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Preliminary Potentiometric Map and Flow Dynamic Characteristics for the Upper-Basalt Confined Aquifer System

F. A. Spane, Jr.
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September 1993

Prepared for the U.S. Department of Energy
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Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
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PRELIMINARY POTENTIOMETRIC MAP AND FLOW DYNAMIC CHARACTERISTICS FOR THE UPPER-BASALT CONFINED AQUIFER SYSTEM

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Richland, Washington 99352

SUMMARY

This report presents the first comprehensive Hanford Site-wide potentiometric map for the upper-basalt confined aquifer system (i.e., the upper Saddle Mountains Basalt). In constructing the potentiometric map, over forty on-site and off-site monitoring wells and boreholes were used. The potentiometric map developed for the upper-basalt confined aquifer is consistent with the areal head pattern indicated for the Mabton interbed, which is a deeper and more areally extensive confined aquifer underlying the Hanford Site (Spane 1987; DOE 1988)

Salient features for the upper-basalt confined aquifer system potentiometric map include:

- a prominent, broad recharge mound extending northeastward from the Yakima Ridge — 200 West Area
- a small recharge mound immediately east of the 200 East Area, in the vicinity of B Pond
- a hydrogeologic barrier (i.e., ground-water flow impediment) at the mouth of Cold Creek Valley
- the presence of a low hydraulic head (potential discharge) region in the Umtanum Ridge — Gable Mountain structural area
- a high hydraulic head region to the north and east of the Columbia River, associated with recharge attributed to agricultural activities in these areas.

The temporal behavior of hydraulic heads within the upper-basalt confined aquifer on the Hanford Site also exhibited two distinct trend patterns. For monitoring wells located along the eastern Hanford Site boundary, an increase in hydraulic head was observed over the two-year period (March 1991 — March 1993). The head increase ranged between 0.4 and 0.6 m, consistent with the steady, long-term increase reported by DOE (1982 and 1988) for underlying Saddle Mountains and Wanapum Basalt confined aquifers, and is attributed to irrigation activities within the area east of the Columbia River. The fact that hydraulic head values continue to increase in this region indicates that equilibrium conditions have not been re-established for the level of recharge from irrigation occurring in this area.

For monitoring wells not located along the eastern Hanford Site boundary (i.e., in the vicinity of the Columbia River), a decrease in hydraulic head was observed over the same two-year monitoring period. The head decrease ranged between 0.1 and 0.3 m, with the greatest declines occurring in the vicinity of the 200 Areas. The declining head patterns were, in most cases, extremely linear in appearance with no recognizable natural seasonal components evident. The decline in hydraulic head is similar to the pattern reported for the overlying unconfined aquifer, which is attributed to the continuing decline in wastewater discharges to the unconfined aquifer in the 200 Areas (Newcomer 1990; Dresel et al. 1993).

ACKNOWLEDGMENTS

A number of people contributed to the development of this report. In particular, important technical peer review comments were provided by P. D. Thorne. In addition, the editorial review and guidance by N. B. Peacock and graphical support provided by W. D. Webber are also acknowledged.

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1.0 INTRODUCTION

As part of the Ground-Water Surveillance Project, Hanford Site Flow System Characterization Task, Pacific Northwest Laboratory (PNL) examines the potential for off-site migration of contamination within the upper-basalt confined aquifer system for U.S. Department of Energy (DOE). As part of this activity, hydraulic head measurements are monitored within selected wells completed in the upper-basalt confined aquifer system. The routine measurement of hydraulic heads provides areal and temporal information that can be utilized in the development of a potentiometric map for inferring lateral ground-water flow patterns and for assessing the flow dynamics of the monitored system.

This report presents the first comprehensive Hanford Site-wide potentiometric map for the upper-basalt confined aquifer system (i.e., hydrogeologic units within the upper Saddle Mountains Basalt). In constructing the potentiometric map, over forty on-site and off-site monitoring wells and boreholes were used. Tables are provided that present pertinent well completion and water-level measurement information. The potentiometric map developed for the upper-basalt confined aquifer is consistent with the areal head pattern indicated for the Mabton interbed, which is a deeper and more areally extensive confined aquifer underlying the Hanford Site (Spane 1987; DOE 1988). A similar hydraulic head pattern for Rattlesnake Ridge interbed was also developed by Jackson (1992) for the Hanford Site, using a more limited data set.

2.0 HYDROGEOLOGIC DESCRIPTION

The upper-basalt confined aquifer system refers collectively to pervious basalt interflow contacts and intercalated sedimentary interbeds that occur within the upper Saddle Mountains Basalt Formation. Confinement to this aquifer system is provided by silt and clay units within the overlying suprabasalt sediments (i.e., Ringold Formation) and dense, low-permeability interior sections of the basalt flows (e.g., Elephant Mountain). Information presented previously by Gephart et al. (1979) and DOE (1982 and 1988) indicates that confined aquifers within the Saddle Mountains Basalt commonly display a high degree of similarity with respect to hydrochemistry and hydraulic properties, with no obvious hydrostratigraphic divisions present. For the purpose of limiting the scope of this investigation, the lower boundary of the upper-basalt confined aquifer system is arbitrarily placed immediately below the first laterally extensive hydrogeologic unit, which for the Hanford Site is the Rattlesnake Ridge interbed (see Figure 2.1).

It should be noted that previously this aquifer system has been referred to as the upper-confined aquifer. However, in limited areas of the Hanford Site, units of the Lower Ringold Formation (which stratigraphically overlies the Saddle Mountains Basalt) can also be locally confined. Where this hydrologic condition occurs, the Lower Ringold units have been grouped by some investigators with the underlying Saddle Mountains Basalt as part of the upper-confined aquifer system. This report pertains solely to pervious hydrogeologic units within the upper Saddle Mountains Basalt which, for the purpose of avoiding confusion, are referred to collectively as the upper-basalt confined aquifer system.

Within Pasco Basin, the Rattlesnake Ridge interbed is the thickest and most widespread sedimentary unit that occurs intercalated within the upper Saddle Mountains Basalt. Stratigraphically the interbed is assigned to the Ellensburg Formation and occurs at the boundary contact between the Elephant Mountain and Pomona basalt flows (Figure 2.1). The interbed varies in thickness from 0 to 33 m. Figure 2.2 is an isopach map that displays the thickness distribution for the interbed within Pasco Basin. As indicated, the interbed is absent primarily in the area to the west of the Hanford Site and within the Hanford Site in the vicinity of the Gable Mountain – Gable Butte structural area. As will be discussed, this absence in the area immediately north of the 200 East Area is of particular hydrogeologic importance.

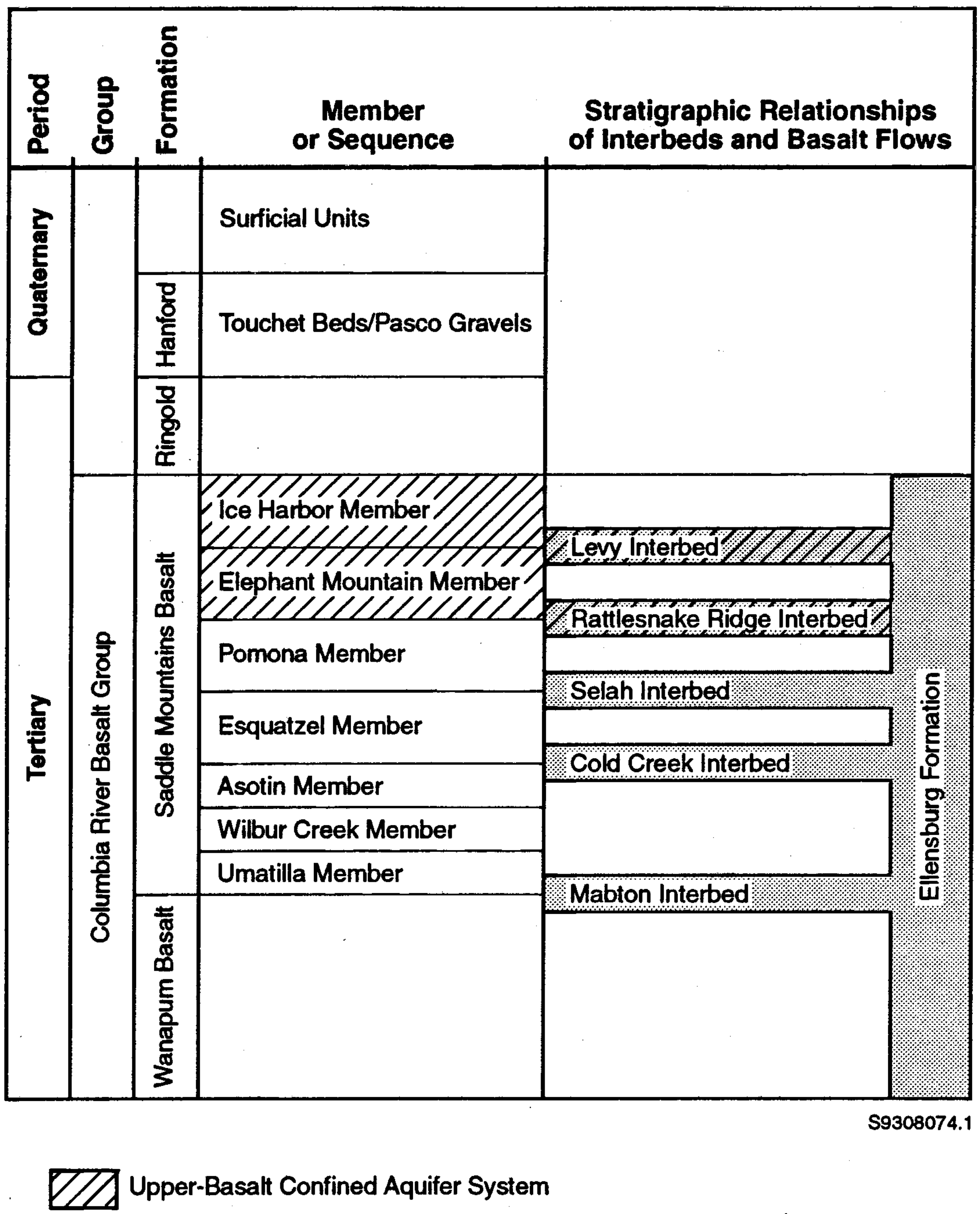

FIGURE 2.1. General Stratigraphic Relationships within Pasco Basin

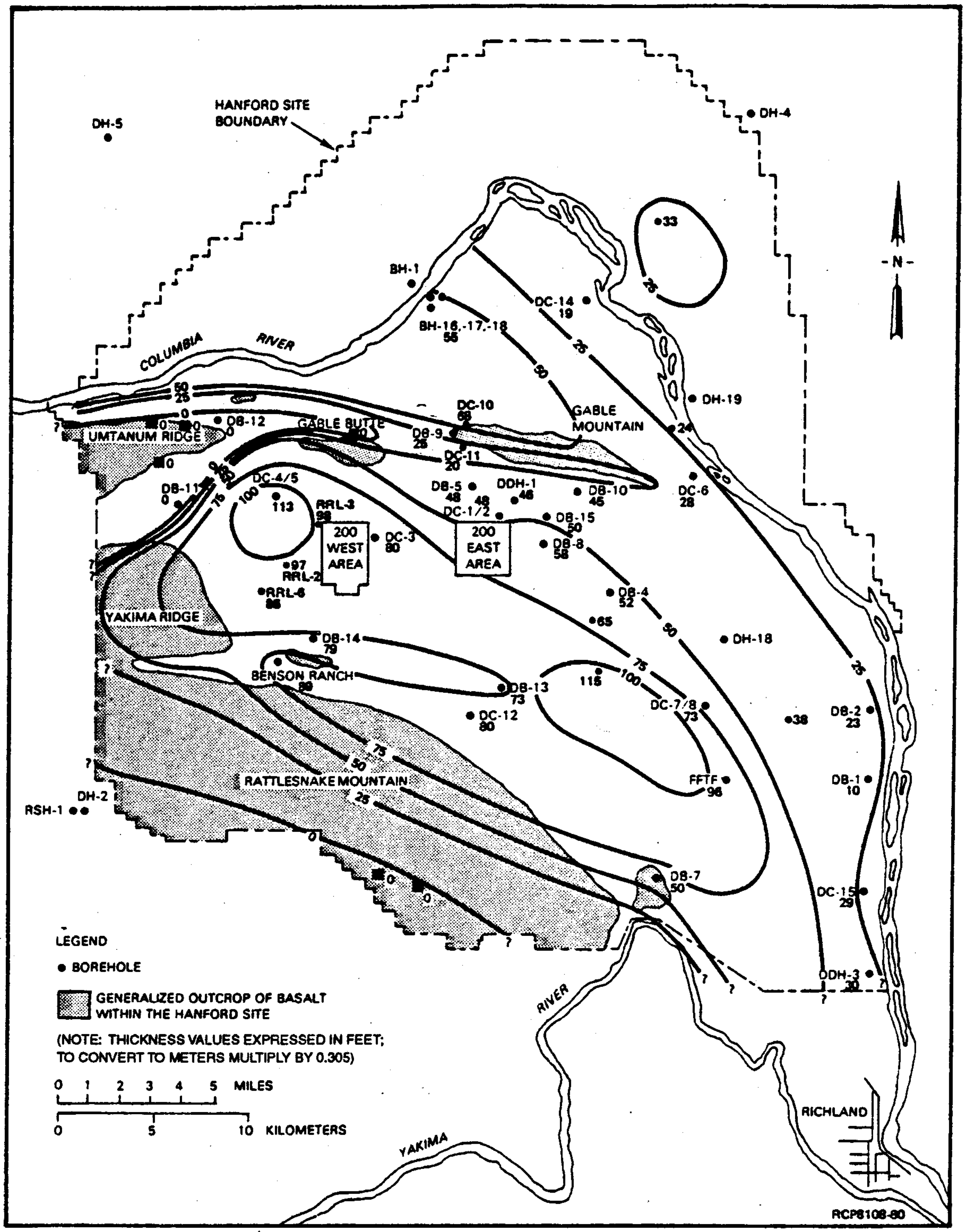

FIGURE 2.2. Isopach Map of the Rattlesnake Ridge Interbed on the Hanford Site (adapted from Reidel and Fecht 1981)

Reidel and Fecht (1981) report that areally the Rattlesnake Ridge interbed can be divided into three distinct facies based on lithology and texture:

- First Facies occurs primarily in the Cold Creek syncline area and consists of three units: (1) a lower clay or tuffaceous sandstone; (2) a middle, micaceous-arkosic and/or tuffaceous sandstone; and (3) an upper, tuffaceous siltstone or tuffaceous sandstone.
- Second Facies occurs in areas where the unit is relatively thin, and consists of a single, tuffaceous sandstone to siltstone unit.
- Third Facies is limited to the northwest section of Pasco Basin, similar in lithology and texture to first facies, but contains a conglomerate with plutonic and metamorphic clasts near its base.

Permeable sandstone units within the interbed are important hydrogeologically in the lateral transmission of ground water. Because of its areal extent, hydraulic properties, and thickness, the Rattlesnake Ridge interbed represents the most important hydrogeologic unit within the upper-basalt confined aquifer system for the potential offsite migration of contamination.

Other locally important hydrogeologic units within the upper-basalt confined aquifer system include the overlying Levey interbed, which occurs along the southern boundary of the Hanford Site, and a pervious interflow contact between two Elephant Mountain basalt flows (i.e., the Elephant Mountain and Ward Gap flows), which occurs in the eastern half of the Hanford Site. Although not as areally extensive as the underlying Rattlesnake Ridge interbed, where these units occur, their hydraulic property characteristics warrant their inclusion in the upper-basalt confined aquifer system. Wells and boreholes completed in the overlying Levey interbed or Elephant Mountain basalt were also included in the preparation of the potentiometric map for the upper-basalt confined aquifer system.

3.0 POTENTIOMETRIC MAP DEVELOPMENT

The following is a brief discussion of the definition, derivation, limitations, and uses of potentiometric maps. Except where noted, the text material is taken largely from Spane (1987).

For Darcian ground-water flow conditions (i.e., for low fluid velocities), hydraulic head can be defined as the energy per unit weight for a fluid of uniform density. In a two-dimensional ground-water flow system, such as an aquifer confined between adjacent low-permeability units, point measurements of hydraulic head can be used to construct a potentiometric map that represents the areal distribution of hydraulic potential within the aquifer. Potentiometric maps can be used to infer directions of ground-water movement, with flow occurring normal to contours of equal potential in systems with isotropic hydraulic conductivity.

Hydraulic head values are commonly determined from field water-level measurements taken within wells that penetrate or isolate an individual aquifer or aquifer system. Hydraulic head measurements are normally expressed as an elevation above a prescribed datum, which for most hydrological investigations is mean sea level. The "observed" hydraulic head, H_o, can be expressed as:

$$H_o = E - h_w \tag{1}$$

where H_o = observed hydraulic head under existing field conditions [L]

E = elevation of datum from which field measurement is made [L]

h_w = depth from datum to the fluid-column surface within the monitoring well [L].

In formations having isotropic hydraulic properties, observed hydraulic heads can be used to develop potentiometric maps and infer lateral ground-water flow directions. In situations where fluid-column densities vary significantly within the study area, observed hydraulic heads must be corrected to a reference density fluid prior to use in potentiometric maps. The reference density fluid normally used in hydrologic investigations is water at standard temperature and pressure conditions, with a density equal to 1.00 g/cm^3 (actually 0.999014 g/cm^3; Spane and Mercer 1985). The observed hydraulic head value corrected to this reference density fluid is referred to as a fresh-water head (Lusczynski 1961; De Wiest 1969).

The fresh-water head (H_{fw}) can be expressed in a modification of the basic equation for observed hydraulic head, Equation (1):

$$H_{fw} = [(P_f - P_a)/p_{fw}\, g] - z_i \qquad (2)$$

and

$$H_o = [(P_f - P_a)/p_o\, g] - z_i \qquad (3)$$

where

$$P_f = [(p_o\, g)h_{fc}] - z_i \qquad (4)$$

and P_f = formation pressure at measuring point i within the aquifer/well fluid column [F/L^2]

P_a = atmospheric pressure at the well fluid-column surface [F/L^2]

p_{fw} = density of fresh-water at standard temperature and pressure conditions (0.999014 g/cm^3 [M/L^3]

p_o = average density of well fluid column above measuring point i [M/L^3]

g = acceleration due to gravity (9.80665 m/s^2) [L/T^2]

h_{fc} = height of well fluid column above measuring point i [L]

z_i = elevation at measuring point i [L].

Contouring areal fresh-water heads produces a relief map of the potentiometric surface within a hydrogeologic unit, from which lateral energy gradients and areas of high and low potential can be delineated (Toth 1978). Analysis of a fresh-water potentiometric surface provides qualitative information concerning the lateral direction and rate of ground-water flow. As noted by Toth (1978), the quantitative interpretation of a potentiometric surface (e.g., for ground-water flow velocity calculations) for a laterally continuous unit is strictly valid only if the distribution of permeability is known, no vertical potential gradients exist, and the formation fluid density remains constant or varies only as a function of pressure.

Rarely are these conditions met in hydrologic studies. This is because vertical potential gradients (and, therefore, vertical leakage through adjoining confining zones) nearly always exist and variations in fluid density also occur. The cited limiting conditions, however, do not preclude the qualitative use of potentiometric maps. In most cases, potentiometric surface information can be used for inferring lateral ground-water flow patterns even in deep geologic basins that possess areally varying formation fluid densities (Hitchon 1969).

The potentiometric map and inferred ground-water flow relationships for the upper-basalt confined aquifer contained in this report are considered preliminary. This is due to the fact that the potentiometric map and inferred ground-water flow directions are based solely on observed hydraulic head data. As indicated in Equations (1) through (4), conversion of observed hydraulic head measurements to equivalent fresh-water head values requires that the average fluid-column density at each measurement site be known.

Spane and Mercer (1985) present a computer program, HEADCO, that can be used to calculate fresh-water head values from field measurements. Figure 3.1 is a schematic of the field-measurement conversion process. As indicated, calculation of the fresh-water head at individual measurement locations requires that the average fluid-column density be known. Spane and Mercer (1985) indicate that, under Hanford Site conditions, the following factors exert the most significant effect on fluid-column density (in decreasing order of importance): fluid-column temperature, hydrostatic pressure, and fluid salinity. Using HEADCO for calculating fresh-water heads, therefore, requires that the fluid-column temperature profile (or fluid temperature versus depth relationship) and average fluid-column salinity are known at each site. This information is currently unavailable for all upper-basalt aquifer measurement sites.

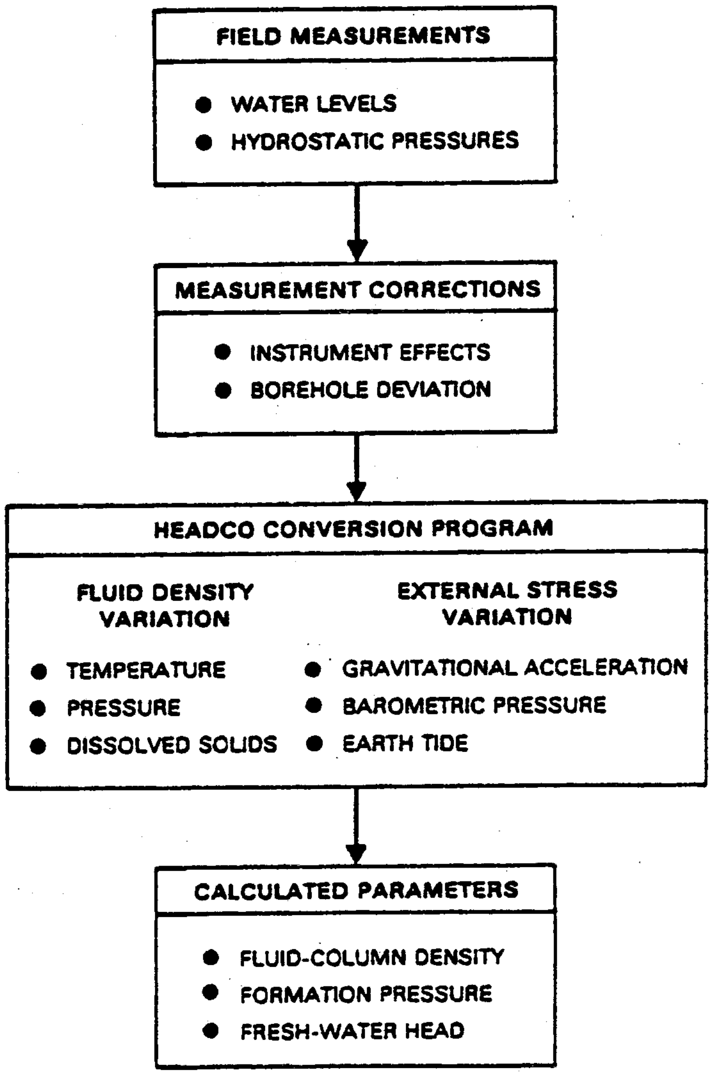

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FIGURE 3.1. Schematic for Conversion of Field Measurements to Fresh-Water Head Values, Using the HEADCO Program (adapted from Spane and Mercer 1985)

In addition, the effects of external stresses (e.g., barometric pressure, river-stage fluctuations) should be known and removed from the field measurements. The removal of external stresses requires the systematic correlation of baseline head monitoring measurements with observed external stress fluctuations. Once the relationship between the external stress and well hydraulic head measurements is established, the rise or decline of the external stress from a standard external-stress reference value can be effectively removed from the hydraulic head measurement. For example, for the removal of barometric pressure variations from hydraulic head measurements at the Hanford Site, Spane (1987) used the long-term atmospheric pressure value (98.916 kPa) recorded at the Hanford Meteorological Station as the reference value. Only a few of the upper-basalt, confined aquifer head measurement sites have long-term monitoring data of sufficient detail to determine external stress relationships. Those with established barometric effect relationships are indicated in Appendix A. An example of the effective removal of external stresses (i.e., barometric and Columbia River stage fluctuations) from Hanford Site head measurements is presented in Spane (1993).

Because temperature/depth profiles, fluid-column salinity, and external-stress effect relationships were not known for all the head measurement sites, these effects were not accounted for in developing the preliminary potentiometric map, which is based on observed head measurements. It should be noted, however, that effects associated with fluid-column density differences and external stresses are expected to be minor. Therefore, because of the small corrections involved (i.e., compared with lateral gradient magnitudes), areal observed and fresh-water head data should indicate a similar pattern of inferred ground-water flow within the upper-basalt confined aquifer system. A similar conclusion was reported in Spane (1987) in constructing a fresh-water potentiometric map for the Mabton interbed, which marks the lower stratigraphic boundary of the Saddle Mountains Basalt (see Figure 2.1).

3.1 DATA AVAILABILITY

In developing the potentiometric map for the upper-basalt confined aquifer system, five measurement sources of monitoring well and borehole hydraulic head information were utilized. The sources included:

- on-site monitoring wells completed primarily within the Rattlesnake Ridge interbed

- on-site monitoring wells completed within other hydrogeologic units of the upper Saddle Mountains Basalt (e.g., Elephant Mountain interflow contact, Levey interbed) overlying the Rattlesnake Ridge interbed
- on-site boreholes completed in the top of the upper Saddle Mountains Basalt
- inactive on-site monitoring wells formerly completed within hydrogeologic units of the upper Saddle Mountains Basalt
- off-site private/domestic wells completed within the upper Saddle Mountains Basalt

Pertinent information concerning well completions, principal hydrogeologic units monitored, and hydraulic head measurements for well/borehole sites used in development of the potentiometric map are provided in the appropriate appendices.

3.2 INTERPRETATION

Plate 1 (in pocket, inside back cover) is the preliminary potentiometric map and inferred ground-water flow pattern, based on observed head values measured for the upper-basalt, confined aquifer system. The potentiometric map shown in Plate 1 was developed primarily from measurements obtained during March 1993. This time period was selected to minimize the effects of offsite irrigation activities and seasonal river-stage fluctuations of the Columbia River. Data obtained from active monitoring sites completed within the Rattlesnake Ridge interbed or upper Saddle Mountains Basalt were used directly in the construction of the potentiometric map. In areas where these data sources were not available, hydraulic head measurements obtained from inactive measurement sites (i.e., measurements obtained for an earlier time period) or for active wells completed in the top of the upper Saddle Mountains Basalt were utilized; however, with less reliance.

The inferred lateral flow pattern shown in Plate 1 is believed to be representative of steady-state, ground-water flow conditions within the upper-basalt, confined aquifer system, and is nearly identical with patterns delineated previously in Spane (1987) and DOE (1988) for the Mabton interbed, which marks the lower stratigraphic boundary of the Saddle Mountains Basalt (see Figure 2.1). Salient features shown in Plate 1 for the upper-basalt confined aquifer system include the following:

- a prominent, broad recharge mound extending northeastward from the Rattlesnake Hills – 200 West Area
- a small recharge mound immediately east of the 200 East Area, in the vicinity of B Pond
- a hydrogeologic barrier (i.e., ground-water flow impediment) at the mouth of Cold Creek Valley, across which hydraulic heads decrease approximately 80 m within the lower Saddle Mountains and upper Wanapum Basalt formations
- the presence of a low hydraulic head potential discharge region in the Umtanum Ridge – Gable Mountain structural area
- a high hydraulic head region to the north and east of the Columbia River, associated with recharge attributed to agricultural activities in these areas.

Similar conclusions are reported by Jackson (1992) and Dresel et al. (1993) for the Rattlesnake Ridge interbed, using a more limited data set.

The broad recharge mound extending from the Rattlesnake Hills – 200 West Area is believed attributable to a combination of 1) natural recharge that occurs within the Dry Creek drainage of the Rattlesnake Hills and 2) localized artificial recharge to the overlying unconfined aquifer (and eventually the upper-basalt aquifer) from past wastewater disposal to U Pond in the 200 West Area. The potential for possible hydrogeologic communication between the unconfined aquifer and hydrogeologic units of the underlying upper-basalt aquifer in this area was noted previously in Spane et al. (1980). The lateral ground-water flow pattern within the upper-basalt confined aquifer is strongly influenced by the presence of the ground-water mound, and causes ground water to flow radially away from this feature (primarily to the north and east) in the western section of the Hanford Site.

Examination of Plate 1 also indicates the presence of a small recharge mound immediately east of the 200 East Area, near B Pond. The recharge mound is associated with local artificial recharge to the unconfined aquifer and underlying upper-basalt aquifer system from wastewater disposal activities at the B pond complex. The potential for possible hydrogeologic communication between the unconfined aquifer and the underlying upper-basalt aquifer in this area was noted previously in Gephart et al. (1979) and Graham et al. (1984). The lateral ground-water flow pattern within the upper-basalt confined aquifer is locally distorted by the presence of this ground-water mound, and causes ground water to flow radially away from this feature (primarily to the northwest and east) in this central region of the Hanford Site.

The presence of a hydrologic barrier (Cold Creek flow impediment) in the upper Cold Creek syncline was first postulated by Newcomb (1969), based on the significant lateral decrease in hydraulic head that occurred for irrigation wells completed in the upper Wanapum Basalt. The nature and geometry of the hydrogeologic feature are not completely understood. However, available well data suggest that the Cold Creek flow impediment interrupts the lateral hydraulic head gradient within the Saddle Mountains, Wanapum, and Grande Ronde Basalts, and extends north – south from the Umtanum Ridge – Gable Mountain structure to Yakima Ridge (Spane 1987; DOE 1988). Identified hydrogeologic units of the upper-basalt confined aquifer system (e.g., Rattlesnake Ridge interbed, Elephant Mountain basalt interflow contact) are not present to the west of this feature. The potentiometric pattern shown suggests that the feature (possibly a fault) acts as an impermeable barrier with no major ground-water transference occurring (either laterally or vertically).

The presence of a low hydraulic head (potential discharge) region in the Umtanum Ridge - Gable Mountain structural area is attributed to the postulated hydraulic intercommunication that occurs between overlying and underlying aquifer systems. Increased hydraulic intercommunication is attributed to the absence of upper-basalt hydrogeologic units, structural deformation, and the presence of erosional paleostream channels in this region (Gephart et al. 1979; Spane 1982; Graham et al. 1984; DOE 1988). Early et al. (1988) also report that hydrochemical data and temporal hydrologic response information support the contention of significant hydraulic intercommunication and downward ground-water movement, from the unconfined and upper-basalt confined aquifers to underlying confined aquifers of the lower Saddle Mountains and Wanapum Basalts within this region.

The high hydraulic head region to the north and east of the Columbia River is associated with recharge attributed to agricultural activities in these areas. The effects of recharge from irrigation and canal leakage (conveyance loss) east of the Columbia River have caused a significant increase in head and hydraulic gradients in this area. The potentiometric map pattern suggests that ground-water in the region northeast of Gable Mountain flows southwest and discharges primarily to underlying confined aquifer systems in the Umtanum Ridge – Gable Mountain structural area. The Columbia River, therefore, does not represent a dominant line-sink discharge area for the upper-basalt confined aquifer along this reach of the river. As will be discussed in

Section 4.0, the temporal hydraulic head pattern for upper-basalt monitoring wells located immediately west of the Columbia River exhibits a trend of increasing hydraulic head, indicating that equilibrium conditions have not been reestablished for the level of recharge that is occurring to the east of the Columbia River. The trend of increasing hydraulic head has also been observed on the Hanford Site for deeper confined aquifer systems within the lower Saddle Mountains and Wanapum Basalts (e.g., Swanson and Leventhal 1984; DOE 1988).

4.0 FLOW SYSTEM DYNAMICS

In this section, the temporal fluctuation of hydraulic heads within the upper-basalt confined aquifer system is examined to provide associations with natural and man-related stresses to the system. As discussed in DOE (1988), the temporal responses exhibited by Hanford Site confined-aquifer monitoring wells are functions of:

- proximity to sources of recharge and discharge
- magnitude and time distribution of recharge and discharge
- presence of intervening geologic structures
- possible river and geologic outcrop relationships.

To provide information concerning recent temporal hydraulic head trends, twenty-six on-site monitoring wells completed in the upper-basalt aquifer were measured quarter-annually between March 1991 and March 1993. Figure 4.1 shows the locations of the monitoring well sites. For comparison, linear-regression analysis was applied to the head measurement values obtained at each monitoring well site. Table 4.1 summarizes the results of the regression analysis. The following temporal patterns within the upper-basalt aquifer system were exhibited:

Area Near Eastern Hanford Site Boundary: a trend of increasing head and significant river-stage fluctuation effects

General Hanford Site Area: a trend of decreasing head and no significant natural seasonal effects.

For monitoring wells located along the eastern Hanford Site boundary, an increase in hydraulic head was observed over the two-year period. The head increase ranged between 0.2 and 0.4 m/yr, consistent with the steady, long-term increase reported by DOE (1982 and 1988) for underlying Saddle Mountains

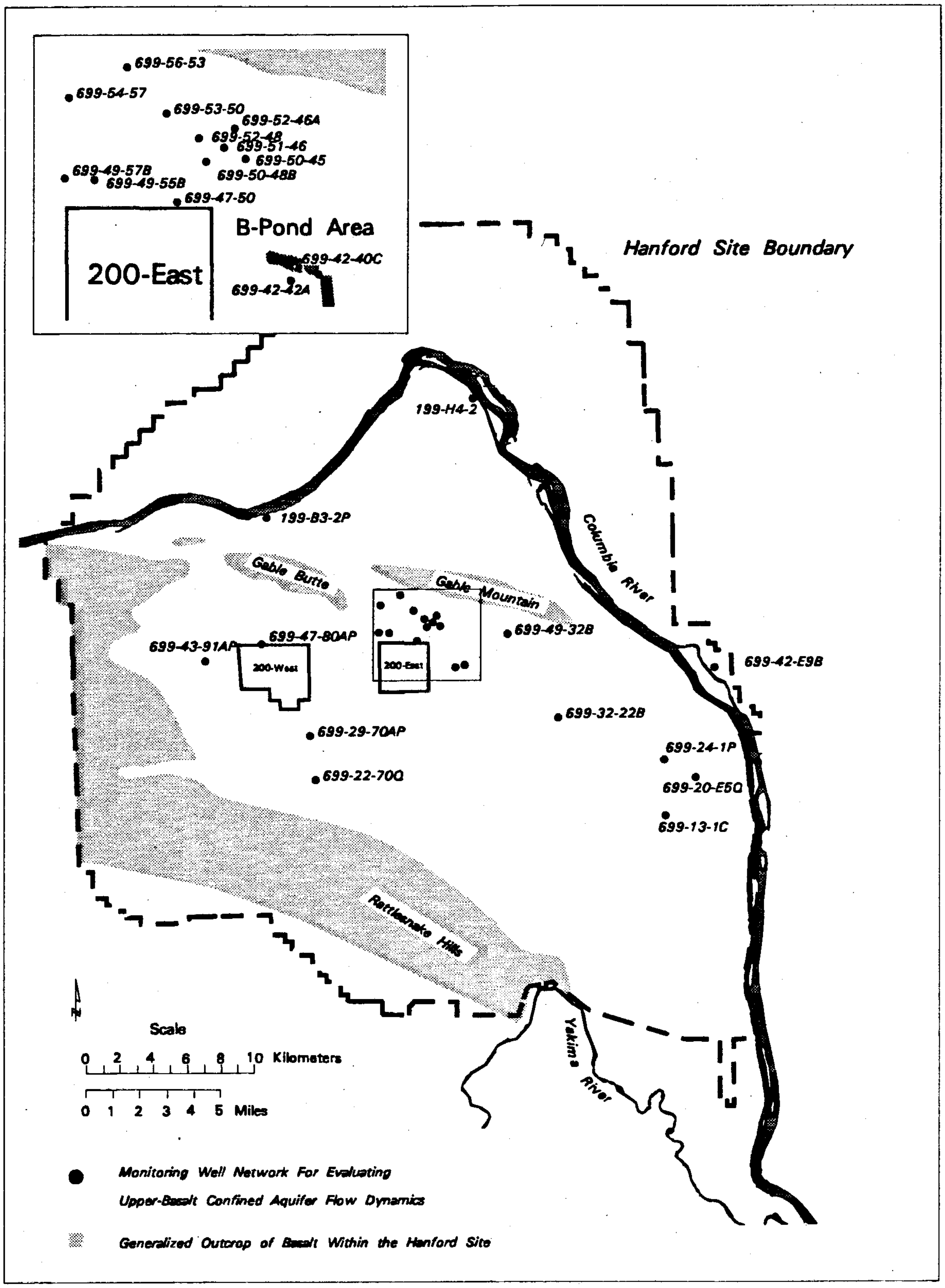


FIGURE 4.1. Locations of Monitoring Wells Used for Evaluating Flow Dynamic Characteristics of the Upper-Basalt Confined Aquifer

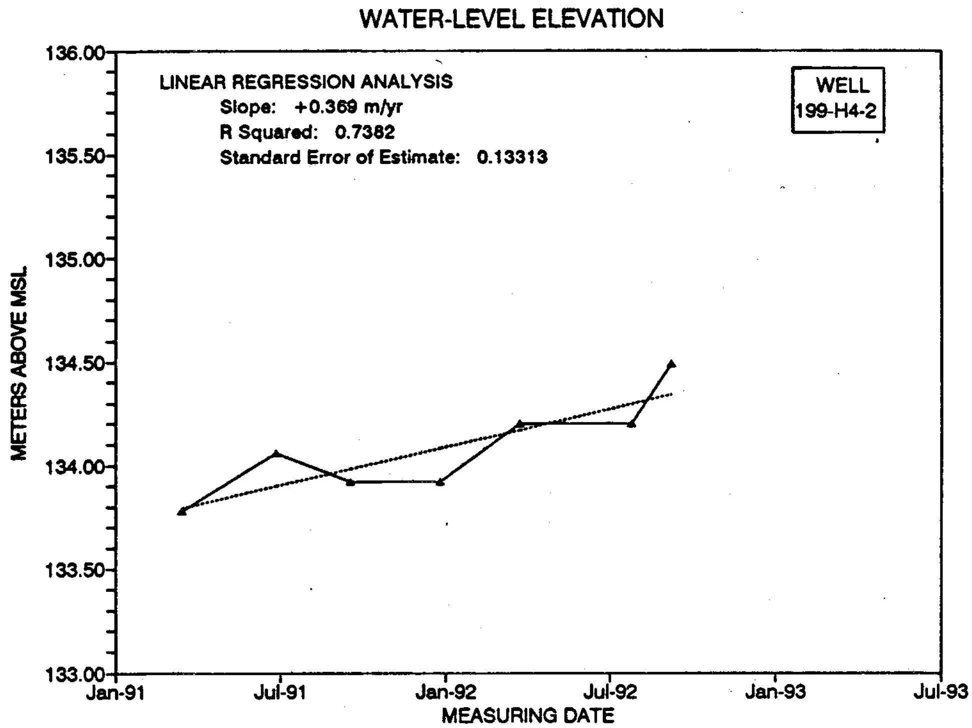
TABLE 4.1 Results of Linear-Regression Analysis for Determination of Hydraulic Head Trends within the Upper-Basalt Aquifer at Selected Hanford Site Monitoring Wells.

Well	Coefficient of Determination (r^2)	Standard Error of Estimate	Linear Trend (m/yr)	Comments
199-B3-2P	0.2844	0.69517	-0.601	influenced by river
199-H4-02	0.7382	0.13313	+0.369	influenced by river
699-13-01C	0.3683	1.66167	-1.941	influenced by water-supply pumping
699-20-E5Q	0.7825	0.02465	-0.065	
699-22-70	0.7835	0.07195	-0.184	
699-22-70Q	0.7830	0.05985	-0.147	
699-24-01P	0.7457	0.10144	+0.240	
699-29-70AP	0.7850	0.06293	-0.165	
699-32-22B	0.9390	0.04955	+0.396	influenced by well construction
699-42-E9B	0.1270	0.47136	-0.281	influenced by well construction
699-42-40C	0.8668	0.06791	-0.240	
699-42-42A	0.7846	0.06580	-0.174	
699-43-91AP	0.9124	0.05543	-0.228	
699-47-50	0.8946	0.04648	-0.187	
699-47-80AP	0.9341	0.03544	-0.182	
699-49-32B	0.7175	0.05487	-0.122	
699-49-55B	0.8471	0.06298	-0.204	
699-49-57B	0.9588	0.03305	-0.245	
699-50-45	0.9594	0.02317	-0.155	
699-50-48B	0.9533	0.02849	-0.177	
699-51-46	0.9651	0.02232	-0.161	
699-52-46A	0.9670	0.01853	-0.138	
699-52-48	0.9785	0.01875	-0.174	
699-53-50	0.9497	0.02996	-0.179	
699-54-57	0.9395	0.04066	-0.220	
699-56-53	0.9330	0.04701	-0.241	

and Wanapum Basalt confined aquifers. The head increase noted for deeper confined aquifers is attributed to large-scale irrigation activities within the area east of the Columbia River. The fact that hydraulic head values continue to increase in this region indicates that equilibrium conditions have not been reestablished for the level of recharge occurring to the east of the Columbia River.

Figure 4.2 shows the increasing head pattern exhibited for Well 199-H4-2 and 699-24-1P. The head patterns shown do not exhibit obvious Columbia river-stage fluctuation effects, as might be expected. This is attributed to the infrequent, discrete nature of the hydraulic head measurements. Figure 4.3 illustrates the close correlation between hydraulic head measurements at well 199-H4-2 and the Columbia River stage fluctuations, as recorded over a four-day period with frequent measurements. As indicated, a close association between river-stage fluctuation and hydraulic head response is exhibited.

Trend analysis results listed in Table 4.1 for all monitoring wells not located along the eastern Hanford Site boundary (i.e., in the vicinity of the Columbia River) recorded a decrease in hydraulic head over the two-year monitoring period. The head decrease ranged between 0.1 and 0.3 m/yr, with the greatest declines occurring in the vicinity of the 200 Areas. The declining head patterns were, in most cases, extremely linear in appearance with no recognizable natural seasonal components. The decline in hydraulic head is similar to the pattern reported for the overlying unconfined aquifer, attributed to the continuing decline in wastewater discharges to the unconfined aquifer in the 200 Areas (Newcomer 1990; Dresel et al. 1993). Figure 4.4 shows the declining head pattern evident for Well 699-29-70AP and 699-50-48B located in proximity to the 200 West and 200 East Areas, respectively.



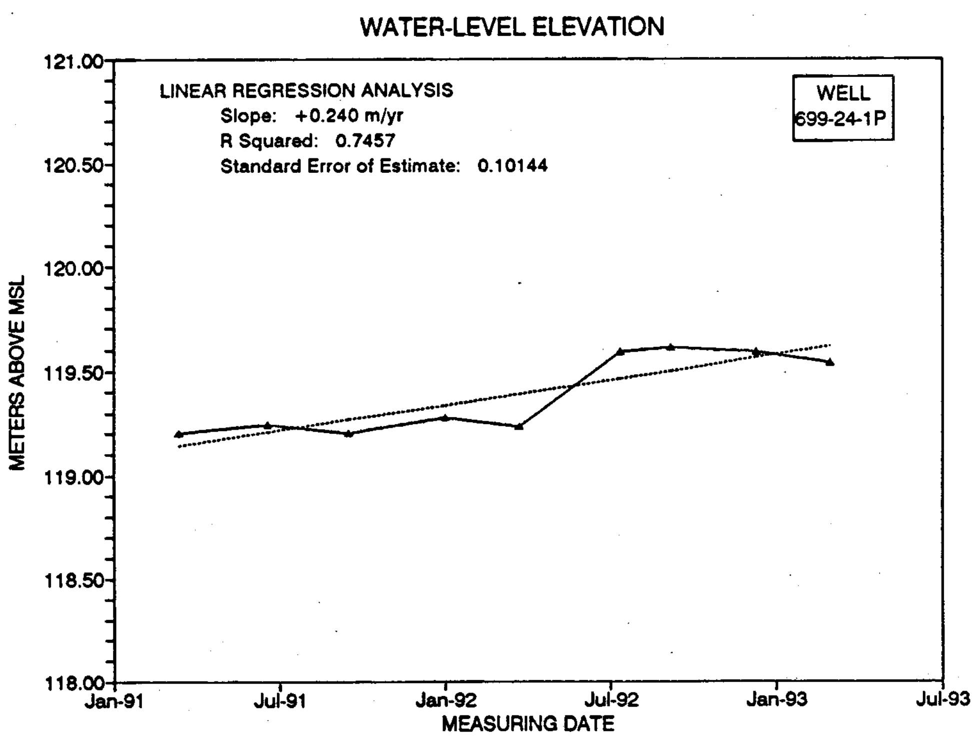


FIGURE 4.2. Temporal Hydraulic Head Measurement Responses for Wells 199-H4-2 and 699-24-1P

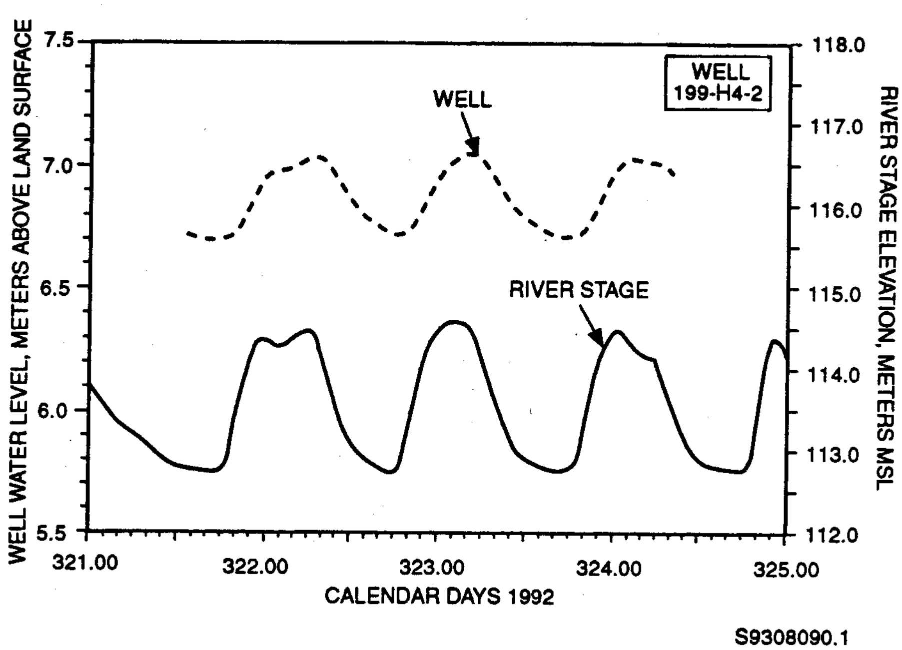
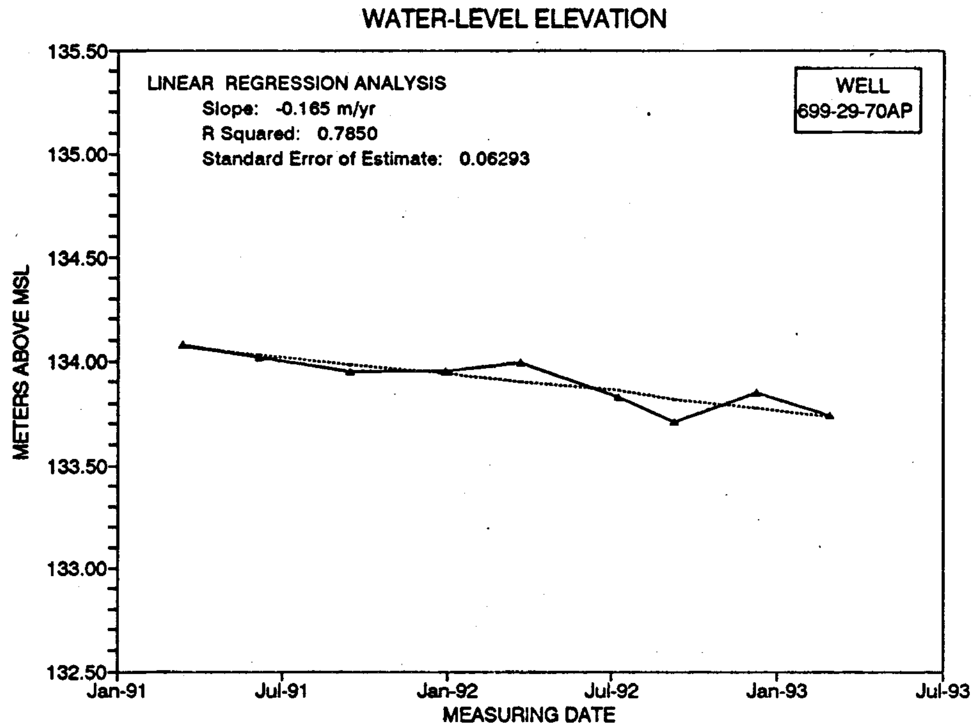
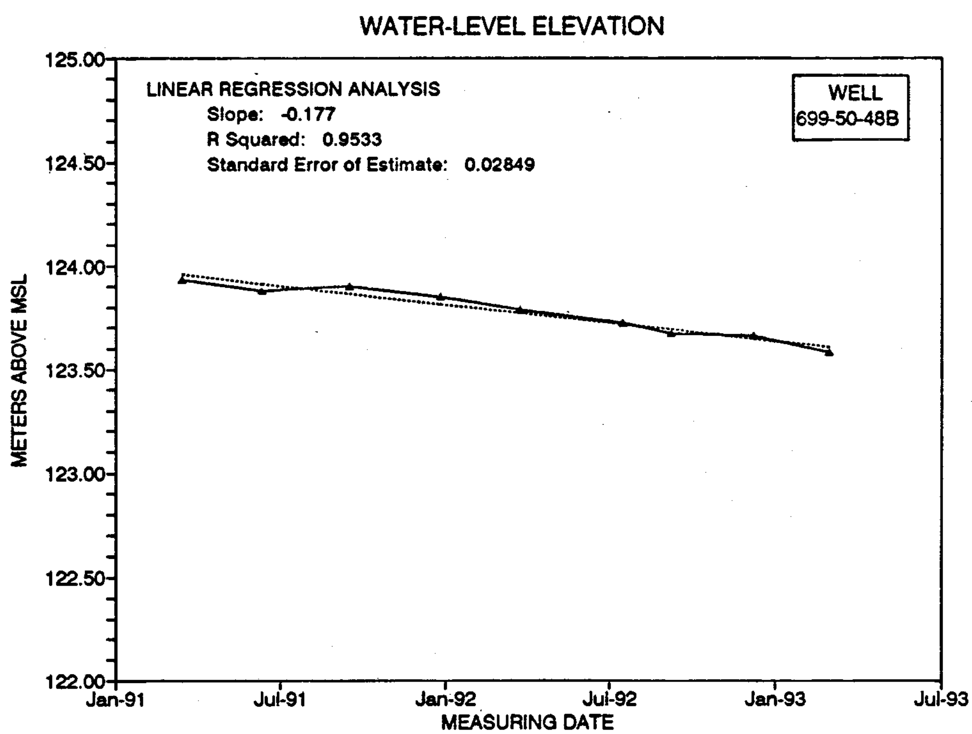


FIGURE 4.3 Short-Term Comparison of Columbia River-Stage Fluctuations and Hydraulic Head Measurements at Well 199-H4-2





<u>FIGURE 4.4</u>. Temporal Hydraulic Head Measurement Responses for Wells 699-29-70AP and 699-50-48B

5.0 REFERENCES

De Wiest, R.J.M. 1969. *Flow Through Porous Media.* Academic Press, New York and London.

DOE (U.S. Department of Energy). 1982. *Site Characterization Report for the Basalt Waste Isolation Project.* DOE/RL 82-3, 3 Vols., U.S. Department of Energy, Richland, Washington.

DOE (U.S. Department of Energy). 1988. *Consultant Draft, Site Characterization Plan, Reference Repository Location, Hanford Site, Washington.* DOE/RW-0164, Vols. 1 and 2, U.S. Department of Energy, Washington, D.C.

Dresel, P. E., D. R. Newcomer, J. C. Evans, W. D. Webber, F. A. Spane, Jr, R. G. Raymond, and B. E. Opitz. 1993. *Hanford Site Ground-Water Monitoring for 1992.* PNL-8716, Pacific Northwest Laboratory, Richland, Washington.

Early, T. O., S. H. Hall, and V. G. Johnson. 1988. "Tritium, Carbon-14, and Iodine-129 as Indicators for Localized Vertical Recharge Along an Anticline in the Columbia River Basalts Using a Decay-Corrected Mixing Model." In *Proceedings of the Ground Water Geochemistry Conference*, February 16-18, 1988, Denver, Colorado, pp. 597-620. National Water Well Association, Dublin, Ohio.

Gephart, R. E., R. C. Arnett, R. G. Baca, L. S. Leonhart, and F. A. Spane, Jr. 1979. *Hydrologic Studies Within the Columbia Plateau Washington: An Integration of Current Knowledge.* RHO-BWI-ST-5, Rockwell Hanford Operations, Richland, Washington

Graham, M. J., G. V. Last, and K. R. Fecht. 1984. *An Assessment of Aquifer Intercommunication in the B Pond - Gable Mountain Pond Area of the Hanford Site.* RHO-RE-ST-12 P, Rockwell Hanford Operations, Richland, Washington.

Hitchon, B. 1969. "Fluid Flow in the Western Canada Sedimentary Basin - 2: Effect of Geology." *Water Resources Research* 5 (2):460-469.

Jackson, R. L. 1992. *Potentiometric Map of the Rattlesnake Ridge Interbed, Hanford Site.* WHC-SD-ER-IT-008, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Lusczynski, N. J. 1961. "Head and Flow of Ground Water of Variable Density." *Journal of Geophysical Research* 66 (12):4247-4256.

Newcomb, R. C. 1969. *Effect of Tectonic Structure on the Occurrence of Ground Water in the Basalt of the Columbia River Group of the Dalles Area, Oregon and Washington.* U.S. Geological Survey, Professional Paper 383-C, pp. C1-C33.

Newcomer, D. R. 1990. *Evaluation of Hanford Site Water-Table Changes - 1980 to 1990.* PNL-7498, Pacific Northwest Laboratory, Richland, Washington.

Reidel, S. P., and K. R. Fecht. 1981. "Wanapum and Saddle Mountains Basalts of the Cold Creek Syncline Area." In *Subsurface Geology of the Cold Creek Syncline*, eds. C. W. Myers and S. M. Price, pp. 3-1 to 3-45. RHO-BWI-ST-14, Rockwell Hanford Operations, Richland, Washington.

Spane, F. A., Jr. 1982. "Hydrologic Studies Within the Pasco Basin." In *Proceedings of the 1982 National Waste Terminal Storage Program Information Meeting*, pp. 23-28. U.S. Department of Energy, DOE/NWTS-30, Richland, Washington.

Spane, F. A., Jr. 1987. *Fresh-Water Potentiometric Map and Inferred Flow Direction of Ground Water Within the Mabton Interbed, Hanford Site, Washington State -- January 1987*. SD-BWI-TI-335, Rockwell Hanford Operations, Richland, Washington.

Spane, F. A., Jr. 1993. *Selected Hydraulic Test Analysis Techniques for Constant-Rate Discharge Tests*. PNL-8539, Pacific Northwest Laboratory, Richland, Washington.

Spane, F. A., Jr, M. D. Howland, and S. R. Strait. 1980. *Hydrogeologic Properties and Ground-Water Chemistry of the Rattlesnake Ridge Interbed at Well 699-25-80 (DB-14), Hanford Site*. RHO-LD-67, Rockwell Hanford Operations, Richland, Washington.

Spane, F. A., Jr., and R. B. Mercer. 1985. *HEADCO: A Program for Converting Observed Water Levels and Pressure Measurements to Formation Pressure and Standard Hydraulic Head*. RHO-BW-ST-71 P, Rockwell Hanford Operations, Richland, Washington.

Swanson, L. C., and B. A. Leventhal. 1984. *Water-Level Data and Borehole Description for Monitoring Wells Used by the Basalt Waste Isolation Project*. SD-BWI-DP-042, Rev. 0, Rockwell Hanford Operations, Richland, Washington.

Toth, J. 1978. "Gravity-Induced Cross-Formational Flow of Formation Fluids, Red Earth Region, Alberta, Canada: Analysis, Patterns, and Evolution." *Water Resources Research* 14 (5):805-843.

APPENDIX A

HYDRAULIC HEAD DATA USED IN DEVELOPMENT OF THE PRELIMINARY POTENTIOMETRIC MAP FOR THE UPPER-BASALT, CONFINED AQUIFER

HYDRAULIC HEAD MEASUREMENTS FOR ACTIVE, ON-SITE UPPER-BASALT, CONFINED AQUIFER WELLS COMPLETED WITHIN THE RATTLESNAKE RIDGE INTERBED; TIME PERIOD: MARCH - APRIL, 1993

Hanford Well Designation	Construction Date/Re-Completion Date	Measuring Point Datum (m-MSL)	Data Record (years)	Most Recent Head Measurement Date	Most Recent Head Measurement (m, MSL)	Barometric Efficiency Estimate (%)	Comments	Data Sources
199-B3-2P*	1953/1970	135.14	1959-75/84-85/89-93	03/02/93	122.86		Water levels affected by river fluctuations	HEIS
199-H4-2	1952/1984	128.36**	1952-54/57-75/84/91-93	03/18/93	134.81		Water levels affected by river fluctuations; Recompleted 3/93	HEIS
299-E26-8	1982	183.72	1982-86/88-90/93	04/20/93	117.50	24.5	Water-level elevation suspect; not used in potentiometric map	HEIS, Graham et al. (1984)
299-E33-12	1953/1982	190.03	1954-56/65-70/72-89/93	03/12/93	122.87	38.3		HEIS, Graham et al. (1984), WHC files
299-E33-40	1991	190.29	91-93	03/12/93	122.51	25.0		HEIS, WHC files, Connelly et al. (1992)
699-13-1C	1978	134.21	91-93	03/10/93	120.16		WPPSS water-supply well; water levels affected by pumping	HEIS
699-22-70*	1962/1977	187.44	1963-80 91-93	03/01/93	132.58			HEIS
699-24-1P*	1966	144.64	1966-80 91-93	03/03/93	119.54			HEIS
699-29-70AP	1984	191.95	1984-87 91-93	03/01/93	133.74	38.6	Former BWIP nested piezometer site	Swanson and Leventhal (1984), Swanson and Wilcox (1985), Yeatman and Wilcox (1985), HEIS

HYDRAULIC HEAD MEASUREMENTS FOR ACTIVE, ON-SITE UPPER-BASALT, CONFINED AQUIFER WELLS COMPLETED WITHIN THE RATTLESNAKE RIDGE INTERBED; TIME PERIOD: MARCH - APRIL, 1993

Hanford Well Designation	Construction Date/Re-Completion Date	Measuring Point Datum (m-MSL)	Data Record (years)	Most Recent Head Measurement Date	Most Recent Head Measurement (m, MSL)	Barometric Efficiency Estimate (%)	Comments	Data Sources
699-32-22B	1991	157.56	1991-93	03/02/93	123.06			HEIS
699-42-E9B	1991	117.78	1991-93	03/03/93	109.12		Water levels affected by river fluctuations	HEIS
699-42-40C	1982	166.47	1982-86/ 89-93	03/02/93	125.91	44.4		HEIS, Graham et al. (1984)
699-42-42A	1956/77/80	183.59	1956-76/ 89-93	03/02/93	125.21			HEIS
699-43-91AP	1984	204.68	1984-87 91-93	03/01/93	134.19	44.8	Former BWIP nested piezometer site	Swanson and Leventhal (1984), Swanson and Wilcox (1985), Yeatman and Wilcox (1985), HEIS
699-47-50	1980	178.38	1982-86/ 88-93	03/02/93	123.31	17.3		HESI, Graham et al. (1984)
699-47-80AP	1983	217.33	1984-87 91-93	03/01/93	134.46	34.2	Former BWIP nested piezometer site	Swanson and Leventhal (1984), Swanson and Wilcox (1985), Yeatman and Wilcox (1985), HEIS
699-49-32B	1980/1986	157.14	1989-93	03/02/93	125.10			HEIS
699-49-55B	1982	161.90	1982-86/ 88-89/91-93	03/02/93	122.60	22 - 41.4		HEIS, Graham et al. (1984), Connelly et al. (1992)

HYDRAULIC HEAD MEASUREMENTS FOR ACTIVE, ON-SITE UPPER-BASALT, CONFINED AQUIFER WELLS COMPLETED WITHIN THE RATTLESNAKE RIDGE INTERBED; TIME PERIOD: MARCH - APRIL, 1993

Hanford Well Designation	Construction Date/Re-Completion Date	Measuring Point Datum (m-MSL)	Data Record (years)	Most Recent Head Measurement Date	Most Recent Head Measurement (m, MSL)	Barometric Efficiency Estimate (%)	Comments	Data Sources
699-49-57B	1991	169.47	1991-93	03/02/93	122.55	19.0		HEIS, Connelly et al. (1992)
699-50-45	1980	137.59	1982-86/ 89-93	03/02/93	124.33	38.5		HEIS, Graham et al. (1984)
699-50-48B	1980	167.76	1982-86/ 89-93	03/02/93	123.58	42.5		HEIS, Graham et al. (1984)
699-50-53B	1991	169.96	91-93	04/19/93	122.61	15.0		HEIS, Connelly et al. (1992)
699-51-46	1980	135.52	1989/91-93	03/01/93	123.88	28.5		Graham et al. (1984)
699-52-46A	1980	138.87	1982-86/ 89/91-93	03/01/93	124.38	40.2	Apparent obstruction in well	HEIS, Graham et al. (1984)
699-52-48	1980	142.06	1982-86/ 89-93	03/01/93	123.22	17.4	Apparent obstruction in well	HEIS, Graham et al. (1984)
699-53-50	1980	135.40	1982-86/ 89-93	03/01/93	123.07	39.2		HEIS, Graham et al. (1984)
699-54-57	1955/1982	175.64	1955-86/ 89/91-93	03/01/93	122.45	13.3 - 15		HEIS, Graham et al. (1984), Connelly et al. (1992)
699-56-53	1982	132.39	1982-1986/ 89/91-93	03/01/93	122.48	25.4		HEIS, Graham et al. (1984)

HYDRAULIC HEAD MEASUREMENTS FOR ACTIVE, ON-SITE UPPER-BASALT, CONFINED AQUIFER WELLS COMPLETED PRIMARILY WITHIN THE UPPER SADDLE MOUNTAINS BASALT; TIME PERIOD: MARCH - APRIL, 1993

Hanford Well Designation	Construction Date/Re-Completion Date	Measuring Point Datum (m-MSL)	Data Record (years)	Most Recent Head Measurement Date	Most Recent Head Measurement (m, MSL)	Barometric Efficiency Estimate (%)	Comments	Data Sources
299-E16-01	1961/1982	212.27	1982-85/89-93	04/20/93	124.02			HEIS
399-05-02	1951	119.09	1952-57/61-62/64-65/68-75/93	04/20/93	116.56			HEIS
699-S11-E12AP	1960/1962	111.50	1992-93	04/21/93	117.07			HEIS
699-22-70Q*	1962/1977	187.44	1990-93	03/01/93	130.97			HEIS
699-56-43	1971/1978	164.72	1971-82/90-93	04/19/93	124.39			HEIS

HYDRAULIC HEAD MEASUREMENTS FOR ACTIVE, ON-SITE UPPER-BASALT, CONFINED AQUIFER BOREHOLES COMPLETED PRIMARILY IN THE TOP OF THE SADDLE MOUNTAINS BASALT; TIME PERIOD: FEBRUARY - APRIL, 1993

Hanford Well Designation	Construction Date/Re-Completion Date	Measuring Point Datum (m-MSL)	Data Record (years)	Most Recent Head Measurement Date	Most Recent Head Measurement (m, MSL)	Barometric Efficiency Estimate (%)	Comments	Data Sources
699-10-E12P	1962/1977	131.33	1993	04/20/93	120.18			HEIS
699-20-E12P	1962	133.27	1961/63-77 91-93	04/21/93	118.75			HEIS
699-26-15C	1980	135.43	1991-93	02/25/93	122.27			HEIS
699-43-84	1982	193.37	1991-93	02/26/93	134.31			HEIS

HYDRAULIC HEAD MEASUREMENTS FOR INACTIVE, ON-SITE UPPER-BASALT, CONFINED AQUIFER WELLS COMPLETED WITHIN THE UPPER SADDLE MOUNTAINS BASALT; TIME PERIOD: 1978 - 1993

Hanford Well Designation	Construction Date/Re-Completion Date	Surface Control Datum (m-MSL)	Data Record (years)	Most Recent Head Measurement Date	Most Recent Head Measurement (ft, MSL)	Barometric Efficiency Estimate (%)	Comments	Data Sources
699-S16-E14	1981	122.54	1980	1980	117.0		Former BWIP drill/test site; now plugged	Gephart (1981a)
699-14-E6P	1966	139.73	1966 - 1980	1980	115.4			HEIS
699-17-47	1959/1979	175.78	1978	1978	127.4		Test borehole site	Gephart et al. (1979)
699-20-E5Q	1966	142.31	-	1993	112.4		Well destroyed in 1993	HEIS
699-25-80	1948/79/	187.58	1978	1978	136.9		Former BWIP drill and test borehole site	Gephart et al. (1979), Spane et al. (1980)
699-31-84A	1981	190.52	1981	1981	136.6		Former BWIP drill/test site; now plugged	Strait and Bruce (1981)
699-46-32	1982/1986	143.32	1989-92	1992	124.6		Possible well blockage	HEIS
699-47-42	1979	143.15	4/79	1979	124.7		Former BWIP drill/test site; now plugged	Strait and Brown (1983)
699-50-96*	1983/1985	243.33	1985 - 1987	1987	132.0		Former BWIP Repository Loc. well; now plugged	WHC files

HYDRAULIC HEAD MEASUREMENTS FOR INACTIVE, ON-SITE UPPER-BASALT, CONFINED AQUIFER WELLS COMPLETED WITHIN THE UPPER SADDLE MOUNTAINS BASALT; TIME PERIOD: 1978 - 1993

Hanford Well Designation	Construction Date/Re-Completion Date	Surface Control Datum (m-MSL)	Data Record (years)	Most Recent Head Measurement Date	Most Recent Head Measurement (ft, MSL)	Barometric Efficiency Estimate (%)	Comments	Data Sources
699-54-45B	1980	150.25	1984-85 91-93	1993			No valid head measurement due to plug in well	HEIS, Last et al. (1990)
699-84-34B	1981	119.65	1/80	1980	121.9		Former BWIP drill/test site; now plugged	Gephart (1981b)

HYDRAULIC HEAD MEASUREMENTS FOR ACTIVE, OFF-SITE UPPER-BASALT, CONFINED AQUIFER BOREHOLES COMPLETED PRIMARILY IN THE TOP OF THE UPPER SADDLE MOUNTAINS BASALT; TIME PERIOD: MARCH - MAY, 1993

Well Designation ***	Construction Date/Re-Completion Date	Measuring Point Datum (m-MSL)	Data Record (years)	Most Recent Head Measurement Date	Most Recent Head Measurement (m, MSL)	Barometric Efficiency Estimate (%)	Comments	Data Sources
9N/28E-05C01	01/57	117.7		03/24/93	111.9			PNL files
10N/27E/23J	03/91	121.9		03/23/93	119.1			PNL files
10N/27E-28B	10/89	176.8		05/05/93	166.1			PNL files
11N/30E-03L01	1959	233.2		05/14/93	219.6			PNL files
12N/28E-23H01	09/80	118.9		05/14/93	116.6		Water levels affected by river fluctuations	PNL files
12N/29E-11M01	08/57	217.9		05/11/93	164.0			PNL files
12N/30E/16Q01	06/58	246.9		05/14/93	235.0			PNL files
12N/30E-30L01	10/61	257.6		05/14/93	225.8			PNL files

* Indicates composite completion with the overlying or underlying formation.

** Measuring point datum altered due to well recompletion. Hydraulic head measurement is approximate.

*** Township/Range-Section.

DATA SOURCES

BWIP - Basalt Waste Isolation Project.

Connelly, M. P., J. V. Borghese, C. D. Delaney, B. H. Ford, I. W. Lindberg, and S. J. Trent. 1992. *Hydrogeologic Model for the 200 East Groundwater Aggregate Area*. WCH-SD-EN-TI-019, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Gephart, R. E. 1981a. *Supporting Document - Borehole DC-15 Hydrostratigraphic Chart*. RHO-BWI-TI-066, Rev. 0, Rockwell Hanford Operations, Richland, Washington.

Gephart, R. E. 1981b. *Supporting Document - Borehole DC-14 Hydrostratigraphic Chart*. RHO-BWI-TI-065, Rev. 0, Rockwell Hanford Operations, Richland, Washington.

Gephart, R. E., F. A. Spane, Jr., L. S. Leonhart, D. A. Palombo, and S. R. Strait. 1979. "Pasco Basin Hydrology." Chapter III in *Hydrologic Studies within the Columbia Plateau, Washington...An Integration of Current Knowledge*. RHO-BWI-ST-5, Rockwell Hanford Operations, Richland, Washington.

Graham, M. L., G. V. Last, and K. R. Fecht. 1984. *An Assessment of Aquifer Intercommunication in the B Pond-Gable Mountain Pond Area of the Hanford Site*. RHO-RE-ST-12P, Rockwell Hanford Operations, Richland, Washington.

HEIS - Hanford Environmental Information System.

Last, G. V., M. A. Young, T. L. Liikala, and E. J. Jensen. 1990. *Well Network and Measurement Schedules for Monitoring Water-Level Changes Beneath the Separations Area of the Hanford Site*. PNL-5895, Pacific Northwest Laboratory, Richland, Washington.

Spane, F. A., Jr., M. D. Howland, and S. R. Strait. 1980. *Hydrogeologic Properties and Ground-Water Chemistry of the Rattlesnake Ridge Interbed at Well 699-25-80 (DB-14), Hanford Site*. RHO-LD-67, Rockwell Hanford Operations, Richland, Washington.

Strait, S. R., and W. R. Brown. 1983. *Hydrologic Test Results for the Rattlesnake Ridge Interbed and Pomona Basalt Flowtop at Borehole DB-15*. SD-BWI-TI-130, Rockwell Hanford Operations, Richland, Washington.

Strait, S. R., and S. R. Bruce. 1981. "Preliminary Results of Hydrologic Testing of the Rattlesnake Ridge Interbed/Pomona Basalt Flowtop in Borehole DC-16A." Internal Letter Report to F. Spane, October 9, 1981, #10120-HSU-81-230, Rockwell Hanford Operations, Richland, Washington.

Swanson, L. C., and B. A. Leventhal. 1984. *Water-Level Data and Borehole*

Swanson, L. C., and B. A. Leventhal. 1984. *Water-Level Data and Borehole Description for Monitoring Wells Used by the Basalt Waste Isolation Project*. SD-BWI-DP-042, Rockwell Hanford Operations, Richland, Washington.

Swanson, L. C., and S. E. Wilcox. 1985. *Water-Level Data for Monitoring Wells Used by the Basalt Waste Isolation Project from October 1, 1984 through March 31, 1985*. SD-BWI-DP-064, Rockwell Hanford Operations, Richland, Washington.

WHC - Westinghouse Hanford Company.

WPPSS - Washington Public Power Supply System.

Yeatman, R. A., and S. E. Wilcox. 1985. "Calculation of Barometric Efficiency and Removal of Atmospheric Effects from Water-Level and Downhole Data." Computational Brief No. 263, Rockwell Hanford Operations, Richland, Washington.

APPENDIX B

WELL/BOREHOLE COMPLETION INFORMATION FOR HYDRAULIC HEAD MEASUREMENT SITES USED IN THE DEVELOPMENT OF THE UPPER-BASALT, CONFINED AQUIFER POTENTIOMETRIC MAP

WELL COMPLETION INFORMATION FOR ACTIVE, ON-SITE UPPER-BASALT, CONFINED AQUIFER WELLS COMPLETED WITHIN THE RATTLESNAKE RIDGE INTERBED

Hanford Well Designation	Construction Date/Re-Completion Date	Measuring Point Datum (m-MSL)	Original/Current Well Depth (m)	Well Casing/Screen-Piez. Diameter (cm, I.D.)	Casing Completion Depth (m)	Screen/Perforation Interval (m-m)	Open Interval (m-m)	Sand/Gravel Pack Interval (m-m)	Cement Interval (m-m)	Comments	Data Sources
199-B3-2P*	1953/1970	135.14	241/237	20.3/3.8	237	231 - 237	200 - 237	200 - 237	196 - 200		PNL files, McGhan (1989)
199-H4-2	1952	128.36	118	15.2	111	-	111 - 118	none			PNL files, McGhan (1989)
299-E26-8	1982	183.72	122	20.3 - 10.2?	101	101 - 121	101 - 122	none	behind casing		PNL files, McGhan (1989)
299-E33-12	1953/1982	189.89	127	15.2/10.2	85	93 - 117	85 - 127	none	behind casing		PNL files, McGhan (1989), Graham et al. (1984)
299-E33-40	1991	190.29	97	10.2/10.2		90 - 93	87 - 94	87 - 94	1 - 6 70 - 86	Bentonite slurry plug: 6 - 70 m	WHC files
699-13-1C*	1978	134.21	212	30.5/15.2	154	154 - 159 172 - 175 209 - 212	154 - 212	154 - 212	behind casing	WPPSS water supply well	WPPSS files
699-22-70*	1962/1977	187.44	114/70	20.3	38		38 - 70	67 - 70	70 - 73	Annular well zone, completed within R.R./E. Mt.	PNL files, McGhan (1989)
699-24-1P*	1966	144.64	164	/3.8		136 - 139	133 - 164	133 - 164	127 - 133		PNL files, McGhan (1989)
699-29-70AP	1984	191.95	245	15.2/4.6	167	218 - 221 222 - 225	195 - 245	195 - 245	176 - 195		Jackson et al. (1984)
699-32-22B	1991	157.56	256	15.2/15.2**	237	237 - 255	232 - 256	232 - 256	behind casing	Bentonite slurry plug: 22 - 232 m	PNL files, Chamness et al. (1993)
699-42-E9B	1991	117.78	119	15.2/15.2**	108	108 - 117	106 - 119	106 - 119	behind casing	Bentonite slurry plug: 5 - 106 m	PNL files, Chamness et al. (1993)
699-42-40C	1982	166.47	119	20.3/3.8-6.4	97	97 - 119	97 - 119	none	behind casing		PNL files, Graham et al. (1984)

WELL COMPLETION INFORMATION FOR ACTIVE, ON-SITE UPPER-BASALT, CONFINED AQUIFER WELLS COMPLETED WITHIN THE RATTLESNAKE RIDGE INTERBED

Hanford Well Designation	Construction Date/Re-Completion Date	Measuring Point Datum (m-MSL)	Original/ Current Well Depth (m)	Well Casing/ Screen-Piez. Diameter (cm, I.D.)	Casing Completion Depth (m)	Screen/ Perforation Interval (m-m)	Open Interval (m-m)	Sand/ Gravel Pack Interval (m-m)	Cement Interval (m-m)	Comments	Data Sources
699-42-42A	1956/77/80	183.55	96/333/ 275	7.6	286	120 - 132	120 - 132	none	behind casing		PNL files
699-43-91AP	1984	204.68	262	15.2/4.6	200	248 - 249 250 - 253	229 - 262	229 - 262	206 - 229		Jackson et al. (1984)
699-47-50	1980	178.0	90	15.2/15.2**	79	79 - 90	79 - 90	none	behind casing		Strait and Moore (1982)
699-47-80AP	1983	217.33	230	15.2/4.6	161	198 - 202 207 - 210 211 - 214	187 - 230	187 - 230	166 - 187		Jackson et al. (1984)
699-49-32B	1980/1986	157.14	104	15.2/15.2**	91	91 - 102	75 - 104	75 - 104	0 - 74.7		PNL files, McGhan (1989)
699-49-55B	1982	161.64	69	20.3/15.2	53	53 - 69	53 - 69	53 - 69	behind casing		PNL files, Graham et al. (1984)
699-49-57B	1991	169.47	70	10.2/10.2		67 - 70	66 - 70	66 - 68	1 - 6 50 - 64	Bentonite slurry plug: 6 - 50 m	WHC files
699-50-45	1980	137.59	54	15.2/15.2**	41	41 - 54	41 - 54	none	behind casing		PNL files, Strait and Moore (1982)
699-50-48B	1980	167.76	76	15.2/15.2**	65	65 - 76	65 - 76	none	behind casing		PNL files, Strait and Moore (1982)
699-50-53B	1991	169.96	69	10.2/10.2		66 - 69	64 - 69	64 - 69	1 - 6 49 - 62	Bentonite slurry plug: 49 - 67 m	WHC files
699-51-46	1980	135.52	51	20.3/15.2**	37	37 - 50	37 - 51	none	behind casing		PNL files, Strait and Moore (1982)
699-52-46A	1980	138.87	69	20.3/15.2**	52	53 - 69	53 - 69	none	behind casing		PNL files, Strait and Moore (1982)

WELL COMPLETION INFORMATION FOR ACTIVE, ON-SITE UPPER-BASALT, CONFINED AQUIFER WELLS COMPLETED WITHIN THE RATTLESNAKE RIDGE INTERBED

Hanford Well Designation	Construction Date/Re-Completion Date	Measuring Point Datum (m-MSL)	Original/ Current Well Depth (m)	Well Casing/ Screen-Piez. Diameter (cm, I.D.)	Casing Completion Depth (m)	Screen/ Perforation Interval (m-m)	Open Interval (m-m)	Sand/ Gravel Pack Interval (m-m)	Cement Interval (m-m)	Comments	Data Sources
699-52-48	1980	142.06	60/59	20.3/15.2**	45	57 - 59	45 - 59	none	behind casing		PNL files, Strait and Moore (1982)
699-53-50	1980	135.40	59	20.3/15.2**	44	44 - 59	44 - 59	none	behind casing		PNL files, Strait and Moore (1982)
699-54-57	1955/1982	175.44	98	15.2/	75	75 - 98	75 - 98	none	behind casing		PNL files, Strait and Moore (1982)
699-56-53	1982	132.39	82	20.3/15.2**	61	61 - 82	61 - 82	none	behind casing		PNL files, Graham et al. (1984)

WELL COMPLETION INFORMATION FOR ACTIVE, ON-SITE UPPER-BASALT, CONFINED AQUIFER WELLS COMPLETED PRIMARILY WITHIN THE UPPER SADDLE MOUNTAINS BASALT

Hanford Well Designation	Construction Date/Re-Completion Date	Measuring Point Datum (m-MSL)	Original/ Current Well Depth (m)	Well Casing/ Screen-Piez. Diameter (cm, I.D.)	Casing Completion Depth (m)	Screen/ Perforation Interval (m-m)	Open Interval (m-m)	Sand/ Gravel Pack Interval (m-m)	Cement Interval (m-m)	Comments	Data Sources
299-E16-01	1961/1982	212.27	155	15.2/15.2**	150		150 - 155	none	behind casing		PNL files, Graham et al. (1984)
399-05-02	1951	119.09	129	20.3	129	59? - 129	59? - 129	none			PNL files, Schalla et al. (1988)
699-S11-E12AP	1960/1962	111.50	86/79	20.3/5.1	70		70 - 79	none	61 - 66	Cement plug above packer at 66 meters	Spane (1981)
699-22-70Q*	1962/1977	187.44	114/88	20.3/3.8	38	78 - 79	73 - 88	73 - 88	70 - 73 88 - 91		PNL files, McGhan (1989)
699-56-43	1971/1978	164.72	47	15.2	44	44 - 47/ 40 - 42	40 - 47	none			PNL files

WELL COMPLETION INFORMATION FOR ACTIVE, ON-SITE UPPER-BASALT, CONFINED AQUIFER BOREHOLES COMPLETED PRIMARILY IN THE TOP OF THE SADDLE MOUNTAINS BASALT

Hanford Well Designation	Construction Date/Re-Completion Date	Measuring Point Datum (m-MSL)	Original/ Current Well Depth (m)	Well Casing/ Screen-Piez. Diameter (cm, I.D.)	Casing Completion Depth (m)	Screen/ Perforation Interval (m-m)	Open Interval (m-m)	Sand/ Gravel Pack Interval (m-m)	Cement Interval (m-m)	Comments	Data Sources
699-10-E12P	1962/1977	131.33	112	20.3/3.8	112	110 - 111	107 - 111	107 - 111	104 - 107		PNL files
699-20-E12P	1962	133.27	109	20.3/3.8	109	98 - 105	98 - 105				PNL files
699-26-15C	1980	135.43	192	8.9	192		192 -	none		Former BWIP Borehole DH-18	Crowley and Ledgerwood (1988)
699-43-84	1982	193.37	176	8.9	176		176 -	none		Former BWIP Borehole DH-24	Crowley and Ledgerwood (1988)

WELL COMPLETION INFORMATION FOR INACTIVE, ON-SITE UPPER-BASALT, CONFINED AQUIFER WELLS COMPLETED WITHIN THE UPPER SADDLE MOUNTAINS BASALT

Hanford Well Designation	Construction Date/Re-Completion Date	Measuring Point Datum (m-MSL)	Original/ Current Well Depth (m)	Well Casing/ Screen-Piez. Diameter (cm, I.D.)	Casing Completion Depth (m)	Screen/ Perforation Interval (m-m)	Open Interval (m-m)	Sand/ Gravel Pack Interval (m-m)	Cement Interval (m-m)	Comments	Data Sources
699-S16-E14	1979/1981	122.54	151/0	20.3	60	none	127 - 151	none	0 - 60	Well has been plugged and abandoned	Gephart (1981a), Crowley and Ledgerwood (1988), McGhan (1989)
699-14-E6P	1966	139.73	155	/3.8		149 - 152	146 - 155	146 - 155	140 - 146		PNL files, McGhan 1989
699-17-47	1959/1978	175.78	166/394	16.8	105	none	141 - 166	none	0 - 105	Well is completed in the Mabton int.	Gephart et al. (1979), Crowley and Ledgerwood (1988)
699-20-E5Q	1966	142.31	129	/3.8		125 - 128	122 - 129	122 - 129	116 - 122	Well was destroyed in 1993	PNL files, McGhan (1989)
699-25-80	1948/79/	187.58	88	20.3/15.2	63	63 - 88	64 - 88	64 - 88	61 - 64	Well has been re-completed in Wanapum	Spane et al. (1980), McGhan (1989)
699-31-84A	1981/1983	190.52	255/0	16.8	183	none	204 - 255	none	0 - 183	Well has been plugged and abandoned	Crowley and Ledgerwood (1988), McGhan (1989), Strait and Bruce (1981)
699-46-32	1982/1986	143.32	130/127	15.2/15.2**	108	108 - 126	88 - 127	88 - 127	behind casing	Possible well blockage	PNL files
699-47-42	1979	143.15	68/0	11.4/	68	none	46 - 68	none	behind casing	Well has been plugged and abandoned	Swanson and Leventhal (1984), McGhan (1989)
699-50-96*	1983/1985	243.33	337/0	8.9/	228	-	228 - 337	none	behind casing	Well has been plugged and abandoned	WHC files
699-54-45B	1980	150.25	96	15.2/15.2**	93	93 - 96	93 - 96	none	behind casing	Well blockage	PNL files, Strait and Moore (1982)
699-84-34B	1980/1981	119.65	164/1023	21.9	109	none	145 - 164	none	0 - 109	Currently monitoring upper Wanapum	Crowley and Ledgerwood (1988), McGhan (1989)

WELL COMPLETION INFORMATION FOR ACTIVE, OFF-SITE UPPER-BASALT, CONFINED AQUIFER BOREHOLES COMPLETED PRIMARILY WITHIN THE UPPER SADDLE MOUNTAINS BASALT

Hanford Well Designation ***	Construction Date/Re-Completion Date	Measuring Point Datum (m-MSL)	Original/ Current Well Depth (m)	Well Casing/ Screen-Piez. Diameter (cm, I.D.)	Casing Completion Depth (m)	Screen/ Perforation Interval (m-m)	Open Interval (m-m)	Sand/ Gravel Pack Interval (m-m)	Cement Interval (m-m)	Comments	Data Sources
9N/28E-05C01	1957	117.7	174	40.6	55	23.5 - 24	55 - 174				PNL files
10N/27E/23J	1991	121.9	50	15.2	6	none	6 - 50	none			PNL files
10N/27E-28B	1989	176.8	46	15.2	12	none	12 - 46	none			PNL files
11N/30E-03L01	1959	233.2	32	15.2	14	none	14 - 32	none			PNL files
12N/28E-23H01D	?/1980	118.9	126	15.2	69	none	74 - 126	none	69 - 74		PNL files
12N/29E-11M01	1957	217.9	65	15.2	51	none	57 - 65	none	51 - 57		PNL files
12N/30E/16Q01	1958	246.9	17	15.2	4	none	4 - 17	none			PNL files
12N/30E-30L01	1961	257.6	67	15.2	54	none	54 - 67	none			PNL files

* Indicates composite completion with the overlying or underlying formation.

** Indicates Telescoping Well-Screen.

*** Township/Range-Section.

DATA SOURCES

Chamness, M. A., T. J. Gilmore, and S. S. Teel. 1993. *Savage Island Project Borehole Completion Report*. PNL-8485, Pacific Northwest Laboratory, Richland, Washington.

Crowley, W. H., and R. K. Ledgerwood. 1988. *Borehole Status Chart and Location Maps*. SD-BWI-DP-044, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Gephart, R. E. 1981a. *Supporting Document - Borehole DC-15 Hydrostratigraphic Chart*. RHO-BWI-TI-066, Rev. 0, Rockwell Hanford Operations, Richland, Washington.

Gephart, R. E., F. A. Spane, Jr., L. S. Leonhart, D. A. Palombo, and S. R. Strait. 1979. 'Pasco Basin Hydrology." Chapter III in *Hydrologic Studies within the Columbia Plateau, Washington...An Integration of Current Knowledge*. RHO-BWI-ST-5, Rockwell Hanford Operations, Richland, Washington.

Graham, M. L., G. V. Last, and K. R. Fecht. 1984. *An Assessment of Aquifer Intercommunication in the B Pond-Gable Mountain Pond Area of the Hanford Site*. RHO-RE-ST-12 P, Rockwell Hanford Operations, Richland, Washington.

Jackson, R. L., L. D. Diediker, R. K. Ledgerwood, and M. D. Veatch. 1984. *Piezometer Completion Report for Borehole Cluster Sites DC-19, DC-20, and DC-22*. SD-BWI-TI-226, Rev. 1, Rockwell Hanford Operations, Richland, Washington.

McGhan, V. L. 1989. *Hanford Wells*. PNL-6907, Pacific Northwest Laboratory, Richland, Washington.

PNL — Pacific Northwest Laboratory

Schalla, R., R. W. Wallace, R. L. Aaberg, S. P. Airhart, D. J. Bates, J.V.M. Carlile, C. S. Cline, D. I. Dennison, M. D. Freshley, P. R. Heller. E. J. Jensen, K. B. Olsen, R. G. Parkhurst, J. T. Rieger, E. J. Westergard. 1988. *Interim Characterization Report for the 300 Area Process Trenches*. PNL-6716, Pacific Northwest Laboratory, Richland, Washington.

Spane, F. A., Jr. 1981. *Hydrogeologic Properties and Hydrochemistry for the Levey Interbed at Well 699-S11-E12A*. RHO-BWI-LD-27, Rockwell Hanford Operations, Richland, Washington.

Spane, F. A., Jr., M. D. Howland, and S. R. Strait. 1980. *Hydrogeologic Properties and Ground-Water Chemistry of the Rattlesnake Ridge Interbed at Well 699-25-80 (DB-14), Hanford Site*. RHO-LD-67, Rockwell Hanford Operations, Richland, Washington.

Strait, S. R., and S. R. Bruce. 1981. "Preliminary Results of Hydrologic Testing of the Rattlesnake Ridge Interbed/Pomona Basalt Flowtop in Borehole DC-16A." Internal Letter Report to F. Spane, October 9, 1981, #10120-HSU-81-230, Rockwell Hanford Operations, Richland, Washington.

Strait, S. R., and B. A. Moore. 1982. *Geohydrology of the Rattlesnake Ridge Interbed in the Gable Mountain Pond Area*. RHO-ST-38, Rockwell Hanford Operations, Richland, Washington.

Swanson, L. C., and B. A. Leventhal. 1984. *Water-Level Data and Borehole Description for Monitoring Wells Used by the Basalt Waste Isolation Project*. SD-BWI-DP-042, Rockwell Hanford Operations, Richland, Washington.

WHC — Westinghouse Hanford Company

WPPSS — Washington Public Power Supply System

APPENDIX C

STRATIGRAPHIC INFORMATION FOR HYDRAULIC HEAD MEASUREMENT SITES USED IN THE DEVELOPMENT OF THE UPPER-BASALT, CONFINED AQUIFER POTENTIOMETRIC MAP

SUBSURFACE GEOLOGIC INFORMATION FOR ACTIVE, ON-SITE UPPER-BASALT, CONFINED AQUIFER WELLS COMPLETED WITHIN THE RATTTLESNAKE RIDGE INTERBED

					STRATIGRAPHIC DEPTH DATA					
Hanford Well Designation	Geologic Log Available (type)	Current Well Depth (m)	Open Interval (m)	Principal Hydrogeologic Unit	Supra-Sediments Depth (m)	Elephant Mt. Basalt Depth (m)	Rattlesnake Ridge Inter-Bed Depth (m)	Pomona Basalt Depth (m)	Comments	Data Sources
199-B3-2P*	Geologist	237.1	199.6 - 237.1	Elephant Mt./ Rat. Ridge Int.	0 - 199.9	199.9 - 234.4	234.4 -	-	Major ground-water influx from 232.9 to 237.1 m	Newcomb et al. (1972), PNL files
199-H4-2	Geologist	117.7	110.6 - 117.7	Rat. Ridge Int.	0 - 108.2	108.2 - 112.8	112.8 - 116.1	116.1 -		Newcomb et al. (1972), PNL files, WHC files
299-E26-8	Driller's	121.9	100.6 - 121.9	Rat. Ridge Int.	0 - 76.2	76.2 - 103.6	103.6 - 120.4	120.4 -		PNL files
299-E33-12	Detailed Driller's	126.5	85.3 - 126.5	Rat. Ridge Int.	0 - 70.7	70.7 - 94.2	94.2 - 114.3	114.3 -		PNL files
299-E33-40	Geologist	96.9	87.2 - 93.9	Elephant Mt./ Rat. Ridge Int.	0 - 69.5	69.5 - 92.7	92.7 -	-		WHC files
699-13-1C*	Detailed Driller's	211.8	154.2 - 211.8	Elephant Mt./ Rat. Ridge Int.	0 - 152.4	152.4 - 189.6	189.6 - 206.0	206.0 -		WPPSS files
699-22-70*	Driller's	70.1	38.1 - 70.1	Elephant Mt./ Rat. Ridge Int.	0 - 37.2	37.2 - 59.4	59.4 -	-		Fecht and Lillie (1982)
699-24-1P*	Driller's	163.7	132.6 - 163.7	Rat. Ridge Int./ Pomona	0 - 103.3	103.3 - 110.3	110.3 - 140.2	140.2 -		Fecht and Lillie (1982)
699-29-70AP	Geologist	245.1	195.4 - 245.1	Rat. Ridge Int.	0 - 164.6	164.6 - 203.6	203.6 - 235.9	235.9 -	Former BWIP nested piezometer	Jackson et al. (1984)
699-32-22B	Geologist	256.0	232.0 - 256.0	Rat. Ridge Int.	0 - 192.3	192.3 - 236.5	236.5 - 255.4	255.4 -		Chamness et al. (1993)

SUBSURFACE GEOLOGIC INFORMATION FOR ACTIVE, ON-SITE UPPER-BASALT, CONFINED AQUIFER WELLS COMPLETED WITHIN THE RATTTLESNAKE RIDGE INTERBED

					STRATIGRAPHIC DEPTH DATA					
Hanford Well Designation	Geologic Log Available (type)	Current Well Depth (m)	Open Interval (m)	Principal Hydrogeologic Unit	Supra-Sediments Depth (m)	Elephant Mt. Basalt Depth (m)	Rattlesnake Ridge Inter-Bed Depth (m)	Pomona Basalt Depth (m)	Comments	Data Sources
699-42-E9B	Geologist	118.9	106.1 - 118.9	Elephant Mt.	0 - 68.9	68.9 - 107.9?	-	107.9? -	Rattlesnake Ridge interbed not detected	Chamness et al. (1993)
699-42-40C	Driller's	118.9	96.6 - 118.9	Rat. Ridge Int.	0 - 65.8	65.8 - 96.6	96.6 - 113.7	113.7 -		PNL files, Graham et al. (1984)
699-42-42A	Geologist	274.9	119.5 - 131.7	Rat. Ridge Int.	0 - 92.7	92.7 - 113.4	113.4 - 131.7	131.7 - 187.8	Former BWIP drill and test borehole site	Fecht and Lillie (1982), Ledgerwood (1986)
699-43-91AP	Geologist	262.4	228.6 - 262.4	Rat. Ridge Int.	0 - 201.8	201.8 - 235.0	235.0 - 258.2	258.2 -	Former BWIP nested piezometer	Jackson et al. (1984)
699-47-50	Driller's	89.9	79.2 - 89.9	Rat. Ridge Int.	0 - 65.5	65.5 - 79.2	79.2 - 89.9	-		Fecht and Lillie (1982)
699-47-80AP	Geologist	230.4	186.8 - 230.4	Rat. Ridge Int.	0 - 161.8	161.8 - 194.6	194.6 - 221.3	221.3 -	Former BWIP nested piezometer	Jackson et al. (1984)
699-49-32B	Geologist	103.6	74.7 - 103.6	Rat. Ridge Int.	0 - 53.3	53.3 - 86.9	86.9 - 101.2	-	Former Golder borehole	PNL files, Fecht and Lillie (1982)
699-49-55B	Driller's	68.9	53.3 - 68.9	Rat. Ridge Int.	0 - 41.5	41.5 - 55.5	55.5 - 68.9	68.9 -		PNL files, Graham et al. (1984)
699-49-57B	Geologist	70.1	65.5 - 70.1	Rat. Ridge Int.	0 - 49.7	49.7 - 65.5	65.5 -		Well completed in upper Rat. Ridge Interbed	WHC files
699-50-45	Driller's	54.3	40.5 - 54.3	Rat. Ridge Int.	0 - 11.3	11.3 - 40.5	40.5 - 54.3	-	No geologic record for the bottom 13.7 m	Strait and Moore (1982), Fecht and Lillie (1982)

SUBSURFACE GEOLOGIC INFORMATION FOR ACTIVE, ON-SITE UPPER-BASALT, CONFINED AQUIFER WELLS COMPLETED WITHIN THE RATTTLESNAKE RIDGE INTERBED

Hanford Well Designation	Geologic Log Available (type)	Current Well Depth (m)	Open Interval (m)	Principal Hydrogeologic Unit	STRATIGRAPHIC DEPTH DATA				Comments	Data Sources
					Supra-Sediments Depth (m)	Elephant Mt. Basalt Depth (m)	Rattlesnake Ridge Inter-Bed Depth (m)	Pomona Basalt Depth (m)		
699-50-48B	Driller's	76.2	64.9 - 76.2	Rat. Ridge Int.	0 - 34.1	34.1 - 64.6	64.6 - 76.2	-	No geologic description for Rat. Ridge Int.	Strait and Moore (1982), Fecht and Lillie (1982)
699-50-53B	Geologist	68.6	63.7 - 68.6	Rat. Ridge Int.	0 - 47.5	47.5 - 62.5	62.5 -	-	Well completed in upper Rat. Ridge Interbed	WHC files
699-51-46	Driller's	51.2	36.6 - 51.2	Rat. Ridge Int.	0 - 3.7	3.7 - 36.6	36.6 - 50.3	50.3 -		Strait and Moore (1982), Fecht and Lillie (1982)
699-52-46A	Driller's	68.6	53.3 - 68.6	Rat. Ridge Int.	0 - 15.2	15.2 - 50.3	50.3 - 68.6	68.6 -		Strait and Moore (1982), Fecht and Lillie (1982)
699-52-48	Driller's	59.4	45.4 - 59.4	Rat. Ridge Int.	0 - 8.5	8.5 - 44.2	44.2 - 59.4	59.4 -		Strait and Moore (1982), Fecht and Lillie (1982)
699-53-50	Driller's	59.1	44.2 - 59.1	Rat. Ridge Int.	0 - 11.0	11.0 - 44.2	44.2 - 59.4	59.1 -		PNL files, Strait and Moore (1982)
699-54-57	Driller's	97.8	74.7 - 97.8	Rat. Ridge Int.	0 - 55.2	55.2 - 75.6	75.6 - 92.2	97.2 -		PNL files, Graham et al. (1984)
699-56-53	Driller's	82.3	61.0 - 82.3	Rat. Ridge Int.	0 - 30.5	30.5 - 62.5	62.5 - 81.1	81.1 -		PNL files, Graham et al. (1984)

SUBSURFACE GEOLOGIC INFORMATION FOR ACTIVE, ON-SITE UPPER-BASALT, CONFINED AQUIFER WELLS COMPLETED PRIMARILY WITHIN THE UPPER SADDLE MOUNTAINS BASALT

					STRATIGRAPHIC DEPTH DATA					
Hanford Well Designation	Geologic Log Available (type)	Current Well Depth (m)	Open Interval (m)	Principal Hydrogeologic Unit	Supra-Sediments Depth (m)	Elephant Mt. Basalt Depth (m)	Rattlesnake Ridge Inter-Bed Depth (m)	Pomona Basalt Depth (m)	Comments	Data Sources
299-E16-01	Geologist	155.4	150.0 - 155.4	Elephant Mt.	0 - 143.9	143.9 -	-	-	Unnamed interbed at 150.9 - 153.9 m	PNL files, Graham et al. (1984)
399-05-02	Geologist	129.2	59.4? - 129.2	Levey/Elephant Mt.	0 - 58.5	91.4 -	-	-	Ice Harbor Basalt? 58.5 - 83.8 m; Levey interbed? 83.8-91.4 m	Crowley and Ledgerwood (1988)
699-S11-E12A	Geologist	78.9	70.1 - 78.9	Levey	0 - 70.4	-	-	-	Ice Harbor Basalt? 70.4 - 72.5 m; Levey interbed? 72.5 m -	Spane (1981), Fecht and Lillie (1982)
699-22-70Q*	Driller's	88.4	73.2 - 88.4	Pomona/ (Rat. Ridge Int.)	0 - 37.2	37.2 - 59.4	59.4 - 74.7	74.7 -	Only 5 ft of Rat. Ridge Interbed in open section	Fecht and Lillie (1982)
699-56-43	Driller's	47.2	39.6 - 47.2	Basalt	0 - 16.2	-	-	-	Undifferentiated Saddle Mts. Basalt	Fecht and Lillie (1982)

SUBSURFACE GEOLOGIC INFORMATION FOR ACTIVE, ON-SITE UPPER-BASALT, CONFINED AQUIFER BOREHOLES COMPLETED PRIMARILY IN THE TOP OF THE UPPER SADDLE MOUNTAINS BASALT

					STRATIGRAPHIC DEPTH DATA			
Hanford Well Designation	Geologic Log Available (type)	Current Well Depth (m)	Open Interval (m)	Principal Hydrogeologic Unit	Supra-Sediments Depth (m)	Saddle Mts. Basalt Depth (m)	Comments	Data Sources
699-10-E12P	Geologist	112.2	106.7 - 111.3	Basalt	0 - 109.1	109.1 -		Fecht and Lillie (1982)
699-20-E12P	Geologist	108.8	97.5 - 105.2	Basalt	0 - 99.1	99.1 -	Dense blue clay 94.5 - 99.1 m	Fecht and Lillie (1982)
699-26-15C	Geologist	192.0	192.0 -	Basalt	0 - 184.4	184.4 -	Cased to bottom	Crowley and Ledgerwood (1988)
699-43-84	Geologist	175.9	175.9 -	Basalt	0 - 166.7	166.7 -	Cased to bottom	Crowley and Ledgerwood (1988)

SUBSURFACE GEOLOGIC INFORMATION FOR INACTIVE, ON-SITE UPPER-BASALT, CONFINED AQUIFER WELLS COMPLETED WITHIN THE UPPER SADDLE MOUNTAINS BASALT

Hanford Well Designation	Geologic Log Available (type)	Original Well Depth (m)	Open Interval (m)	Principal Hydrogeologic Unit	STRATIGRAPHIC DEPTH DATA: Supra-Sediments Depth (m)	Elephant Mt. Basalt Depth (m)	Rattlesnake Ridge Inter-Bed Depth (m)	Pomona Basalt Depth (m)	Comments	Data Sources
699-S16-E14	Geologist	151.2	126.8 -151.2	Rat. Ridge Int.	0 - 94.8	94.8 - 133.7	133.7 - 140.2	140.2 -	BWIP drill and test borehole site	Ledgerwood (1986)
699-14-E6P	Driller's	154.5	146.3 - 154.5	Rat. Ridge Int.	0 - 122.8	122.8 - 144.5	144.5 - 152.4	152.4 -		Fecht and Lillie (1982)
699-17-47	Geologist	165.8	140.8 - 165.8	Rat. Ridge Int.	0 - 104.2	104.2 - 141.1	141.1 - 163.4	163.4 -	BWIP drill and test borehole site	Fecht and Lillie (1982), Ledgerwood (1986)
699-20-E5Q	Driller's	128.6	121.6 - 128.6	Rat. Ridge Int.	0 - 97.5	97.5 - 109.1	109.1 - 127.7	127.7 -	Well completed in lower Rat. Ridge interbed	Fecht and Lillie (1982)
699-25-80	Geologist	87.8	64.0 - 87.8	Rat. Ridge Int.	0 - 33.2	33.2 - 63.7	63.7 - 87.2	87.2 -	BWIP drill and test borehole site	Fecht and Lillie (1982), Ledgerwood (1986)
699-31-84A	Geologist	254.5	203.6 - 254.5	Rat. Ridge Int.	0 - 182.3	182.3 - 208.5	208.5 - 242.6	242.6 -	BWIP drill and test borehole site	Ledgerwood (1986)
699-46-32	Geologist	127.1	88.4 - 127.1	Rat. Ridge Int.	0 - 62.5	62.5 - 103.6	103.6 - 121.0	121.0 -	Former Golder borehole	PNL files
699-47-42	Geologist	67.7	45.7 - 67.7	Rat. Ridge Int.	0 - 20.4	20.4 - 50.6	50.6 - 65.8	65.8 -	BWIP drill/test site; borehole now plugged	Fecht and Lillie (1982), Ledgerwood (1986)
699-50-96*	Geologist	337.1	228.0 - 337.1	Upper Saddle Mts.	0 - 228.0	228.0 - 241.4	241.4 - 264.3	264.3 - 323.4	Former BWIP monitoring site; currently plugged	WHC files

SUBSURFACE GEOLOGIC INFORMATION FOR INACTIVE, ON-SITE UPPER-BASALT, CONFINED AQUIFER WELLS COMPLETED WITHIN THE UPPER SADDLE MOUNTAINS BASALT

					STRATIGRAPHIC DEPTH DATA					
Hanford Well Designation	Geologic Log Available (type)	Original Well Depth (m)	Open Interval (m)	Principal Hydrogeologic Unit	Supra-Sediments Depth (m)	Elephant Mt. Basalt Depth (m)	Rattlesnake Ridge Inter-Bed Depth (m)	Pomona Basalt Depth (m)	Comments	Data Sources
699-54-45B	Driller's	95.7	93.0 - 95.7	Rat. Ridge Int.	0 - 54.3	54.3 - 92.7	92.7 -	-		PNL files
699-84-34B	Geologist	164.0	144.8 - 164.0	Rat. Ridge Int.	0 - 107.9	107.9 - 149.7	149.7 - 155.4	155.4 -	BWIP drill and test borehole site	Strait (1980), Ledgerwood (1986)

SUBSURFACE GEOLOGIC INFORMATION FOR ACTIVE, OFF-SITE UPPER-BASALT, CONFINED AQUIFER BOREHOLES COMPLETED PRIMARILY WITHIN THE UPPER SADDLE MOUNTAINS BASALT

Hanford Well Designation **	Geologic Log Available (type)	Well Depth (m)	Open Interval (m)	Principal Hydrogeologic Unit	STRATIGRAPHIC DEPTH DATA: Supra-Sediments Depth (m)	Uppermost Saddle Mts. Basalt Depth (m)	Uppermost Ellensburg Interbed depth (m)	Underlying Saddle Mts. Basalt Depth (m)	Comments	Data Sources
9N/28E-05C01	Driller's	174	55-174	Composite Upper-Basalt Aquifer	0 - 53	53 - 86	86 - 104	104 - 149		PNL files
10N/27E/23J	Driller's	50	6 - 50	Uppermost Saddle Mts. Basalt	0 - 4	4 - 50+	-	-	Water-bearing zone with possible interbed unit in bottom 3 meters	PNL files
10N/27E-28B	Driller's	46	12 - 46	Uppermost Saddle Mts. Basalt	0 - 7	7 - 46+	-	-	Water-bearing zone with possible interbed unit in bottom 12 meters	PNL files
11N/30E-03L01	Driller's	32	14 - 32	Uppermost Saddle Mts. Basalt/Interbed	0 - 14	14 - 30	30 - 32+	-	Water-bearing zones noted between 29-32 meters	PNL files
12N/28E-23H01D01	Driller's	126	74 - 126	Composite Upper-Basalt Aquifer	0 - 74	74 - 93	93 - 102?	102 - 126+	Water-bearing zone 93-102 meters	PNL files
12N/29E-11M01	Driller's	65	57 - 65	Uppermost Saddle Mts. Basalt	0 - 50	50 - 65+	-	-	Water-bearing zone with possible interbed unit: 59-61 meters	PNL files
12N/30E/16Q01	Driller's	17	4 - 17	Uppermost Saddle Mts. Basalt	0 - 3	3 - 17+	-	-	Water-bearing zone with possible interbed unit: 14-16 meters	PNL files
12N/30E-30L01	Driller's	67	54 - 67	Uppermost Saddle Mts. Basalt/Interbed	0 - 51	51 - 65	65 - 66?	66 - 67+	Water-bearing zone at interbed or interflow contact: 65-66 meters	PNL files

* Indicates composite completion with the overlying or underlying formation.

** Township/Range-Section.

DATA SOURCES

BWIP - Basalt Waste Isolation Project

Chamness, M. A., T. J. Gilmore, and S. S. Teel. 1993. *Savage Island Project Borehole Completion Report*. PNL-8485, Pacific Northwest Laboratory, Richland, Washington.

Crowley, W. H., and R. K. Ledgerwood. 1988. *Borehole Status Chart and Location Maps*.

Fecht, K. R., and J. T. Lillie. 1982. *A Catalog of Borehole Lithologic Logs from the 600 Area, Hanford Site*. RHO-LD-158, Rockwell Hanford Operations, Richland, Washington.

Graham, M. L., G. V. Last, and K. R. Fecht. 1984. *An Assessment of Aquifer Intercommunication in the B Pond-Gable Mountain Pond Area of the Hanford Site*. RHO-RE-ST-12P, Rockwell Hanford Operations, Richland, Washington.

Jackson, R. L., L. D. Diediker, R. K. Ledgerwood, and M. D. Veatch. 1984. *Piezometer Completion Report for Borehole Cluster Sites DC-19, DC-20, and DC-22*. SD-BWI-TI-226, Rev. 1, Rockwell Hanford Operations, Richland, Washington.

Ledgerwood, R. K. 1986. *Borehole Depths and Thicknesses for Saddle Mountains and Wanapum Basalts*. BWI-DP-068, Rockwell Hanford Operations, Richland, Washington.

Newcomb, R. C., J. R. Strand, and F. J. Frank. 1972. *Geology and Ground-Water Characteristics of the Hanford Reservation of the U.S. Atomic Energy Commission, Washington*. U.S. Geological Survey Professional Paper 717, 78p.

PNL — Pacific Northwest Laboratory

Spane, F. A., Jr. 1981. *Hydrogeologic Properties and Hydrochemistry for the Levey Interbed at Well 699-S11-E12A*. RHO-BWI-LD-27, Rockwell Hanford Operations, Richland, Washington.

Strait, S. R. 1980. "Hydrogeologic Properties of Aquifers in the Saddle Mountains Basalt Formation at Well DC-14, Hanford Site, Washington." Unpublished formation report, Rockwell Hanford Operations, Richland, Washington.

Strait, S. R., and B. A. Moore. 1982. *Geohydrology of the Rattlesnake Ridge Interbed in the Gable Mountain Pond Area*. RHO-ST-38, Rockwell Hanford Operations, Richland, Washington.

WHC — Westinghouse Hanford Company

WPPSS — Washington Public Power Supply System

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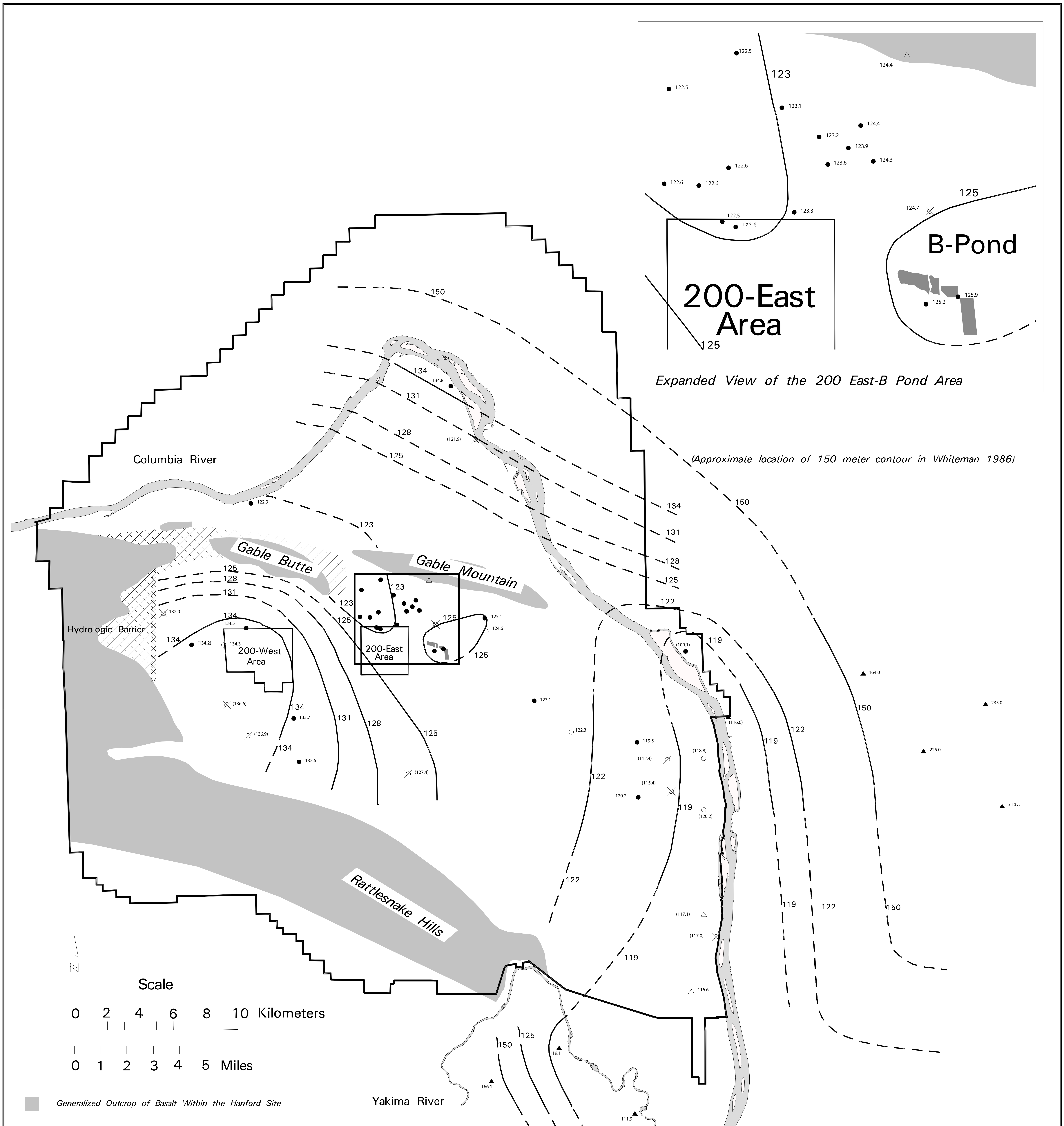

Generalized Outcrop of Basalt Within the Hanford Site

Upper-Basalt Confined Aquifer Not Present

Hanford Site Boundary

Water-Level Elevation Contour: Meters above mean sea level; General contour interval 3 meters for Hanford Site Contour interval 25 meters for areas off the Hanford Site; Contour lines are dashed where location is approximate

Hanford Site Wells Completed Within the Rattlesnake Ridge Interbed

Hanford Site Wells Completed Within the Upper Saddle Mountains Basalt

Hanford Site Wells Completed Primarily in the Top of the Saddle Mountains Basalt (hydraulic head data are considered to be qualitative and used only for general contouring purposes)

Inactive Hanford Site Wells Formerly Completed Within the Upper Saddle Mountains Basalt (hydraulic head data are considered to be qualitative and used only for general contouring purposes)

Offsite Private/Domestic Wells Completed Within the Upper Saddle Mountains Basal

Plate 1. Preliminary Potentiometric Map of the Upper-Basalt Confined Aquifer System - March 1993

Note:

(1) Hydraulic head data for wells located within 1.5 km of the Columbia River are subject to daily and seasonal river-stage fluctuation effects. Hydraulic head data for these well sites are used only for general contouring purposes.

(2) Well site water-level elevations enclosed by parantheses are considered to be of qualitative value. See Appendix tables for comments.

Reference:

Whiteman, K.J. 1986. Ground-Water Levels In Three Basalt Hydrologic Units Underlying the Columbia Plateau. U.S. Geological Survey, Water-Resources Investigations Report, 86-4046.