**Basalt Waste Isolation Project
Drilling and Testing
Quarterly Report**

**January 1, 1983
through
March 31, 1983**

**Staff
Drilling and Testing Group**

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Prepared for the United States
Department of Energy
Under Contract DE-AC06-77RL01030

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Rockwell Hanford Operations
Energy Systems Group
Richland, WA 99352

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BASALT WASTE ISOLATION PROJECT
DRILLING AND TESTING QUARTERLY REPORT

JANUARY 1, 1983 THROUGH MARCH 31, 1983

Staff
Drilling and Testing Group
Basalt Waste Isolation Project

April 1, 1983

Prepared for the United States
Department of Energy Under
Contract DE-AC06-77RL01030

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SUMMARY

Rockwell Hanford Operations Drilling and Testing Group is responsible for all borehole drilling and testing conducted in support of the Basalt Waste Isolation Project. Geologic and hydrologic characterization data obtained by the group are an integral part of the studies required to assess the feasibility of using the deep basalts beneath the Hanford Site for the terminal disposal of nuclear waste.

This document is a summary of drilling and testing results during the first calendar quarter (January through March 1983). The principal work during this period included the drilling and/or testing of boreholes RRL-2, RRL-6, RRL-14, DC-4/DC-5, DC-16A, DC-16B, and the McGee Well. Specific highlights of this work are summarized in the following paragraphs.

BOREHOLE RRL-2

Hydrologic testing was performed on the McCoy Canyon flow interior at borehole RRL-2. The value of transmissivity ranges between 10^{-10} to 10^{-9} ft²/sec (10^{-11} to 10^{-10} m²/sec). No hydraulic head could be determined due to the low transmissivity.

BOREHOLE RRL-6

Hydrologic testing of the Umtanum flow interior and Umtanum flow bottom was completed. Values of transmissivity ranged from 10^{-13} to 10^{-10} ft²/sec (10^{-14} to 10^{-11} m²/sec) for the flow interior. The transmissivity of the flow bottom ranged from 10^{-7} to 10^{-8} ft²/sec (10^{-8} to 10^{-9} m²/sec). Due to the low transmissivity of the zones tested, hydrostatic conditions were not achieved during testing.

BOREHOLE RRL-14

Hydrologic testing was completed for the Cohasset flow interior. Transmissivities for this zone ranged from 10^{-13} to 10^{-11} ft²/sec (10^{-14} to 10^{-12} m²/sec).

BOREHOLE DC-4/DC-5

The constant head injection phase of vertical permeability testing at boreholes DC-4 and DC-5 was terminated after 8 weeks of injection. Injection rates at DC-5 declined from an initial value of about 14 gpm to 0.13 gpm, recorded at the end of testing. Associated pressure responses during testing were monitored at borehole DC-4 for the injection zone (Cohasset flow top) and an interior section of the overlying basalt flow (confining layer). Although an associated test pressure in excess of 130 psi was induced in the Cohasset flow top, no formation pressure

response attributed to testing was discerned within the dense basalt interior section monitored at borehole DC-4. Additional reduction and analyses of test data will be required prior to reporting estimates of vertical hydraulic conductivity for the basalt interior section overlying the Cohasset flow top.

BOREHOLE DC-16A

Borehole DC-16A was cored from 3,360 to 3,599 ft (1,024.1 to 1,097.0 m) in the upper sequence of the Grande Ronde Basalt. Transmissivities for intervals tested ranged from 10^{-9} to 10^{-5} ft²/sec (10^{-9} to 10^{-6} m²/sec). The observed head for these intervals was 402 ft (122.5 m) above mean sea level. Drilling and testing of DC-16A was on schedule at the end of this quarter.

BOREHOLE DC-16B

Hydrologic testing was initiated for the Mabton interbed at this existing borehole site. Hydrologic testing revealed a preliminary transmissivity with a range of 10^1 to 10^0 ft²/sec (10^0 to 10^{-1} m²/sec).

McGEE WELL

The McGee Well was cored from 1,780 to 1,942 ft (542.5 to 591.9 m) into the top of the Grande Ronde Basalt. For the lower Frenchman Springs interval tested, the preliminary values for transmissivity range from 10^{-5} to 10^{-4} ft²/sec (10^{-5} to 10^{-4} m²/sec). The hydraulic head is 918 ± 2 ft (279.8 ± 1 m) above mean sea level. The Vantage interbed was being tested at the end of the first quarter.

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INTRODUCTION

PURPOSE AND SCOPE

The Basalt Waste Isolation Project (BWIP) was begun in 1976 to investigate the feasibility of using basalts of the Columbia River Basalt Group as a repository site for deep geologic disposal of high-level radioactive waste. Rockwell Hanford Operations was selected by the U.S. Department of Energy to serve as the prime contractor for performance of the required site exploration and repository design studies.

The BWIP work breakdown structure in support of site exploration and repository design has been divided into the following departments: Systems, Waste Package, Site, Repository, Regulatory and Institutional, Test Facilities, and Quality Assurance. The Site Department has been assigned responsibility for collection of hydrologic and geologic data. Acquisition of subsurface hydrologic and geologic information within the Site Department is the responsibility of the Drilling and Testing Group. One of its functions is to deliver data to support the following BWIP tasks:

- Site identification data base
- Geologic characterization data base
- Hydrologic characterization data base
- Environmental monitoring.

The drilling and testing activity in surface-based boreholes is a necessary and economical method for the acquisition of geologic and hydrologic data. These activities are governed in general accordance with the BWIP drilling and testing plan. The information-gathering performed by the Drilling and Testing Group is in accordance with recognized national standards and established procedures.

This document is a summary of the technical progress accomplished by the Drilling and Testing Group during the first quarter of calendar year 1983 (January 1 through March 31). Work during this period was performed on boreholes RRL-2, RRL-6, RRL-14, DC-4/DC-5, DC-16A, DC-16B, and the McGee Well. The general location of these boreholes is shown in Figure 1. The results presented in this document are preliminary; the final results will be contained in the Interval Reports, Data Objective Reports, and Borehole Completion Reports upon completion of drilling and testing for the various boreholes.

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GENERALIZED GEOLOGY OF THE PASCO BASIN

Geologic studies have shown that the Pasco Basin contains laterally continuous basalt flows with thick, dense interiors that are part of the Columbia River Basalt Group of Miocene age (Fig. 2). The oldest and most voluminous formation penetrated to date in the Pasco Basin is the Grande Ronde Basalt. The basalts of this formation are overlain by the Wanapum Basalt, which in turn is overlain by the Saddle Mountains Basalt. Within the Pasco Basin, the upper basalt sequence is interbedded with clastic sediments of the Ellensburg Formation and overlain by the fluvial-lacustrine Ringold Formation and catastrophic flood deposits of the Hanford sands and gravels (Fig. 2).

Lava flows of the Columbia River Basalt Group erupted from linear vent systems, remnants of which are exposed as dikes, primarily in the eastern and southeastern portions of the plateau. Because of their high fluidity and large volume, the lavas spread considerable distances from their source vents. In so doing, they covered vast areas, inundated older rocks and structures within the plateau interior, and overlapped onto the highlands around the plateau margin. In the Cold Creek syncline (within the Pasco Basin) (Fig. 3), flows are nearly flat and lie within an area in excess of tens of square kilometers. For further details of the geology of the Pasco Basin and the Cold Creek syncline, refer to Myers, Price, and others (1979) and Myers and Price (1981).

GENERALIZED HYDROGEOLOGY OF THE PASCO BASIN

Groundwater beneath the Hanford Site occurs principally in the saturated sediments of the Hanford sands and gravels, Ringold Formation, and underlying basalt sequence of the Columbia River Basalt Group. Aquifers within the Hanford and Ringold Formations are unconfined to semiconfined. Groundwater in the layered basalt sequence is under artesian (confining) conditions.

Values of hydraulic conductivity for the unconfined system range from about 10^{-6} to 10^{-1} ft/sec (10^{-6} to 10^{-1} m/sec). The highest hydraulic conductivity values are found in glaciofluvial sand and gravel deposits associated with buried paleochannels in the vicinity of Gable Mountain and Gable Butte.

The confined aquifer system includes the basalt flows and associated interbeds within the Grande Ronde, Wanapum, and Saddle Mountains Basalts. Groundwater occurs principally in interbeds and interflow zones. Dense flow interiors tend to act as barriers to vertical movement of groundwater.

For interbed and interflow zones in the Saddle Mountains and Wanapum Basalts, preliminary measured hydraulic conductivities range primarily between 10^{-10} to 10^{-2} ft/sec (10^{-10} to 10^{-2} m/sec) and average about 10^{-7} to

[illegible]

FIGURE 2. Stratigraphic Nomenclature of the Columbia River Basalt Group, Pasco Basin.

FIGURE 3. Location of Columbia Plateau, Hanford Site, Cold Creek Syncline, and Reference Repository Location.

10^{-5} ft/sec (10^{-7} to 10^{-5} m/sec). The larger of these values is associated with interbeds within the Saddle Mountains Basalt and selected interflow zones within the upper half of the Wanapum Basalt.

Limited hydrologic data are available for the Grande Ronde Basalt. Measured values of hydrologic conductivity for interflow zones range primarily between 10^{-10} to 10^{-3} ft/sec (10^{-10} to 10^{-3} m/sec) and averaged 10^{-5} ft/sec (10^{-5} m/sec). For the dense flow interior zones, the measured hydraulic conductivity ranges from about 10^{-13} to 10^{-12} ft/sec (10^{-13} to 10^{-12} m/sec).

Aquifers within the Columbia River Basalt Group are under confining conditions. Groundwater flow is influenced by areal hydraulic head patterns that are controlled by a number of factors including topography, structure, stratigraphy, and hydraulic properties of aquifers. Within the Cold Creek syncline (beneath the Hanford Site), the heads in the confined system are estimated to be at about 400 ft (122 m) above mean sea level (MSL).

For a more detailed discussion of the hydrology of the Pasco Basin, refer to Gephart and others (1979). A summary of the groundwater conditions at the Hanford Site as it affects a potential nuclear waste repository in basalt has been described by Deju (1981).

DRILLING AND TESTING ACTIVITIES

The work accomplished by the BWIP Drilling and Testing Group during the first quarter of calendar year 1983 is described for boreholes RRL-2, RRL-6, RRL-14, DC-4/DC-5, DC-16A, DC-16B and the McGee Well (see Fig. 1).

BOREHOLE RRL-2

Purpose

Borehole RRL-2 was drilled as the principal borehole for the BWIP Exploratory Shaft. The borehole is designed to provide information on depths and thicknesses of geologic units that will be penetrated by the shaft, as well as engineering properties of the rock units. The borehole will also provide hydrologic data to support shaft design and numerical modeling of solute travel time from a repository.

Location

Borehole RRL-2 is located in the southwestern part of the reference repository location (RRL) near the axis of the Cold Creek syncline in the Pasco Basin (Fig. 1). The borehole collar elevation is approximately 634 ft (193.2 m) above MSL. The Washington State coordinates for the borehole are 444,297 ft (135,421.7 m) north and 2,211,185 ft (673,969 m) east.

Borehole Construction Details

The as-built borehole construction details for RRL-2 are shown in Figure 4.

The initial phase of drilling was performed between February and September 1981 as part of a program of six boreholes drilled to identify an exploratory shaft site. The work during this period involved drilling the hole to a depth of 1,544 ft (470.6 m) and installing a string of surface casing, a string of polyvinyl chloride (PVC) casing and 5.5 in. (14.0 cm) steel casing to the top of the basalt (Fig. 4). The sediments overlying the basalt were drilled by cable tool and mud rotary methods to a depth of 615 ft (187.4 m). The top of basalt was encountered at a depth of 603 ft (183.8 m). A Chicago Pneumatic Model (CP) 50 core drill, using a 4.625 in. (11.7 cm) diameter diamond bit, was used to drill the basalt sequence from 615 ft (187.8 m) to a depth of 1,544 ft (470.6 m). For this interval, the borehole penetrated the Saddle Mountains Basalt and was terminated in the interior of the Priest Rapids II flow of the Wanapum Basalt.

In January 1982, drilling was resumed using a CP-50 core drill. Prior to drilling, a 4.5 in. (11.4 cm) outside diameter (OD) steel casing was cemented to the total depth of 1,545 ft (470.9 m). Between January and June of 1982 the borehole was advanced from 1,545 ft (470.9 m) to a depth of 2,713 ft (826.9 m) using a 3.937 in. (10 cm) diameter diamond bit and triple-tube core barrel. After hydrologic testing and geophysical logging, 3.5 in. (8.9 cm) OD casing was cemented to the total depth of 2,713 ft (826.9 m). The borehole was then drilled, using 2.98 in. (7.6 cm) diameter diamond bits, to the total depth of 3,973 ft (1,211.0 m). All coring utilized triple-tube core barrels. The core recovery for the hole exceeded 99%. Drilling was completed June 23, 1982.

Borehole Geophysical Logging

No borehole geophysical logging was performed on borehole RRL-2 during this quarter.

Geologic Description

The stratigraphy of borehole RRL-2 is shown in Table 1.

Hydrologic Description

The stratigraphic interval tested and hydrologic properties for the McCoy Canyon interior are shown in Table 2.

Hydraulic Head. No hydraulic head for the McCoy Canyon basalt interior could be determined because of its low transmissivity.

FIGURE 4. Borehole RRL-2, As-Built Drawing.

TABLE 1. Stratigraphy of Borehole RRL-2.

Flow or interbed		Depth below ground surface, ft	Thickness, ft
Saddle Mountains Basalt			
Elephant Mountain		603 - 686	83
Rattlesnake Ridge			
interbed		686 - 783	97
Pomona		783 - 941	158
Selah interbed		941 - 986	45
Esquatzel		986 - 1,104	118
Cold Creek interbed		1,104 - 1,167	63
Umatilla		1,167 - 1,399	232
Mabton interbed		1,399 - 1,523	124
Wanapum Basalt			
Priest Rapids	II	1,523 - 1,689	166
	I	1,689 - 1,749	60
Roza		1,749 - 1,922	173
Frenchman Springs	1	1,922 - 2,104	182
	2	2,104 - 2,217	113
	3	2,217 - 2,271	54
	4	--	--
	5	2,271 - 2,381	110
	6	2,381 - 2,489	108
	7	2,489 - 2,617	128
	8	2,617 - 2,683	66
Vantage interbed		2,683 - 2,687	4
Grande Ronde Basalt			
Grande Ronde	1	2,687 - 2,720	33
	2	2,720 - 2,823	103
	3	2,823 - 2,993	170
Cohasset	4	2,993 - 3,255	262
	5	3,255 - 3,388	133
	6	3,388 - 3,417	29
	7	3,417 - 3,475	58
McCoy Canyon	8	3,475 - 3,607	132
Umtanum	9	3,607 - 3,839	232
Very high Mg	10	3,839 - 3,903	64
	11	3,903 - 3,973	70

Note: To convert feet to meters, multiply by 0.3048.

TABLE 2. Borehole RRL-2, Hydrologic Properties.

Interval	Depth below ground surface, ft (m)	Observed hydraulic head above MSL, ft (m)	Preliminary transmissivity, ft ² /sec (m ² /sec)
McCoy Canyon flow interior	3,568-3,593 (1,087.5-1,095.1)	--	10-10-10-9 (10-11-10-10)

Transmissivity. The value of transmissivity (Table 2) for the McCoy Canyon interior ranges between 10-10 to 10-9 ft²/sec (10-11 to 10-10 m²/sec). The transmissivity value obtained from this zone is within the range commonly reported in the Grande Ronde Basalt (Strait and others, 1982).

Storativity. No reliable estimates of storativity were obtained during hydrologic testing due to single borehole testing.

Tests Planned. Hydrologic testing planned on borehole RRL-2 include the McCoy Canyon flow top, composite interflows of the middle Grande Ronde Basalt, Grande Ronde 3 flow interior, and a retest of the Umtanum Basalt fracture zone.

BOREHOLE RRL-6

Purpose

Borehole RRL-6 was deepened to provide geologic information on the intraflow structure characteristics of the candidate horizons in the southwestern part of the RRL. It will also provide additional hydrologic and rock mechanics data on the candidate horizons.

Location

Borehole RRL-6 is located in the southwestern part of the RRL approximately 1.4 mi (2.3 km) southwest of the principal borehole, RRL-2 (Fig. 1). The borehole collar elevation is approximately 643 ft (196.0 m) above MSL. The Washington State coordinates for the borehole are 438,580.38 ft (133,679.3 m) north and 2,206,423.00 ft (672,517.7 m) east.

Borehole Construction Details

The as-built borehole construction details for RRL-6 are shown in Figure 5.

Borehole RRL-6 was initially drilled in 1981, along with five other RRL boreholes, to better define the structural interpretation of the top-of-basalt in the western half of the RRL. Boreholes RRL-6 and RRL-2 were then deepened by coring (from March to September 1981) to the top of the Wanapum Basalt to provide more data on the structure and stratigraphy of the Saddle Mountains Basalt flows and the structure of the top of the Wanapum Basalt.

FIGURE 5. Borehole RRL-6, As-Built Drawing.

Borehole RRL-6 was started with a cable tool rig. A 12.0 in. (30.5 cm) diameter entry hole was drilled and cased to 83 ft (25.3 m) prior to rotary drilling. Rotary drilling was accomplished using a conventional bentonite-mud system. The hole was drilled into the top of basalt using an 11 in. (27.9 cm) diameter tricone bit and cased with 8 in. (20.3 cm) PVC pipe to 668 ft (203.6 m). A 6.625 in. (16.8 cm) diameter steel casing was then cemented to 668 ft (203.6 m). Coring was completed to 1,611 ft (491.0 m) in the Wanapum Basalt using 5.25 in. (13.3 cm) diameter diamond bits.

The deepening of borehole RRL-6 was initiated on July 10, 1982. A 4.5 in. (11.4 cm) OD steel casing was run into the existing 1,611 ft (491.0 m) deep, 5.25 in. (13.3 cm) diameter hole and cemented in place. The hole was cored to 2,843 ft (866.5 m) using 3.937 in. (10.0 cm) diameter diamond bits. The hole was cased with 3.5 in. (8.9 cm) OD casing to 2,843 ft (866.5 m) and then drilled to completion at 4,040 ft (1,231.4 m) using 2.98 in. (7.6 cm) diameter diamond bits.

Borehole Geophysical Logging

Geophysical logging of the Grande Ronde Basalt was conducted this quarter at borehole RRL-6. The type of logs, dates logged, and intervals logged are shown in Table 3. The neutron-epithermal neutron log was conducted in a previous quarter. The sonic log was not run because the probe was malfunctioning; this log will be run when equipment and scheduling permit.

TABLE 3. Borehole RRL-6, Geophysical Logs.

Geophysical log	Interval logged, ft (m)	
	2/14/83	2/15/83
Gamma-gamma	2,292-2,958 (698.6-901.6)	2,936-4,027 (894.9-1,227.4)
Natural-gamma	--	2,790-4,027 (850.4-1,227.4)
Fluid temperature	190-4,030 (57.9-1,228.3)	--
Caliper	2,820-4,027 (859.5-1,227.4)	--
Spontaneous potential	--	2,840-4,027 (856.6-1,227.4)
Resistivity	--	2,840-4,027 (865.6-1,227.4)
Magnetics	2,840-4,027 (865.6-1,227.4)	--

Geologic Description

The stratigraphy for borehole RRL-6 is shown on Table 4.

Hydrologic Description

The stratigraphic intervals and hydrologic properties for horizons tested during this quarter are shown in Table 5. Intervals tested were the Umtanum interior and Umtanum flow bottom.

Hydraulic Head. Reliable heads were not obtained due to the low transmissivity of the intervals tested.

Transmissivity. The best preliminary estimates of transmissivity are shown in Table 5. Pulse and constant head injection tests were analyzed to determine the transmissivity of the Umtanum flow interior. Results ranged from 10^{-13} to 10^{-10} ft²/sec (10^{-14} to 10^{-11} m²/sec). The transmissivity of the Umtanum flow bottom was determined from analyses of pulse, slug, and constant head injection tests. The results of tests on the Umtanum flow bottom ranged from 10^{-8} to 10^{-7} ft²/sec (10^{-9} to 10^{-8} m²/sec).

Storativity. No reliable estimates of storativity were obtained from hydrologic testing in the single borehole configuration.

Tests Planned. Hydrologic testing during the next quarter will focus upon determining the hydrologic properties of flows adjacent to the candidate horizons.

BOREHOLE RRL-14

Purpose

Drilling and testing of RRL-14 are part of the BWIP subsurface site selection and characterization activities. The borehole is designed to provide information on depths and thicknesses of geological units as well as hydrological data.

Location

Borehole RRL-14 is located in the western portion of the RRL. The borehole collar elevation is 656 ft (199.9 m) above MSL. The Washington State coordinates for the borehole are 446,540.60 ft (136,105.6 m) north and 2,203,991 ft (671,776.5 m) east.

TABLE 4. Stratigraphy of Borehole RRL-6.

Flow or interbed		Depth below ground surface, ft	Thickness, ft
Saddle Mountains Basalt			
Elephant Mountain		651 - 742	91
Rattlesnake Ridge			
interbed		742 - 847	105
Pomona		847 - 1,005	158
Selah interbed		1,005 - 1,048	43
Esquatzel		1,048 - 1,172	124
Cold Creek interbed		1,172 - 1,241	69
Umatilla		1,241 - 1,480	239
Mabton interbed		1,480 - 1,595	115
Wanapum Basalt			
Priest Rapids	II	1,595 - 1,776	181
	I	1,776 - 1,841	65
Roza		1,841 - 2,020	179
Frenchman Springs		2,020 - 2,023	interbed
	1	2,023 - 2,201	178
	2	2,201 - 2,313	112
	3	2,313 - 2,380	67
	4	2,380 - 2,483	103
	5	2,483 - 2,581	98
	6	2,581 - 2,706	125
	7	2,706 - 2,770.8	64.8
Vantage interbed		2,770.8 - 2,771.2	0.4
Grande Ronde Basalt			
Grande Ronde	1	2,771.2 - 2,807	35.8
	2	2,807 - 2,847	40
		2,847 - 2,924	57
	3	2,924 - 3,092	168
	3a		
Cohasset	4	3,092 - 3,344	252
	5	3,344 - 3,516	172
	5a		
Grande Ronde	6		
	7	3,516 - 3,576	60
McCoy Canyon	8	3,576 - 3,715.5	139.5
Umtanum	9	3,715.5 - 3,946	230.5
High Mg Flow	9a		
beneath Umtanum			
Very high Mg			
flow	10	3,946 - 3,999	53
	10a		
	11	3,999 - 4,040	--

Note: To convert feet to meters, multiply
by 0.3048.

TABLE 5. Borehole RRL-6, Hydrologic Properties.

Interval	Depth below ground surface, ft (m)	Observed hydraulic head above MSL, ft (m)	Preliminary transmissivity, ft ² /sec (m ² /sec)
Umtanum flow interior	3,827-3,938 (1,166.5-1,200.3)		10-13-10-10 (10-14-10-11)
Umtanum flow bottom	3,946-4,040 (1,202.7-1,231.4)		10-8-10-7 (10-9-10-8)

Borehole Construction Details

The as-built borehole construction details for RRL-14 are shown in Figure 6.

Brinkerhoff-Signal's Cardwell KM-250 rotary drill was moved onto the location on August 1, 1982, and began drilling on that date. Drilling progressed from ground surface to 60 ft (18.3 m) using a 17.5 in. (44.5 cm) tricone bit. A 13.375 in. (34.0 cm) OD steel casing was cemented to a depth of 60 ft (18.3 m). The hole was then reduced to 12.5 in. (31.8 cm) and drilled through the top of basalt to 683 ft (208.2 m). A string of 9.625 in. (24.4 cm) steel casing was cemented into place at 684 ft (208.5 m). Drilling continued with a 8.625 in. (21.9 cm) diameter bit to a depth of 1,696 ft (516.9 m). After geophysical logging was completed, a 7 in. (17.8 cm) OD steel casing was cemented to a depth of 1,696 ft (516.9 m). Drilling progressed with a 6.25 in. (15.9 cm) OD bit to 2,872 ft (875.4 m). The hole was then geophysically logged and 4.5 in. (11.4 cm) OD steel casing was cemented to a depth of 2,870 ft (874.8 m). Brinkerhoff-Signal demobilized on August 31, 1982, 15 days ahead of schedule.

Boyles Brothers Drilling Company began drilling on September 4, 1982, and advanced the hole from 2,872 to completion at 4,000 ft (875.4 to 1,219.2 m) using a 3.937 in. (10.0 cm) diameter diamond bit.

Geologic Description

The stratigraphy of borehole RRL-14 is shown on Table 6.

Hydrologic Description

During this quarter, the Cohasset flow interior was tested for hydrologic property determinations. The hydrologic properties for this test interval are listed in Table 7.

FIGURE 6. Borehole RRL-14, As-Built Drawing.

TABLE 6.. Stratigraphy of Borehole RRL-14.

Flow or interbed		Depth below ground surface, ft	Thickness, ft
Saddle Mountains Basalt			
Elephant Mountain		682 - 770	88
Rattlesnake Ridge			
interbed		770 - 862	92
Pomona		862 - 967	105
Selah interbed		967 - 1,051	84
Esquatzel		1,051 - 1,170	119
Cold Creek interbed		1,170 - 1,254	84
Umatilla		1,254 - 1,480	226
Mabton interbed		1,480 - 1,604	124
Wanapum Basalt			
Priest Rapids	II	1,604 - 1,776	172
	I	1,776 - 1,837	61
Roza	II	1,837 - 1,954	117
	I	1,954 - 2,013	59
Frenchman Springs	1	2,013 - 2,207	194
	2	2,207 - 2,306	99
	3	2,306 - 2,363	57
	4	2,363 - 2,481	118
	5		
	6	2,481 - 2,590	109
	7	2,590 - 2,707	117
	8	2,707 - 2,789	82
Vantage interbed		2,789 - 2,795	6
Grande Ronde Basalt			
Grande Ronde	1	2,795 - 2,819	24
	2	2,819 - 2,902	83
	3	2,902 - 3,082	180
	3a		
Cohasset	4	3,082 - 3,323	241
	5	3,323 - 3,441	118
	5a		
	7	3,497 - 3,576	79
McCoy Canyon	8	3,576 - 3,724	148
Umtanum	9	3,724 - 3,922	198
High Mg	9a	3,922 - 3,983	61
below Umtanum			
Very high Mg	10	3,983 - 4,000	TOTAL
	10a		DEPTH
	11		

Note: To convert feet to meters, multiply by 0.3048.

TABLE 7. Borehole RRL-14, Hydrologic Properties.

Interval	Depth below ground surface, ft (m)	Observed hydraulic head above MSL, ft (m)	Preliminary transmissivity, ft ² /sec (m ² /sec)
Cohasset flow interior	3,140-3,313 (957.1-1,009.8)		10-13-10-11 (10-14-10-12)

Hydraulic Head. Due to the low transmissivity of this zone no reliable estimate of hydraulic head was obtained during testing.

Transmissivity. As shown in Table 7, the preliminary range of transmissivity values for the Cohasset flow interior was 10-13 to 10-11 ft²/sec (10-14 to 10-12 m²/sec). Estimates of transmissivity were determined from analysis of field data obtained from overpressure pulse and constant head injection tests.

Storativity. No reliable estimates of storativity were obtained during hydrologic testing due to single borehole testing.

Tests Planned. During the next quarter, hydrologic testing will be focused on obtaining hydrologic properties for the candidate horizon zones.

BOREHOLES DC-4/DC-5

Purpose

Boreholes DC-4 and DC-5 were selected to obtain baseline horizontal hydrologic properties of selected intervals, followed by vertical hydraulic conductivity measurements of selected zones. Hydrologic properties that will be obtained include horizontal and vertical hydraulic conductivity, storativity, hydraulic head, effective porosity, and dispersivity. The present configuration of the dual boreholes will allow for hydrologic testing between DC-4 and DC-5 for several Grande Ronde Basalt intervals. In addition, this configuration will allow for tracer and interference testing with the application of state-of-the-art techniques and equipment.

Location

These boreholes are located on the northern edge of the RRL (Fig. 1). The elevation of the site is approximately 746 ft (227.4 m) above MSL. Borehole DC-4 is located approximately 103 ft (31.4 m) southwest of DC-5. The Washington State coordinates for DC-4 are 454,469.15 ft (138,522.2 m) north and 2,209,990.78 ft (673,605.2 m) east; and for DC-5 are 545,537.3 ft (166,279.8 m) north and 2,210,067.8 ft (673,628.7 m) east.

Borehole Construction Details

The as-built drawings for DC-4 and DC-5 are shown in Figures 7 and 8, respectively. Borehole DC-4 was drilled from March through December 1978 and borehole DC-5 from December 1977 through February 1978.

Borehole DC-4 was drilled to the top of the basalt with a cable tool rig. The surface pipe was drilled and cased 12.25 in. (31.1 cm) OD to a depth of 21 ft (6.4 m). A 12 in. (30.48 cm) diameter hole was then drilled to 375 ft (114.3 m) and an 8 in. (20.32 cm) diameter hole drilled from 375 to 500 ft (114.3 to 152.4 m). A 6.625 in. (16.83 cm) OD casing with a 7.375 in. (18.73 cm) OD drive shoe was run to 500 ft (152.4 m). The hole was then advanced to 623 ft (189.9 m) with a 6 in. (15.24 cm) bit. A 6 in. (15.24 cm) OD casing was driven to 617 ft (188.1 m).

A CP-50 core drill was then set over the hole and a 4.95 in. (12.57 cm) hole was drilled from 623 to 1,538 ft (189.89 to 468.8 m). A 4.5 in. (11.43 cm) OD casing was then cemented in place from the surface to 1,538 ft (468.8 m). The hole was then cored from 1,538 to 2,639 ft (468.8 to 804.4 m) with 3.937 in. (10.0 cm) core bits. A 3.5 in. (8.9 cm) OD casing was then run and cemented to a depth of 2,639 ft (804.4 m). The hole was then cored to a diameter of 3.032 in. (7.70 cm) to a total depth of 3,998 ft (1,218.6 m).

Borehole DC-5 was rotary drilled to 26 in. (66.04 cm) in diameter, to a depth of 42 ft (12.8 m), and 20 in. (50.8 cm) OD conductor casing was cemented in place. The surface hole was then drilled to 17.5 in. (44.45 cm) diameter from 42 to 635 ft (12.80 to 193.55 m) depth. Surface casing, 13.375 in. (33.97 cm) OD, was then cemented to 622 ft (189.6 m) depth. A 12.25 in. (31.12 cm) hole was then drilled to 2,635 ft (803.15 m) and 9.625 in. (24.45 cm) OD string casing was cemented from 2,635 ft (803.15 m). An 8.625 in. (21.9 cm) hole was then drilled to a total depth of 3,990 ft (1,216.15 m).

Hydrologic Description

The stratigraphic intervals tested and monitored during vertical hydraulic conductivity testing during this quarter are listed in Table 8. Vertical hydraulic conductivity testing was performed by injecting fluid into the Cohasset flow top at borehole DC-5 under constant head conditions, and monitoring any pressure response associated with testing at borehole DC-4 for the Cohasset flow top and a confining section of overlying basalt interior Grande Ronde 3. Constant head testing was terminated after 8 weeks of injection. No formational response for testing was discernible in the overlying confining basalt section. Estimates of vertical hydraulic conductivity (i.e., less than values) will be reported following the reduction and analysis of test data.

FIGURE 7. Borehole DC-4, As-Built Drawing.

FIGURE 8. Borehole DC-5, As-Built Drawing.

TABLE 8. Boreholes DC-4/DC-5, Stratigraphic Intervals Tested.

Interval	Depth below ground surface, ft (m)	Borehole relationship	Test interval relationship
DC-5 Cohasset flow top	2,950-3,019 (899.2-920.2)	Injection borehole	Stress zone
DC-4 Cohasset flow top	2,945-3,012 (897.6-918.1)	Observation borehole	Monitored stress zone
Grande Ronde 3 flow interior	2,894-2,942 (882.1-896.7)		Monitored confined zone

Hydraulic Head. The observed static head for the composite Cohasset flow top has not been determined due to the long time the borehole has been open prior to testing.

Storativity. No reliable estimates of storativity were obtained from hydrologic testing due to the single borehole test analysis.

BOREHOLE DC-16A

Purpose

Borehole DC-16A is one of three closely spaced boreholes designed to be used in a cluster to provide hydrologic information in and around the RRL. After completion of drilling and single borehole testing, DC-16A will be used as an observation well during high-stress constant-discharge pumping in selected horizons. Subsurface geologic and hydrologic information obtained from the basalt sequence at borehole DC-16A will support site characterization and repository design.

Location

Borehole DC-16A is located adjacent to the southern border of the RRL (Fig. 1). The ground-surface elevation is about 625 ft (190.5 m) above MSL. The Washington State coordinates for DC-16A are 436,403 ft (133,015.6 m) north and 2,221,516 ft (677,118.1 m) east.

Borehole Construction Details

The proposed and actual as-built borehole construction details for DC-16A are shown on Figure 9.

FIGURE 9. Borehole DC-16A, Predicted and Actual As-Built Drawing.

Prior Drilling Activities. Initial work for DC-16A was completed in June 1981. The sediments overlying the basalt were drilled by the cable tool method to a depth of 602 ft (183.5 m). Between July and December 1981, the 5.25 in. (13.3 cm) diameter hole was drilled to a depth of 1,569 ft (478.2 m) using a Stratmaster Model 100 drill. Reaming and casing operations were conducted between January and March 1982. The borehole was reamed to accept a string of 5.5 in. (14.0 cm) OD steel casing. Between April and September 1982 the borehole was drilled from 1,828 to 2,822 ft (557.2 to 860.1 m) using a 4.828 in. (12.3 cm) diameter bit. Borehole DC-16A was cased with a 4.5 in. (11.4 cm) steel casing to 2,827 ft (861.7 m) and deepened to 3,360 ft (1,024.1 m) between September and December 1982 using a 3.937 in. (10 cm) diamond bit.

Drilling Activities This Quarter. During this quarter, DC-16A was advanced from 3,360 to 3,599 ft (1,024.1 to 1,097 m).

Drilling Schedule. The proposed and actual drill and test schedules for DC-16A are summarized in Figure 10. The borehole drilling and testing were on schedule at the end of this quarter.

Borehole Geophysical Logging

Borehole geophysical logs are used for stratigraphic relationships, selection of potential zones of high or low porosity and permeability, and heat-flow relationships. Geophysical logging was performed by Pacific Northwest Laboratory and included neutron-epithermal neutron, gamma-gamma, natural gamma, sonic, fluid temperature, caliper, and spontaneous potential/resistivity. The various borehole geophysical logs, the logged interval, and the date logged are shown in Table 9.

Geologic Description

The stratigraphic units penetrated by DC-16A from the 2,822 to 3,360 ft (860.1 to 1,024.1 m) depth are shown in Table 10. Core recovered was lithologically and geotechnically logged, photographed, boxed, and then stored at the Hanford Geotechnical Sample Library.

Hydrologic Description

The stratigraphic intervals and hydrologic properties for horizons tested during this quarter are shown in Table 11. Three interflow zones (Cohasset flow bottom, Grande Ronde test interval No. 7, and McCoy Canyon flow top) were hydrologically tested.

Hydraulic Head. The observed hydraulic head for the tested zones is summarized in Table 11. The data indicate a relatively uniform hydraulic head of 402 ft (122.5 m) above MSL.

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FIGURE 10. Borehole DC-16A, Drill and Test Schedule.

TABLE 9. Borehole DC-16A, Geophysical Logs.

Geophysical log	Interval logged, ft (m)	
	2/3/83	2/24/83
Neutron-epithermal neutron	3,493-3,300 (1,064.7-1,005.8)	3,547-3,450 (1,081.1-1,051.6)
Gamma-gamma	--	3,020-2,950 (920.5-899.2)
		3,547-3,450 (1,081.1-1,051.6)
Natural-gamma	--	3,020-2,950 (920.5-899.2)
		3,547-3,450 (1,081.1-1,051.6)
Sonic	3,493-3,300 (1,064.7-1,005.8)	--
Fluid temperature	3,495-2,700 (1,065.3-823.0)	3,546-3,000 (1,080.8-914.4)
Caliper	3,494-3,300 (1,065.0-1,065.3)	3,020-2,950 (920.5-899.2)
		3,547-3,450 (1,081.1-1,051.6)
Spontaneous potential	--	3,020-2,950 (920.5-899.2)
		3,547-3,450 (1,081.1-1,051.6)
Resistivity	--	3,020-2,950 (920.5-899.2)
		3,547-3,450 (1,081.1-1,051.6)

TABLE 10. Borehole DC-16A, Predicted and Observed Stratigraphy.

Flow or interbed		Predicted depth below ground surface, ft	Predicted thickness, ft	Observed depth below ground surface, ft	Observed thickness, ft
Saddle Mountains Basalt					
Elephant Mountain				615 - 684	69
Rattlesnake Ridge				684 - 796	112
interbed				796 - 942	146
Pomona				942 - 996	54
Selah interbed				996 - 1,106	110
Esquatzel				1,106 - 1,179	73
Cold Creek interbed				1,179 - 1,419	240
Umatilla				1,419 - 1,540	121
Mabton interbed					
Wanapum Basalt					
Priest Rapids	II				
	I	1,710 - 1,771	61	1,540 - 1,708	168
Roza		1,771 - 1,947	176	1,708 - 1,771	63
Frenchman Springs	1	1,947 - 2,125	178	1,771 - 1,947	176
	2	2,125 - 2,241	116	1,947 - 2,125	178
	3	2,241 - 2,296	55	2,125 - 2,236	111
	4	2,296 - 2,409	113	2,236 - 2,278	42
	5	2,409 - 2,520	111	2,278 - 2,331	53
	6	2,520 - 2,652	132	2,331 - 2,388	57
	7	2,652 - 2,720	68	2,388 - 2,500	112
	8			2,500 - 2,599	99
	9			2,599 - 2,716	117
Vantage interbed		2,720 - 2,723	3	2,716 - 2,719	3
Grande Ronde Basalt					
Grande Ronde	1a	2,723 - 2,761	38	2,719 - 2,737	18
	1b			2,737 - 2,767	30
	2	2,761 - 2,866	105	2,767 - 2,850	83
	3	2,866 - 3,037	171	2,850 - 2,984	134
	3a			2,984 - 3,028	44
Cohasset	4	3,037 - 3,298	261	3,028 - 3,283	255
	5	3,298 - 3,426	128	3,283 - 3,397	114
	6	3,426 - 3,452	26	3,397 - 3,440	43
	7	3,452 - 3,528	76	3,440 - 3,520	80
McCoy Canyon	8	3,528 - 3,654	126	3,520 -	
Umtanum	9	3,654 - 3,872	218		
Very high Mg	10	3,872 - 3,892	20		
	11	3,892 - 4,104	212		

Note: To convert feet to meters, multiply by 0.3048.

TABLE 11. Borehole DC-16A, Hydrologic Properties.

Interval	Depth below ground surface, ft (m)	Observed hydraulic head above MSL, ft (m)	Preliminary transmissivity, ft ² /sec(m ² /sec)
Cohasset flow bottom	3,254-3,360 (991.8-1,024.1)	402 +1 (122.5±0.3)	10 ⁻⁸ -10 ⁻⁶ (10 ⁻⁹ -10 ⁻⁷)
Grande Ronde test interval No. 7	3,383-3,495 (1,031.1-1,065.3)	402 +1 (122.5±0.3)	10 ⁻⁹ -10 ⁻⁷ (10 ⁻¹⁰ -10 ⁻⁸)
McCoy Canyon flow top	3,512-3,549 (1,070.5-1,081.7)	402 +1 (122.5±0.3)	10 ⁻⁷ -10 ⁻⁵ (10 ⁻⁸ -10 ⁻⁶)

Transmissivity. Values of transmissivity shown in Table 8 were determined by constant-discharge air-lift pumping, slug injection/withdrawal, and constant head injection tests. The transmissivity for the intervals ranged from 10⁻⁹ to 10⁻⁵ ft²/sec (10⁻¹⁰ to 10⁻⁶ m²/sec). The transmissivity values obtained are within the range commonly reported for the Grande Ronde interflows (Strait and others, 1982).

Storativity. No reliable estimates of storativity were obtained from hydrologic testing due to the single borehole testing.

Tests Planned. Hydrologic tests planned for DC-16A include the testing of additional interflow zones of the Grande Ronde Basalt. Three low-permeability tests will also be conducted in the interior of the basalt flows of the Wanapum and Grande Ronde Basalt.

BOREHOLE DC-16B

Purpose

Borehole DC-16B is one of three closely spaced boreholes designed to provide hydrologic information about a large area within the RRL. Borehole DC-16B will be used as the pumping well during hydrologic testing of the cluster boreholes.

Location

Borehole DC-16B is located about 50 ft (15.2 m) directly south of DC-16A as shown in Figure 1. The elevation at borehole DC-16B is 625.1 ft (190.5 m). The Washington State coordinates have not yet been determined.

Borehole Construction Details

The proposed and actual as-built borehole construction details for DC-16B are shown in Figure 11.

DC-16B was completed during the first quarter of 1982 to a depth of 1,600 ft (487.7 m). A screen assembly was set across the Mabton interbed for the cluster tests. Cluster testing will begin in August 1983 and drilling of the remainder of DC-16B will be completed during the summer of 1983.

Geologic Description

Stratigraphic units at DC-16B, as recorded by geologist records, closely matched those of DC-16A. Further details of the units will be obtained from the geophysical logs at a later date. Chip samples were collected at 5 ft (1.5 m) intervals during drilling operations and stored at the Hanford Geotechnical Sample Library.

Hydrologic Description

The Mabton interbed is the only stratigraphic interval tested during this quarter. The hydrologic properties are shown in Table 12.

Hydraulic Head. The observed hydraulic head for the Mabton interbed is summarized in Table 12. The data indicate a hydraulic head of 421 ft (128.3 m) above MSL.

Transmissivity. Values of transmissivity shown in Table 10 were determined by constant-discharge air-lift pumping and constant discharge submersible pumping tests. The transmissivity for the Mabton interbed ranged from 10^1 to 10^0 ft²/sec (10^0 to 10^{-1} m²/sec). The transmissivity values obtained are within the range commonly reported for the Mabton interbed (Gephart and others, 1979).

Storativity. No reliable estimates for storativity were obtained from hydrologic testing due to the single borehole testing.

Tests Planned. At the completion of DC-16A, cluster testing will be completed on the Mabton interbed. Testing will be done before DC-16B is completed at a total depth of approximately 3,720 ft (1,133.9 m).

TABLE 12. Borehole DC-16B, Hydrologic Properties.

Interval	Depth below ground surface, ft (m)	Observed hydraulic head above MSL, ft (m)	Preliminary transmissivity, ft ² /sec (m ² /sec)
Mabton interbed	1,410-1,570 (429.8-478.5)	421 (128.3)	10^1 - 10^0 (10^0 - 10^{-1})

FIGURE 11. Borehole DC-16B, Predicted and Actual As-Built Drawing.

McGEE WELL

Purpose

The drilling and testing of the McGee Well are part of the BWIP subsurface site selection and site characterization activities.

The objectives of testing in the McGee Well are to obtain hydrologic and geologic information from the upper Cold Creek syncline, west of the Cold Creek hydrologic barrier, in an area of relatively high hydraulic head.

Location

The McGee Well is located in the upper Cold Creek Valley approximately 2.5 mi (4 km) west-northwest of the RRL (Fig. 1). The ground surface elevation is about 835 ft (254.5 m) above MSL. Washington State coordinates for the McGee Well are 457,783 ft (139,532.3 m) north and 2,191,784 ft (668,055.8 m) east.

Borehole Construction Details

The proposed and actual as-built borehole construction details for the McGee Well are shown in Figure 12.

Prior Drilling Activities. The McGee Well was drilled in 1927 from ground surface to 978 ft (298.1 m). In 1982, 8 in. (20.3 cm) steel casing was set down through the Mabton interbed into the top of the Priest Rapids basalts at 691 ft (210.6 m). A 4.5 in. (11.4 cm) coupled steel joint casing with an inflatable packer attached was run down to a depth of 983 ft (299.6 m). A Longyear-44 (LY-44) diamond core drilling rig was then moved to the well site. Drilling commenced on June 14, 1982, and advanced from 1,096 to 1,780 ft (334.1 to 542.5 m) using a 3.937 in. (10.0 cm) diamond core bit.

Drilling Activities This Quarter. During this quarter the borehole was advanced from 1,780 to 1,942 ft (542.5 m to 591.9 m) using a 3.937 in. (10.0 cm) diamond bit. All coring utilized triple-tube core barrels. Core recovery for this period exceeded 98%.

Drilling Schedule. The proposed and actual drill and test schedule for McGee is shown on Figure 13. During the first quarter, a total of 162 ft (49.4 m) were drilled and one interval was tested for hydraulic head, hydraulic properties, and hydrochemical determinations. At the end of this quarter the McGee Well was 2 months behind schedule.

Borehole Geophysical Logging

Borehole geophysical logs are used for stratigraphic relationships, selection of potential zones of high or low porosity and permeability, and heat-flow relationships. Geophysical logging was performed by Pacific

FIGURE 12. McGee Well, Predicted and Actual As-Built Drawing.

FIGURE 13. McGee Well, Drill and Test Schedule.

Northwest Laboratory and included neutron-epithermal neutron, sonic, flowmeter, fluid temperature, and caliper. The various borehole geophysical logs, the logged interval, and the date logged are shown in Table 13.

TABLE 13. McGee Well, Geophysical Logs.

Geophysical log	Interval logged, ft (m)
	2/17/83
Neutron-epithermal neutron	1,700-1,831 (518.2-558.1)
Gamma-gamma	--
Natural gamma	--
Sonic	--
Fluid temperature	1,700-1,832 (518.2-558.4)
Caliper	1,400-1,831 (426.7-558.1)
Resistivity and spontaneous potential	--
Flowmeter	1,700-1,831 (518.2-558.1)

Geologic Description

The stratigraphic units penetrated by the McGee Well from 1,780 to 1,942 ft (542.5 to 591.9 m) are shown in Table 14. Core recovered was lithologically and geotechnically logged, photographed, boxed, and then stored at the Hanford Geotechnical Sample Library.

The borehole is presently in the top of the Grande Ronde Basalt. No other boreholes in the upper Cold Creek syncline are stratigraphically deeper than the McGee Well, therefore, the stratigraphic predictions as summarized in Table 14 include a predicted thickness range.

Hydrologic Description

The stratigraphic horizons and hydrologic properties for intervals tested during this quarter are shown in Table 15. All hydrologic testing took place in the Wanapum Basalt and included the Frenchman Springs test interval No. 7.

TABLE 14. McGee Well, Predicted and Observed Stratigraphy.

Basalt flow or interbed		Predicted depth below elevation datum, ft	Predicted thickness, ft	Predicted Thickness range, ft	Observed depth below elevation datum, ft	Observed thickness, ft
Saddle Mountains Basalt						
Umatilla					480 - 548	68
Mabton interbed					548 - 691	143
Wanapum Basalt						
Priest Rapids	II				691 - 820	129
	I				820 - 930	110
Roza	II	- 1105	175		930 - 1070	140
	I				1070 - 1125	55
Frenchman Springs	1	1105 - 1294	189		1125 - 1332	207
	2	1294 - 1392	98		1332 - 1410	78
	3	1392 - 1437	45		1410 - 1453	43
	4	1437 - 1479	42		1453 - 1501	48
	5	1479 - 1544	65		1501 - 1597	96
	6	1544 - 1664	120		1597 - 1695	98
	7	1664 - 1793	129		1695 - 1821	126
	8	1793 - 1861	68		1821 - 1875	154
Vantage interbed		1861 - 1871	10	5 - 20	1875 - 1905	30
Grande Ronde Basalt						
Grande Ronde	1	1871 - 1928	57	48 - 68	1905 -	
	2	1928 - 1983	55	50 - 79		
	3	1983 - 2132	149	140 - 170		
Cohasset	4	2132 - 2390	258	248 - 268		
	5	2390 - 2514	124	115 - 135		
	6	2514 - 2568	54	45 - 65		
	7	2568 - 2634	66	58 - 75		
McCoy Canyon	8	2634 - 2796	162	152 - 172		
Umtanum	9	2796 - 3033	237	227 - 247		
Very high Mg	10	3033 - 3056	23	15 - 40		
	10a		0	0 - 25		
	11	3056 - 3286	230	180 - 255		

Note: To convert feet to meters, multiply by 0.3048.

TABLE 15. McGee Well, Hydrologic Properties.

Interval	Depth below ground surface, ft (m)	Observed hydraulic head above MSL, ft (m)	Preliminary transmissivity, ft ² /sec (m ² /sec)
Frenchman Springs test interflow No. 7	1,765-1,844 (538.0-562.1)	918 $\pm$ 2 (279.8 $\pm$ 1)	10 ⁻⁵ -10 ⁻⁴ (10 ⁻⁶ -10 ⁻⁵)

Hydraulic Head. Hydraulic head determined for the interval tested during this quarter is 918 ± 2 ft (279.8 ± 1 m) and is shown in Table 15. Hydraulic head was determined from surface pressure measured during periods of shut-in.

Transmissivity. Values of transmissivity shown in Table 15 were determined by constant-discharge air-lift pumping, constant drawdown and under-pressure pulse tests. The transmissivity values ranged from 10⁻⁵ to 10⁻⁴ ft²/sec (10⁻⁶ to 10⁻⁵ m²/sec). The transmissivity values obtained are within the range commonly reported for the Wanapum Basalt interflows (Strait and others, 1982).

Storativity. No reliable estimates of storativity were obtained from hydrologic test data due to the single borehole testing.

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