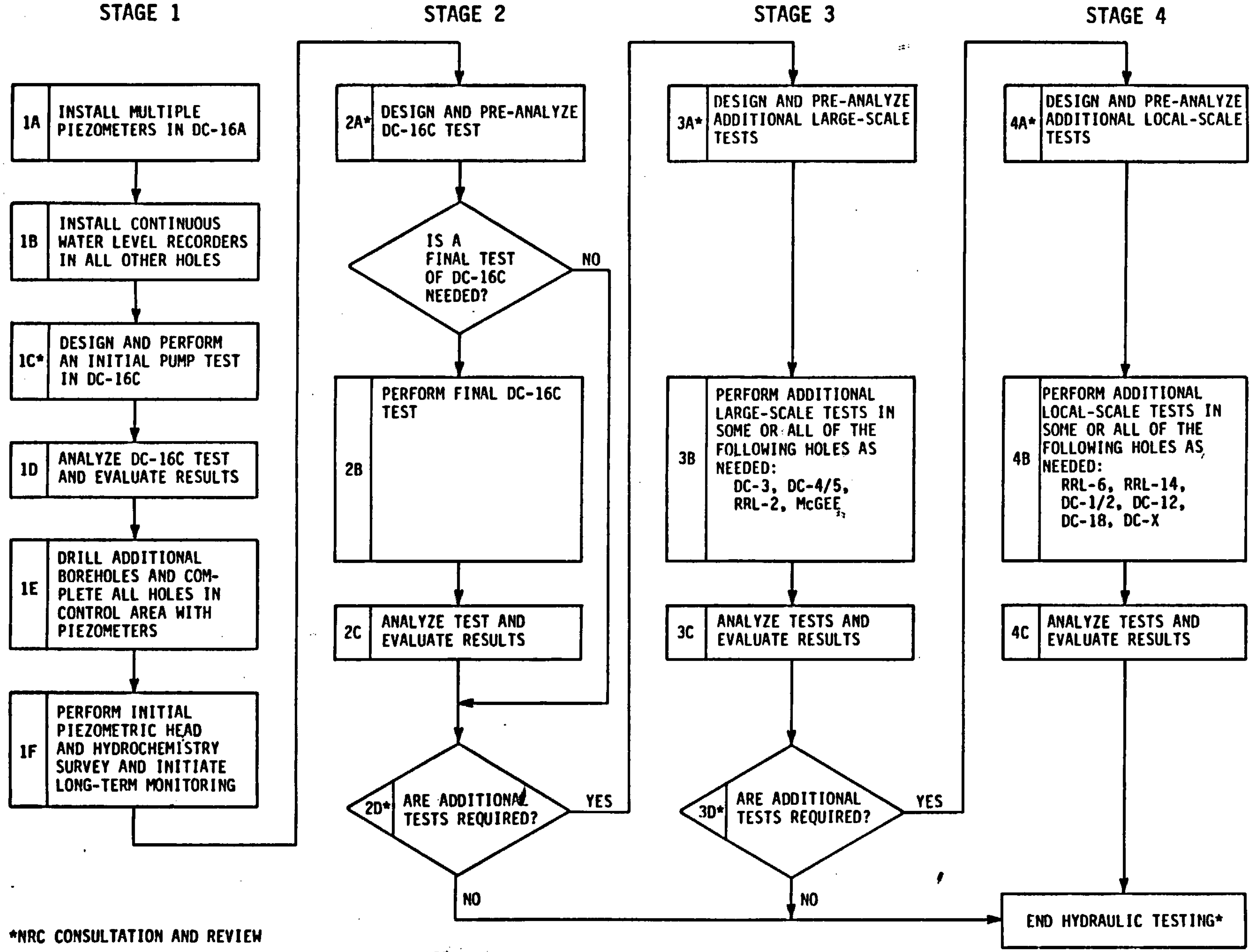
Figure 2



SUMMARY LOGIC CHART FOR A POSSIBLE GROUNDWATER TESTING STRATEGY AT THE BWIP SITE

Figure 3



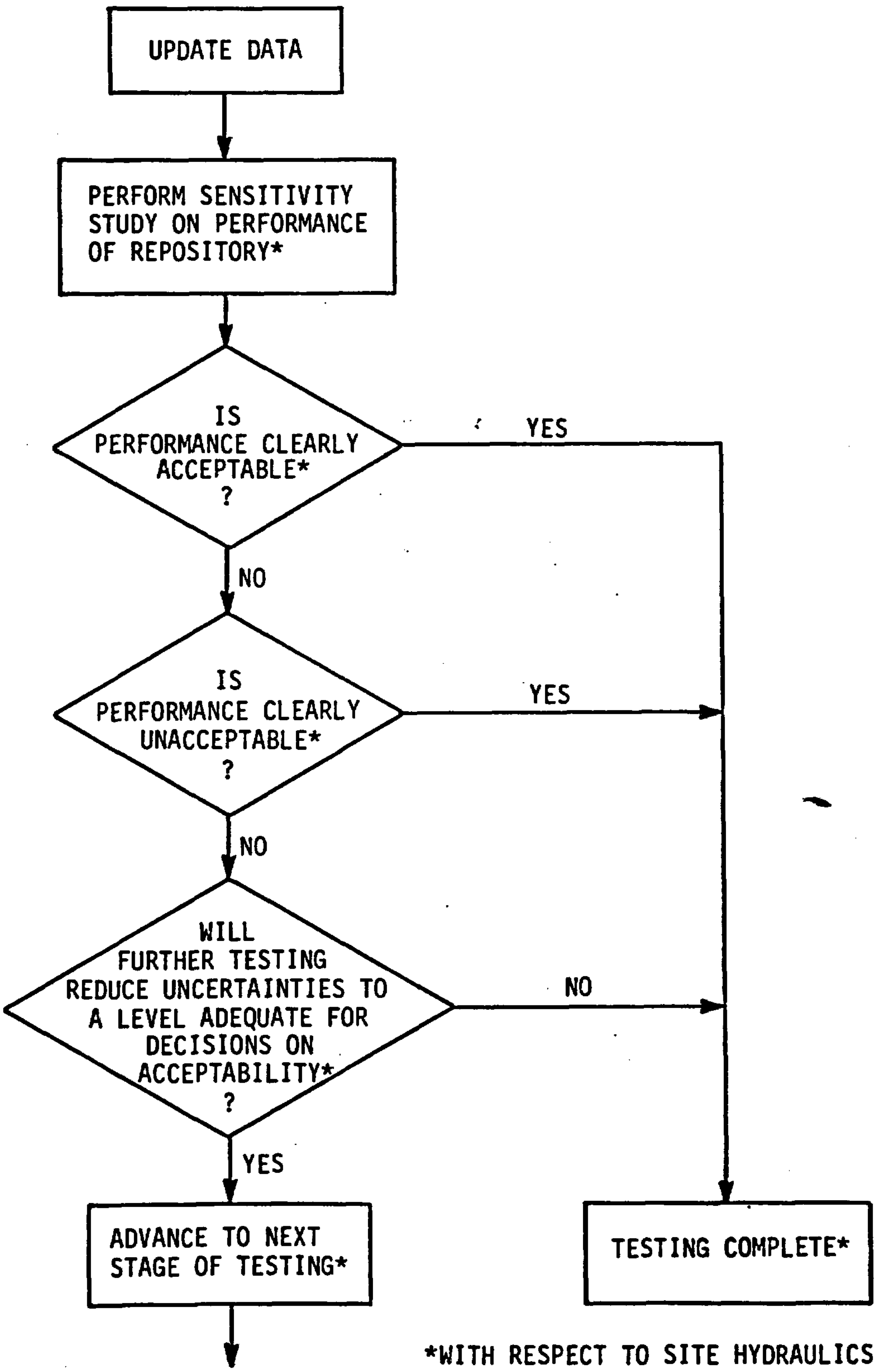



DETAILED LOGIC CHART FOR A POSSIBLE GROUNDWATER TESTING STRATEGY AT THE BWIP SITE

Figure 4

## DECISION MAKING PROCESS FOR TESTING AT BWIP

Figure 5




*WITH RESPECT TO SITE HYDRAULICS