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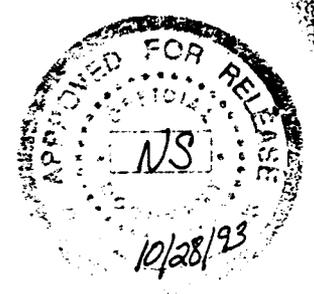
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Executive Summary

This report documents the results of a detailed evaluation of the suitability of a site proposed for disposal of treated effluents from the 200 Areas of the Hanford Site. Before their discharge, the effluents will be treated and monitored by the best available technology to ensure that they comply with the best management practice consistent with WAC-173-200 and the conditions specified by the WAC-173-216 permit. Therefore, the evaluation focused on the changes in the elevation of the water table resulting from treated effluent disposal at the proposed site, and their potential to remobilize known contamination associated with the 200 East Area or parts of the B Pond complex.

Three wells were drilled to bedrock adjacent to the proposed site – one hydraulically upgradient and two hydraulically downgradient. The wells were geologically logged and samples of each major lithology were collected. These samples were analyzed to determine the presence or absence of contamination and to characterize their physical properties that determine hydraulic behavior. Samples of water from the uppermost aquifer were collected every 3 months and analyzed to determine the presence or absence of contaminants. Constant-discharge, single-well aquifer tests were conducted in each well to determine the transmissivity of the uppermost aquifer.

The potentiometric surface and the thickness, location, and continuity of major hydrostratigraphic units were mapped. A refined conceptual model of the hydrologic system was then constructed using site characterization data. A computer was used to simulate the refined conceptual model to predict the hydraulic effects that would result from operating the proposed facility at the site.

The results of these simulations, in conjunction with the other site-specific data, were used to confirm the suitability of the proposed site based on previously specified criteria. Use of the site to dispose of the projected volumes of treated effluents from the 200 Areas was determined to have no potentially adverse effects on human health or the environment. Hence, the site is judged to be suitable for disposal of the treated effluents.

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1.0 INTRODUCTION

This report describes the results of work performed to evaluate the suitability of the Project W-049H site (Figure 1) tentatively selected for disposal of treated effluent from the 200 Areas of the Hanford Site. Construction and operation of the 200 Areas Treated Effluent Disposal Basin (TEDB) is planned for the site.

1.1 BACKGROUND

Past effluent disposal practices at the Hanford Site included discharge of untreated effluents to facilities that infiltrated the effluents into thick, unconsolidated sediments overlying basalt bedrock. This practice was accepted at that time because the area was isolated from major population centers and had low annual precipitation, a deep water table, and favorable ion-exchange properties of the sediments.

In March 1987, the U. S. Department of Energy's (DOE) Richland Field Office (RL) published a position paper (DOE-RL 1987) stating that the DOE would end its discharge of untreated effluents at the Hanford Site. The *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989) established a schedule and performance milestones to ensure that effluents are either treated prior to their discharge or that the discharge is eliminated. The collection system, treatment facilities, and treated effluent disposal system for Phase I effluents (Crane 1992, p. 1-1) are to be in operation by June 1995. The system will handle treated effluents from the 200 Areas.

Before their discharge, the effluents will be treated by the best available known technology and meet groundwater quality requirements for primary and secondary contaminants and radionuclides as per ¶3, §8.3.5 of the Westinghouse Hanford Company (WHC) *Environmental Compliance Manual* (WHC 1988). After treatment, compliance of the effluents with the best management practice consistent with Washington Administrative Code (WAC) 173-200 will be verified. The actual compliance limits will be negotiated with the Washington State Department of Ecology (Ecology) following submittal of the state Waste Discharge Permit application. No dangerous waste as per WAC 173-303 will be discharged.

A recent analysis of the relative merits of alternative methods to dispose of treated effluent from the 200 Areas of the Hanford Site indicated that disposal to a land-based infiltration facility was the best choice (WHC 1992). Other alternatives evaluated included discharge to the Columbia River, solar or mechanically-assisted evaporation, and use in irrigation. The evaluation was based on overall environmental impact, regulatory compliance costs, life-cycle costs, and implementability.

The criteria and the process used to tentatively choose a preferred location for construction of the 200 Areas TEDB from among several candidates was given by Davis (1992). Davis and Delaney (1992) identified additional information needed to

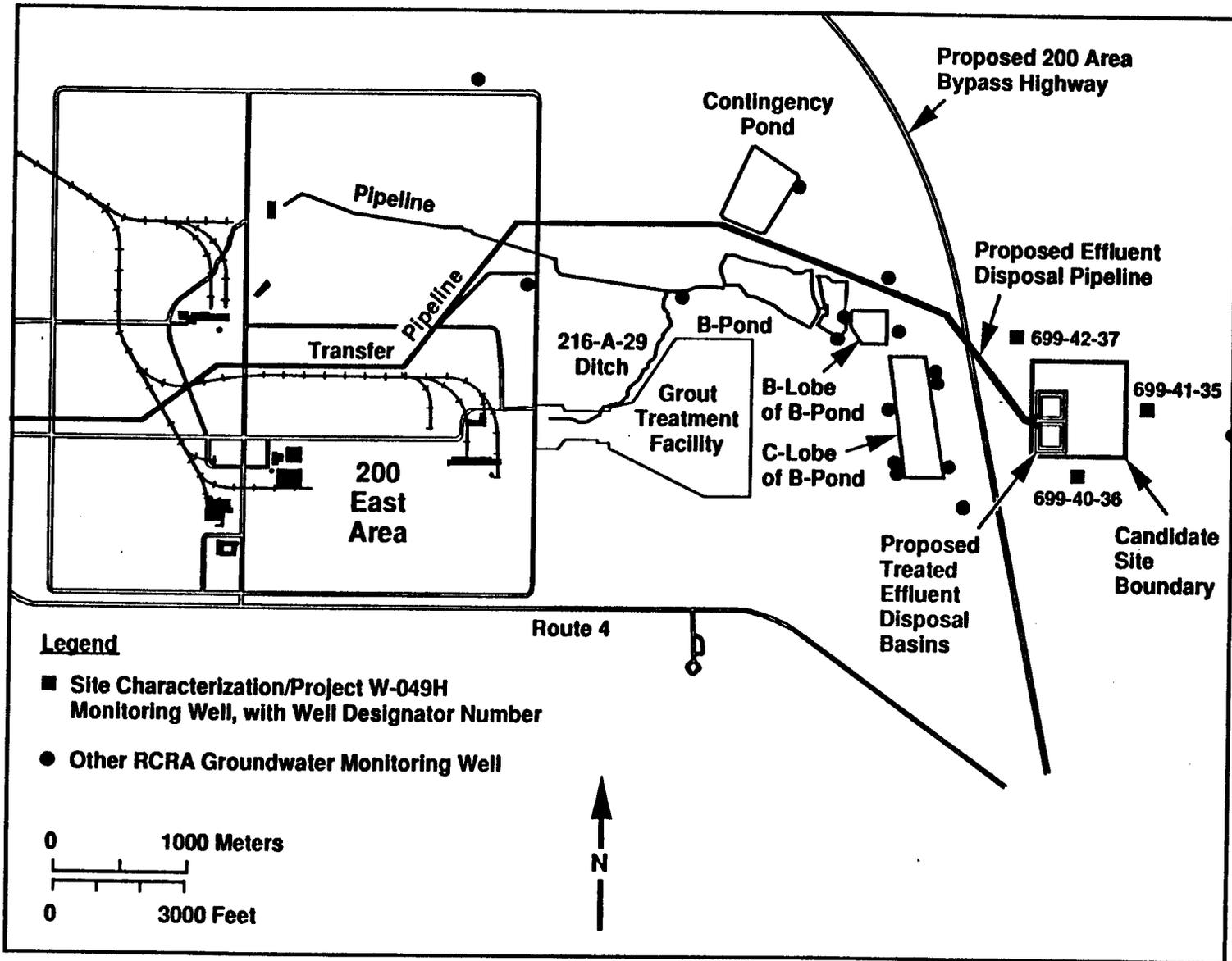


Figure 1. Site Proposed for Disposal of Treated Effluent from the 200 Areas.

characterize the site, provided rationale for why it was needed, and described the tasks that would be performed to obtain the information.

1.2 OBJECTIVES OF WORK

The intent of site characterization and evaluation work described by this report was to ensure compliance with applicable regulatory requirements in identifying an environmentally acceptable site for disposal of treated effluents from the 200 Areas. Approval by Ecology will be sought to construct and operate the 200 Areas TEDB respectively through the submission of plans and reports for construction of wastewater facilities (WAC-173-240) and the Washington State Waste Discharge Permit Program (WAC 173-216) (Ecology 1988). The purpose of permits issued under the auspices of WAC 173-216 is to ensure compliance with Section 307 of the Federal Water Pollution Control Act (33 U.S.C., §1251).

The objective of performing the work was to obtain sufficient hydrogeologic information to judge the suitability of the proposed site for operating the TEDB. The evaluation focused on the potential for the TEDB to remobilize contamination associated with parts of the 200 East Area or the B Pond Complex. Methods used for the evaluation complied with those approved by the DOE and Ecology for assessing the effects of effluent discharges on groundwater at the Hanford Site (Tyler 1991).

Results of the evaluation given in this report provide the information needed to support the findings of the engineering report required by WAC 173-240 and the application needed to obtain a WAC 173-216 discharge permit. Compliance with the National Environmental Policy Act (NEPA) previously was demonstrated by the Environmental Assessment of the Hanford Environmental Compliance Project (DOE 1992). The scope of that environmental assessment includes the impacts expected from construction and operation of Project W-049H.

1.3 SCOPE OF WORK

This report addresses the results of work that was identified and described in Section 5.0 of Davis and Delaney (1992) to characterize the site proposed for disposal of treated effluent from the 200 Areas. Details of how and why data and analyses were identified as required for the site characterization are given in Section 3.0 of the same report.

1.3.1 Summary of Site Characterization Methods

Three wells compliant with requirements of the Resource Conservation and Recovery Act (RCRA) were drilled to the top of the basalt bedrock; one hydraulically upgradient and two hydraulically downgradient from the proposed site (see Figure 4 of Delaney 1993). The wells were geologically logged. The easternmost of these wells,

699-41-35, was additionally logged by spectral gamma. Samples were collected every 5 ft (see Attachment 1 for metric conversion chart) and analyzed to characterize their radiological, chemical, and physical properties. These samples included sediments from the Pasco gravels member of the Hanford formation and the lower mud unit and unit A of the Ringold Formation.

Laboratory data were collected on porosity, bulk density, particle size distribution, saturated hydraulic conductivity, and moisture characteristic curves. In addition, sediments in the first 20 ft from the surface were sampled by split spoon and analyzed for evidence of chemical or radionuclide contamination. X-ray fluorescence analyses were made of samples from the uppermost basalt flow to confirm its identity. The presence or absence of this lava flow, the Elephant Mountain Member, is important in evaluating the potential for movement of water to deeper, confined aquifers.

Water samples were collected in the three site characterization wells. Groundwater from the uppermost aquifer was collected and analyzed for the presence of contaminants. Water samples were collected and analyzed quarterly to obtain a 1-yr baseline of water quality. Thereafter, the wells will continue to be sampled as part of the Hanford Site RCRA well-monitoring program.

Infiltration tests were conducted in the bottom of a 13-ft-deep trench at the location and depth projected to become the bottom of the proposed infiltration basin. These data were collected to estimate the initial infiltration capacity of the sediments at the surface of the bottom of the proposed basin.

Constant-discharge, single-well aquifer tests were conducted to obtain site-specific hydraulic conductivity. These values were used to estimate groundwater flow velocities and support numerical simulations of the uppermost aquifer.

Data resulting from the site characterization work were used to refine previously developed conceptual and numerical models (see Appendix A.3, Davis 1992) of the uppermost aquifer for the proposed site. The refined models were used to predict the effects on the aquifer of operating the TEDB at the proposed site. This information, in turn, was used to help reevaluate the suitability of the proposed site using criteria previously identified (see Sections 3.0 and 4.0 of Davis 1992).

Eight tasks were completed to obtain and analyze the information deemed necessary to adequately characterize the proposed site. The following sections briefly describe the scope of these tasks. The issuance of this report constitutes documentation of completion of the ninth and final task identified by Davis and Delaney (1992) -- determination of site suitability.

1.3.2 Well Construction

Three RCRA-compliant wells were constructed in accordance with WHC-S-014 (WHC 1991) and Ecology (1989) to evaluate the suitability of the proposed TEDB site.

The wells were completed in the upper part of the uppermost aquifer. Appendix A provides the construction details for these wells. Basic data on the well locations, elevations, and construction are in Table 1.

Table 1. Basic Well Construction Information.

Well	Hanford coordinates (C/L casing)	Elev. of brass cap in concrete well pad (ft)	Casing & screen dia. (in)	Screened interval & length (ft)	Screen slot size
699-40-36	N39830 W36432	525.79	4	209.2-219.5/ (stainless) 10.3	10
699-41-35	N40856 W35479	517.42	4	189.8-200.1/ (stainless) 10.3	10
699-42-37	N41846 W37451	516.18	4	144.2-154.5/ (stainless) 10.3	10

1.3.3 Geological Logging

Samples of well cuttings were collected at 5-ft intervals and/or at each significant lithologic change. The wells were geologically logged in accordance with the WHC environmental investigation instruction (EII) 5.10 (1989). The samples are in the Hanford Geologic Sample Library and provide a permanent record of lithologies at the well sites. Geologic logs for each well (WHC 1993b) are summarized in Appendix A and Section 3.0.

1.3.4 Geophysical Logging

High-resolution spectral gamma-ray logging using a high-purity germanium detector was completed in well 699-41-35, immediately east of the proposed 200 Areas TEDB. The logging was done after the temporary well-construction casing was removed, and after well-sealing materials and permanent stainless steel casing were installed. The survey was made in accordance with EII 11.1 (WHC 1989) at 0.5-ft increments from the surface to 198 ft. A count-time of 180 seconds for each depth increment was used.

The logging was done to document a baseline response for the subsurface conditions. A second objective of the logging was to determine the presence or absence of man-made gamma-ray-emitting radionuclides to confirm the results of radiochemical analyses of sediments from this well. The logging methods and results from the spectral gamma-ray survey are discussed in Appendix B.

1.3.5 Sediment Sampling and Analysis

Samples for determining the physical properties of sediments intercepted by the three site characterization wells were obtained with a 2-ft-long split-spoon drive tube that had a 2.36-in. inside-diameter stainless steel liner. The samples were collected after the well had been bailed clean to the depth of the drive shoe. Samples for chemical analysis also were obtained by using a stainless steel split-spoon sampler -- in this case, a 4-in. inside-diameter sampler with four stainless steel liners, each 6-in. long. A minimum of one split-spoon sample per sediment lithology was collected in each well for determination of physical properties. The physical properties determined and the test methods used to determine them are listed in Table 2. Results of the physical properties analyses are given in Section 3.4. Laboratory data sheets for the physical properties determinations are provided as part of the borehole data package (WHC 1993b).

Table 2. Physical Properties Measured and Method of Measurement.

Physical property	Method of measurement
Porosity	ASTM D-698 and D-1557
Bulk density	ASTM D-698 and D-1557
Particle size distribution	ASTM D-422
Soil moisture	ASTM D-2216
Hydraulic conductivity	ASTM D-2434
Soil moisture characteristic curves	ASTM D-2325 and D-3152
Cation exchange capacity	American Society of Agronomy (1982)

A split-spoon sample of each lithology encountered was deposited in the Hanford Geologic Sample Library to provide material for potential future verification or contingency testing. Samples placed in the archive were retained in the original stainless steel liner; the ends of the liner were sealed by Teflon (a trademark of E. I. duPont de Nemours) caps or equivalent caps that were Teflon-taped to the liners to achieve an air-tight seal.

The samples for chemical analysis were double wrapped in plastic, labeled, and stored in an ice chest. Samples were then packaged and shipped to the analytical laboratory in accordance with EII 5.11 (WHC 1989), with documentation of their chain of custody as per EII 5.1 (WHC 1989).

Samples of well cuttings were monitored by the well-site geologist during drilling to ensure that all significant changes in lithology were sampled. In addition, one split-spoon sample was taken from each 5-ft interval in the first 20 ft of sediments intersected by each well. The samples were analyzed for the constituents listed in Table 3. Results of the chemical analyses of sediment samples are provided in Section 3.5. Laboratory data sheets for these analyses are published separately from this report as a data package (WHC 1993c).

Table 3. Constituents and Analytical Methods for Chemical Analysis of Sediments.

Constituent analyzed	Analytical method
Metals	CLP ILM02
Hexavalent chromium	SW-846 method 7196 (ion extraction)
Anions	EPA method 353.2 (batch leach anions from sample with water and analyze leachate)
Cyanide	CLP ILM02
Volatile organic compounds	SW-846 method 8240
Semi-volatile organic compounds	SW-846 method 3540, or 3550 and 8270
CaCO ₃	ASTM method D-4373
Radiation	
gross alpha	Approved standard laboratory operating procedure
gross beta	Approved standard laboratory operating procedure
gamma	Gamma-ray scan
pH	SW-846 method 9040

1.3.6 Groundwater Sampling and Analysis

The objective of this task was to obtain samples adequate to determine the quality of any perched water and water of the uppermost aquifer at the proposed site. The objective was achieved by installing groundwater monitoring wells, collecting water samples from a 10.3-ft screened interval in the top 20 ft of the aquifer, and chemically analyzing the samples.

Perched water was encountered in only one well, 699-40-36, at a depth of 112 ft. Temperature, pH, and electrical conductivity were measured to provide additional information for the WAC-173-216 permit application. Ammonium and total organics, which are not included in WAC 173-200-040, were also analyzed. All samples were collected, processed, analyzed, and the results reported in accordance with applicable provisions of the *Quality Assurance Plan for RCRA Groundwater Monitoring Activities* (Jackson 1990). The methods and procedures used and the constituents analyzed are specified in Table 4. Analytical results are in Section 4.3. The laboratory data sheets for these analyses comprise Appendix C.

1.3.7 Determination of Infiltration Rates

Tests of infiltration capacity were conducted at the elevation and location that are projected to become the bottom of the proposed infiltration basin (Figure 2). The infiltration tests were made to estimate the baseline value of the vertical hydraulic conductivity of sediments in the bottom of a trench 13 ft below the ground surface. These data were used to verify the initial estimates of infiltration rates and provide information for the initial conditions used in simulating the effects on the aquifer of effluent disposal at the TEDB site. Both constant-head and falling-head test methods were used. Results of the analysis are provided in Section 4.4. The complete report from the infiltration capacity tests is provided in Appendix D.

Table 4. Constituents and Analytical Methods for Chemical Analysis of Groundwater.

Constituent	Analytical group	Analytical method
1,1 Dichloroethane	Volatile organics	SW-846 method 8010
1,1,1 Trichloroethane	Volatile organics	SW-846 method 8010
1,2 Dichloroethane	Volatile organics	SW-846 method 8010
Aluminum	ICP ^a metals	SW-846 method 6010
Americium-241	Gross alpha	Laboratory method
Arsenic	AA ^b metals	SW-846 method 7060
Barium	ICP metals	SW-846 method 6010
Bisphthalate (2-ethylhexyl)	Semivolatile organics	SW-846 method 7060
Cadmium	ICP metals	SW-846 method 6010
Cesium-137	Gross beta	Laboratory method
Chloride	Anions	ASTM method D4327-88
Chloroform	Volatile organics	SW-846 method 8010
Chromium	ICP metals	SW-846 method 6010
Cobalt-60	Gross beta	Laboratory method
Coliform bacteria	Coliform	SW-846 method 9131/9132
Copper	ICP metals	SW-846 method 6010
Cyanide	Cyanide	SW-846 method 9010
DDT	Pesticides	SW-846 method 8080
Fluoride	Anions	ASTM method D4327-88
Gross alpha	Gross alpha	Laboratory method
Gross beta	Gross beta	Laboratory method
Hydrazine	Hydrazine	ASTM method D1385
Iodine-129	Iodine-129	Laboratory method
Iron	ICP metals	SW-846 method 6010
Lead	AA metals	SW-846 method 7421
Manganese	ICP metals	SW-846 method 6010
Mercury	AA metals	SW-846 method 7470
N-nitrosodimethylamine	Semivolatile organics	SW-846 method 7060
Nitrate	Anions	ASTM method D4327-88
Plutonium-239/240	Gross alpha	Laboratory method
Radium	Gross alpha	Laboratory method
Selenium	AA metals	SW-846 method 7740
Silver	ICP metals	SW-846 method 6010
Strontium-90	Gross beta	Laboratory method
Sulfate	Anions	ASTM method D4327-88
Technetium-99	Gross beta	Laboratory method
Tetrachloroethylene	Volatile organics	SW-846 method 8010
Toluene	Volatile organics	SW-846 method 8010
Trichloroethylene	Volatile organics	SW-846 method 8010
Tritium	Tritium	Laboratory method
Xylene-o,p	Volatile organics	SW-846 method 8010
Zinc	ICP metals	SW-846 method 8010
Trans-1, dichloroethylene	Volatile organics	SW-846 method 8010
pH	pH	ASTM D1293
Conductivity	Conductivity	SM 214 A
Total organic carbon	Total organic carbon	ASTM D1293
Total organic halides	Total organic halides	SW-846 method 9020

^a ICP = inductively coupled plasma.

^b AA = atomic absorption.

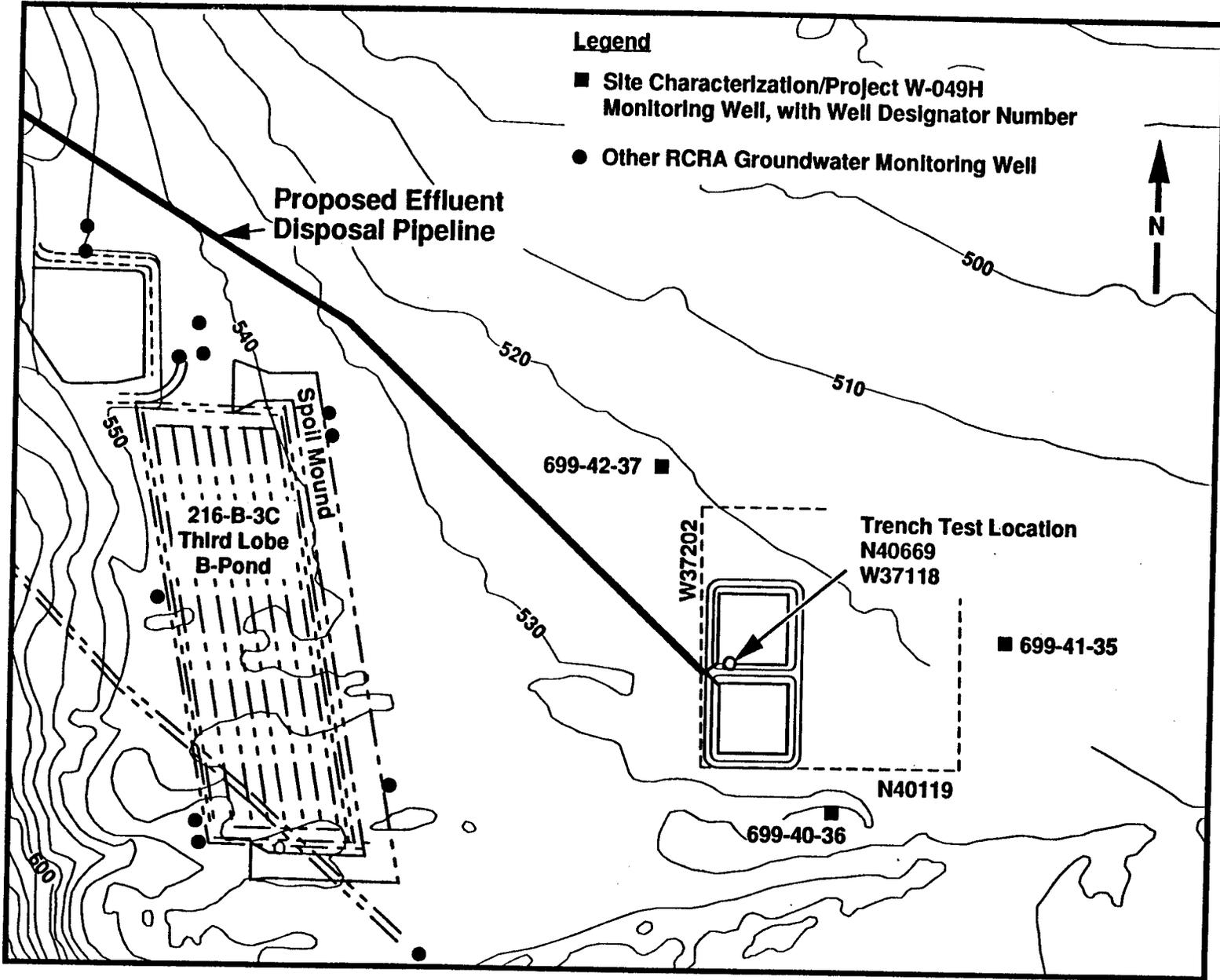


Figure 2. Location of Trench for Tests to Determine Vertical Hydraulic Conductivity.

1.3.8 Aquifer Testing

Constant-rate discharge and instantaneous-slug tests of the uppermost aquifer were conducted at the three wells drilled to characterize the proposed site. The testing was conducted in accordance with the *Hydrologic Test Plan* (Delaney 1993) EII 10.1 (WHC 1989) and Section 5.7, *Aquifer Testing*, of the *Site Characterization Work Plan* (Davis and Delaney, 1992). The objective of the tests was to obtain reliable drawdown and recovery data to estimate the transmissivity of the uppermost aquifer at the proposed TEDB site.

Instantaneous slug injection/withdrawal data obtained after completion of the wells were analyzed by the Bouwer and Rice (1976) and Cooper et al. (1967) methods. The Cooper and Jacob (1946) method was used to analyze the constant-discharge test results. Results of the analyses are provided in Section 4.5. Data analysis methods are provided in Appendix E. Test data are in the borehole data package WHC (1993b).

1.3.9 Numerical Modeling of Predicted Effects on Aquifer

The site characterization data resulting from the above-described tasks were used to refine the conceptual and numerical models that previously were developed (see Appendix A.3 of Davis 1992) to evaluate the hydrologic effects of the proposed facility. The effects on the groundwater system were evaluated for a projected 30-yr operating period plus a 10-yr post-operation period for the aquifer to reequilibrate to its natural state.

Simulations were made to (1) evaluate whether the vertical and lateral extent of mounding of the water table that will result from operation of the TEDB would be sufficient to potentially remobilize known contamination above the present water table in the 200 East Area or associated with parts of the B Pond complex, and (2) determine the minimum time required for water from the TEDB to reach the Columbia River. The evaluations were made for a wide range of discharge rates. Results of the simulations are in Section 4.6.

1.3.10 Determination of Site Suitability

The results from the eight site characterization tasks were used to confirm the suitability of the proposed TEDB site using the criteria previously described by Davis (1992). Based on this information, a determination was made of whether the site complied with these criteria and the applicable and pertinent requirements of the *Environmental Compliance Manual* (WHC 1988). The results of that determination are in Section 5.0.

2.0 HYDROGEOLOGIC SETTING

The Hanford Site is located within the Pasco Basin of south-central Washington (Figure 3). The site proposed for construction of the 200 Areas TEDB is near the center of the Hanford Site, approximately 2 mi east of the eastern boundary of the 200 East Area (see Figure 1).

2.1 PREVIOUS WORK

The geologic setting of the Hanford Site and the Pasco Basin has been discussed by Myers et al. (1979) and Delaney et al. (1991). The hydrologic setting of the same area has been described by Gephart et al. (1979) and more recently by Delaney et al. (1991). Geologic structures of the Hanford Site that may affect the hydrology downgradient from the proposed TEDB, including the May Junction Fault, are discussed in PSPL (1982).

The geology of the 200 Areas was discussed by Tallman et al. (1979). The hydrology of the 200 Areas was described by Graham et al. (1981). Lindsey (1991) described the geology of the sediments of the Hanford Site, with emphasis on the Ringold Formation of Miocene-Pliocene age.

Lindsey et al. (1992) recently discussed the origin of sediments overlying the basalt bedrock in the 200 Areas and provided a detailed description of their stratigraphic relationships. Connelly et al. (1992) have developed a conceptual hydrologic model and maps of groundwater contamination for the 200 East Area. Graham et al. (1984) assessed aquifer intercommunication in the 216-B-3 Pond (B Pond) and Gable Mountain Pond areas, respectively, west and northwest of the proposed 200 Areas TEDB.

The geology and hydrology of the location proposed for construction of the 200 Areas TEDB were initially described by Davis and Delaney (1992). Since completion of that report, five additional groundwater monitoring wells were installed in the vicinity of the proposed site. Three of these wells were site characterization wells drilled immediately adjacent to the proposed TEDB site; two of the wells were drilled nearby to the west to improve groundwater monitoring in the vicinity of the B Pond RCRA facility (see Figure 1). Consequently, based on the data from these five new wells, Delaney (1993) updated the description of the stratigraphy, lithology, and hydrology of the proposed site.

2.2 STRATIGRAPHY

The Saddle Mountains Basalt of the Miocene-age Columbia River Basalt Group is the uppermost basalt formation beneath the Hanford Site (Figure 4). The Elephant Mountain Member of the Saddle Mountains Basalt is the uppermost basalt flow

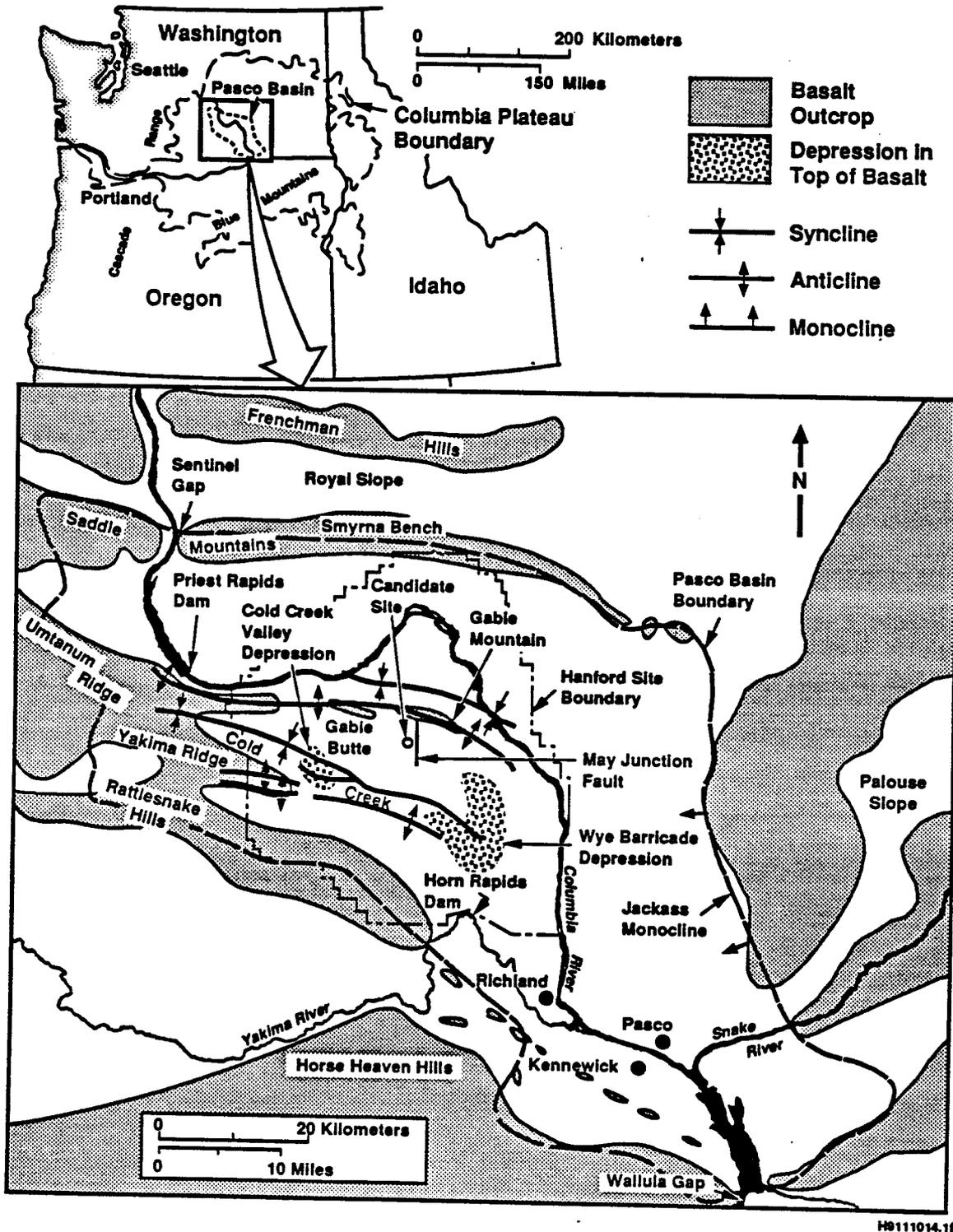
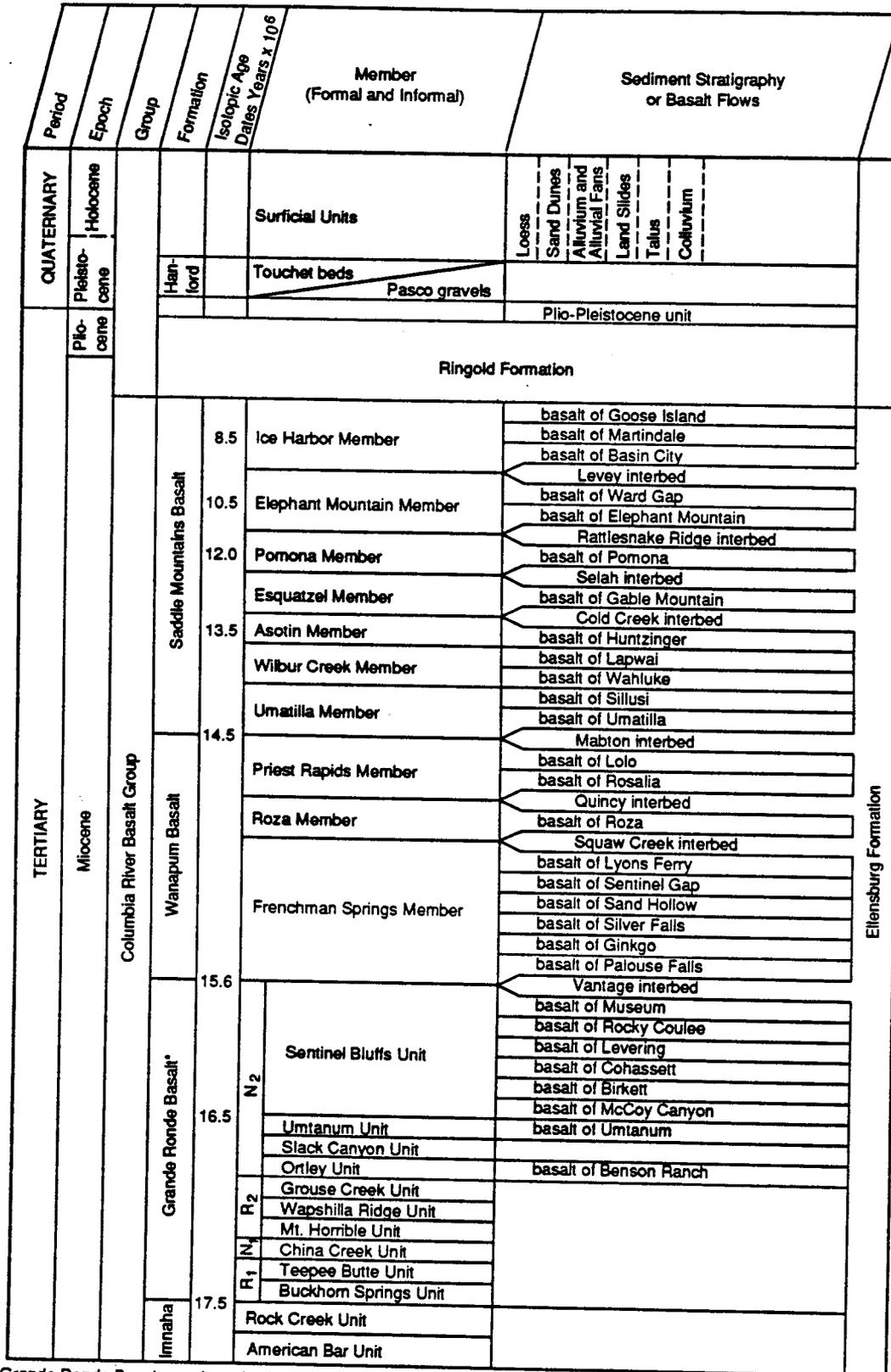


Figure 3. Geologic and Geographic Setting of the Hanford Site.



*The Grande Ronde Basalt consists of at least 120 major basalt flows. Only a few flows have been named. N₂, R₂, N₁ and R₁ are magnetostratigraphic units.

H9102029.6
CWC

Figure 4. Generalized Stratigraphic Column for the Hanford Site.

beneath the proposed TEDB site and immediately surrounding areas. This was established by the fact that all three site characterization wells, as well as the two new B Pond monitoring wells drilled in 1992, older B Pond wells, and a well to the east of the proposed site (well 699-40-33C) encountered this basalt flow beneath the Ringold Formation.

Erosional "windows" through the relatively impervious interior of the Elephant Mountain Member are known to occur in the northeast corner of the 200 East Area (see Figure A.1.8 of Appendix A in Davis 1992). Erosional windows of this type could permit direct hydraulic communication, in areas of artificial recharge with downward hydraulic potential (Kasza and Schatz 1989), from the uppermost aquifer to deeper, confined aquifers (Gephart et al. 1979). Hence, occurrence of the Elephant Mountain Member throughout the vicinity of the proposed site precludes this possibility.

The Ellensburg Formation consists of bedded volcanoclastic and siliciclastic sediments that occur between flows of the Columbia River Basalt. At the Hanford Site the three uppermost of these sedimentary units are the Selah, Rattlesnake Ridge, and Levey interbeds. Reidel and Fecht (1981) discussed the details of the Ellensburg Formation as they pertain to the Hanford Site and vicinity.

The Rattlesnake Ridge interbed was determined to be 50 to 80-ft-thick beneath the 200 Areas (Graham et al. 1981, 1984). The direction of groundwater flow within this interbed is generally toward the west or northwest in the vicinity of the 200 East Area. Although the three wells drilled to characterize the proposed TEDB site were not sufficiently deep to encounter the Rattlesnake Ridge interbed, projection from other nearby wells (Connelly et al. 1992) suggests that it is likely present below the Elephant Mountain Basalt at the proposed TEDB site.

Sediments overlying the Columbia River Basalt at the Hanford Site (see Figure 4) include (from oldest to youngest):

- The Ringold Formation of late Miocene to Pliocene age
- Plio-Pleistocene alluvium and paleosol
- Gravel that may predate Pleistocene sediments, termed "pre-Missoula" gravel
- "Early Palouse soil" comprised of silt and loess
- Pleistocene-age sediments, informally known as the Hanford formation, that were deposited from catastrophic floods
- Holocene surficial alluvium and dune sand less than 30 ft thick.

The total thickness of these sediments within the boundaries of the Hanford Site ranges from 0 to 750 ft.

The sediments of principal interest at the proposed TEDB site are the Ringold Formation and the Hanford formation. General descriptions of these formations, abstracted from Delaney et al. (1991) and Lindsey et al. (1992), are provided in the following sections. The stratigraphy, geochemistry, and physical properties of these sediments, as determined from the three site characterization and other nearby boreholes, are described in detail in Section 3.0.

2.2.1 Ringold Formation

The Ringold Formation is comprised of fluvial-lacustrine sediments of late Miocene and Pliocene age. These sediments vary in thickness from ~600 ft in the west-central to 0 in the northeastern part of the Hanford Site. Pleistocene erosion is known to have removed the Ringold Formation north of the northern one-third of the 200 East Area, ~1 mi northwest of the proposed TEDB site. Dominant facies of the Ringold Formation are:

- Fluvial gravel
- Fluvial sand
- Overbank deposits of fine-grained sand and silt
- Clay and silt of lacustrine origin
- Alluvial fan deposits.

The upper part of the Ringold Formation is dominated by fine-grained sediments of fluvial and lacustrine origin. The upper part is not present in or near the TEDB site. Five distinct gravel-dominated strata have been identified in the lower half of the Ringold Formation (Lindsey 1991). These gravel units are separated by fine-grained strata of lacustrine or fluvial overbank origin. The lowermost of these fine-grained units is informally termed the "lower mud sequence." Only the lowermost gravel sequence, designated unit "A", and the lower mud sequence are present beneath the proposed TEDB site.

Groundwater in the uppermost aquifer moves principally within unit A of the Ringold Formation in areas south and east of the 200 East Area. Beginning in the vicinity of the B Pond, this aquifer becomes progressively more confined to the south and east, toward the proposed TEDB site, by the lower mud sequence of the Ringold Formation.

2.2.2 Hanford Formation

Pleistocene catastrophic flood deposits, known informally as the Hanford formation, are up to 350 ft thick within the boundaries of the Hanford Site. These strata unconformably overlie the Ringold Formation and other, laterally discontinuous Plio-Pleistocene sediments.

The Hanford formation has been subdivided into gravel-, sand-, and silt-dominated facies by Lindsey et al. (1992). The gravel-dominated unit, also informally known as the Pasco gravel, comprises most of the unsaturated section at the proposed site.

At the TEDB site, the Pasco gravel directly overlies the lower mud unit of the Ringold Formation. Perched groundwater was encountered at the base of the Hanford formation, at the top of the lower mud unit, during the drilling of site characterization well 699-40-36 and monitoring wells near the B Pond complex (see Section 4.3.3).

3.0 STRATIGRAPHY AND RESULTS OF LITHOLOGIC ANALYSES

This section describes in detail the stratigraphy and lithology of the Ringold and Hanford formations, as encountered by the three site characterization and other wells (Figure 5) in the vicinity of the proposed site. It also indicates the evidence that confirms the presence of the Elephant Mountain aquitard.

3.1 COLUMBIA RIVER BASALT

Reidel et al. (1989) have identified individual flows within the Columbia River Basalt Group (see Figure 4) based on major and trace element contents. Samples of the basalt cuttings encountered at the bottom of the three site characterization wells indicate that the uppermost basalt flow is the Elephant Mountain Member of the Saddle Mountains Formation. This flow forms an aquitard separating the uppermost aquifer from deeper, confined aquifers occurring in flow tops and bottoms, and in sedimentary interbeds of the Ellensburg Formation. As calculated from intercepts in the three boreholes at the proposed TEDB site, the Elephant Mountain Member dips 0.5° (1.1%) in a direction 30° west of south. However, the general trend of the dip in the vicinity of the TEDB is south to southeast at approximately 0.5° (Figure 6). The results for major and trace element analyses of basalt samples from the three wells are at the back of Appendix A.

3.2 RINGOLD FORMATION

Only the lower mud unit and unit A of the Ringold Formation are present at the proposed TEDB site (Figures 7 and 8). In the vicinity of the proposed TEDB, the Ringold Formation becomes thinner to the north and pinches out where it has been eroded from the northern one-third of the 200 East Area and north of the B Pond complex (Lindsey et al. 1992). Detailed geologic logs of the three site characterization wells are in Appendix A.

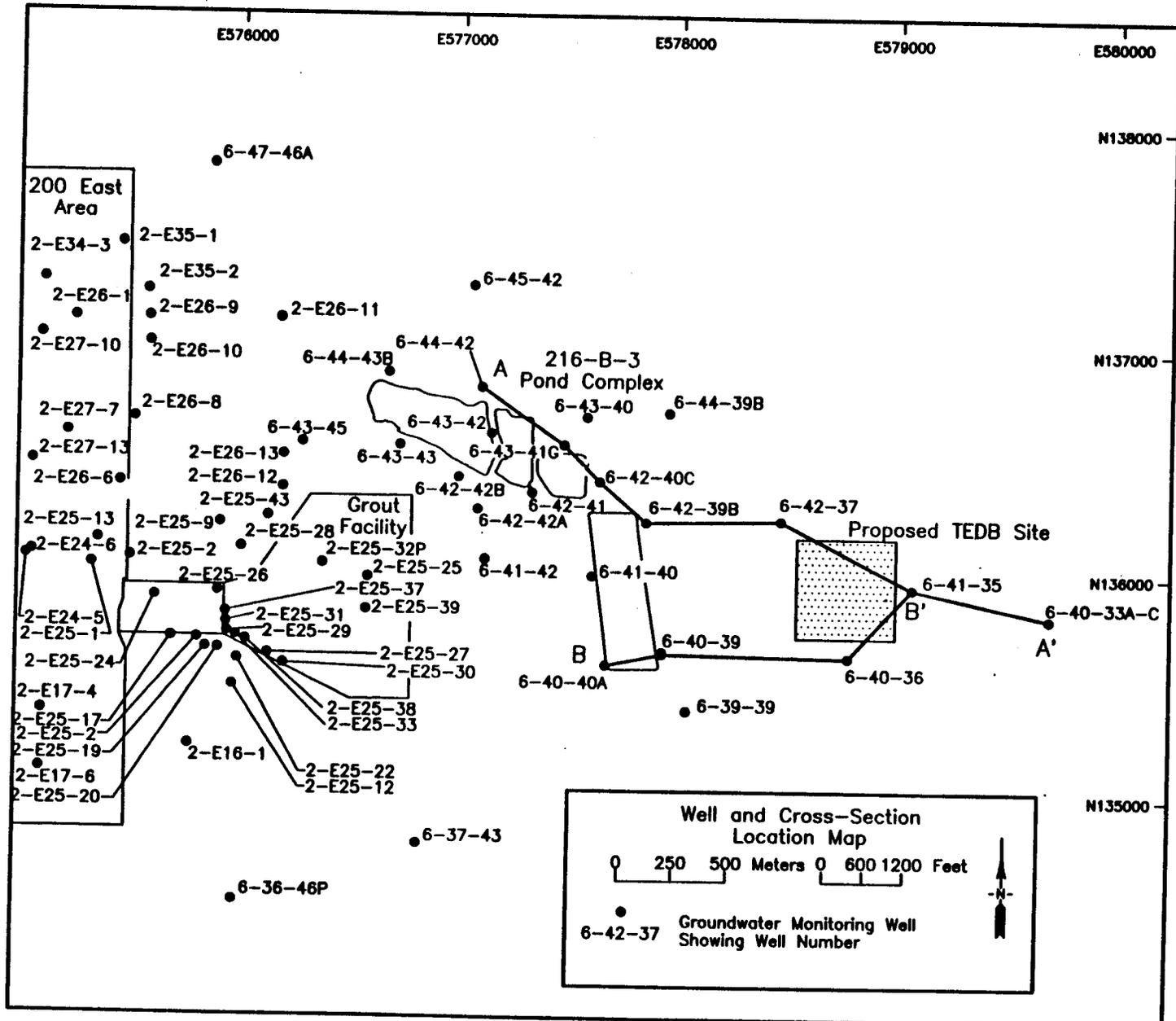


Figure 5. Locations and Identities of Wells in the Vicinity of the Proposed Site.

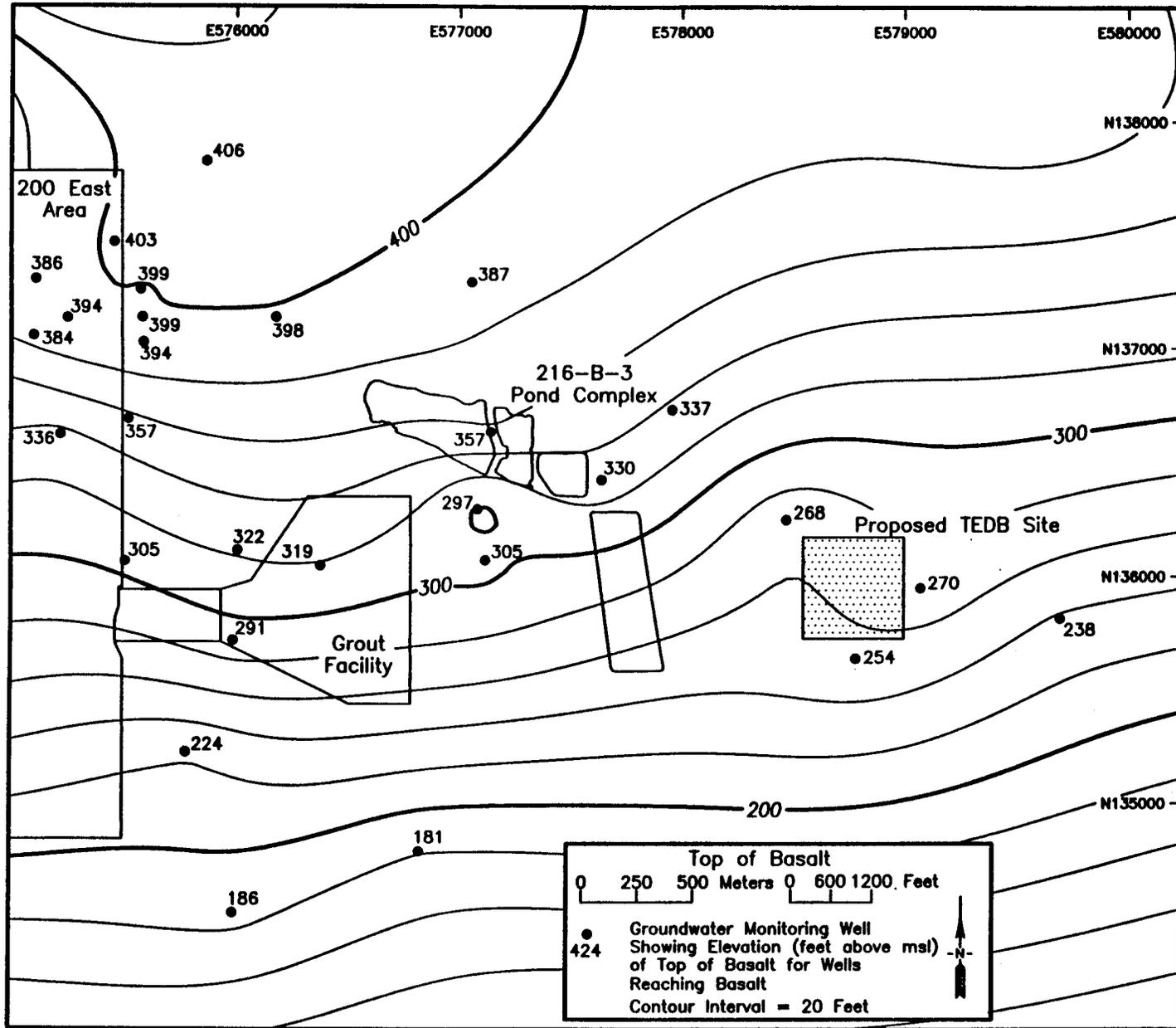
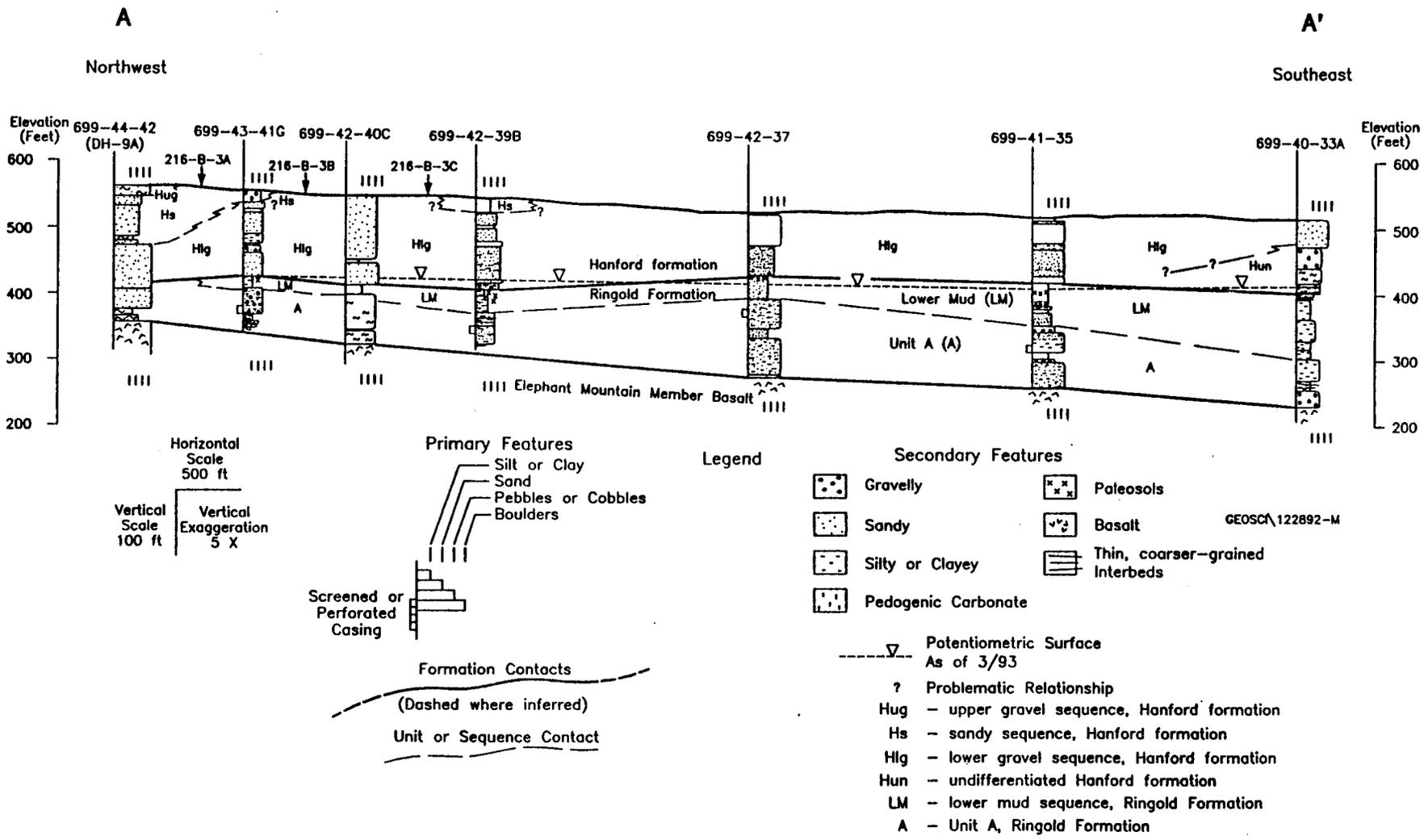


Figure 6. Structure Contour Map of the Top of Columbia River Basalt.

Figure 7. Geologic Cross Section A-A'



Horizontal Scale
500 ft

Vertical Scale
100 ft

Vertical Exaggeration
5 X

Primary Features

- Silt or Clay
- Sand
- Pebbles or Cobbles
- Boulders

Screened or Perforated Casing

Formation Contacts
(Dashed where inferred)

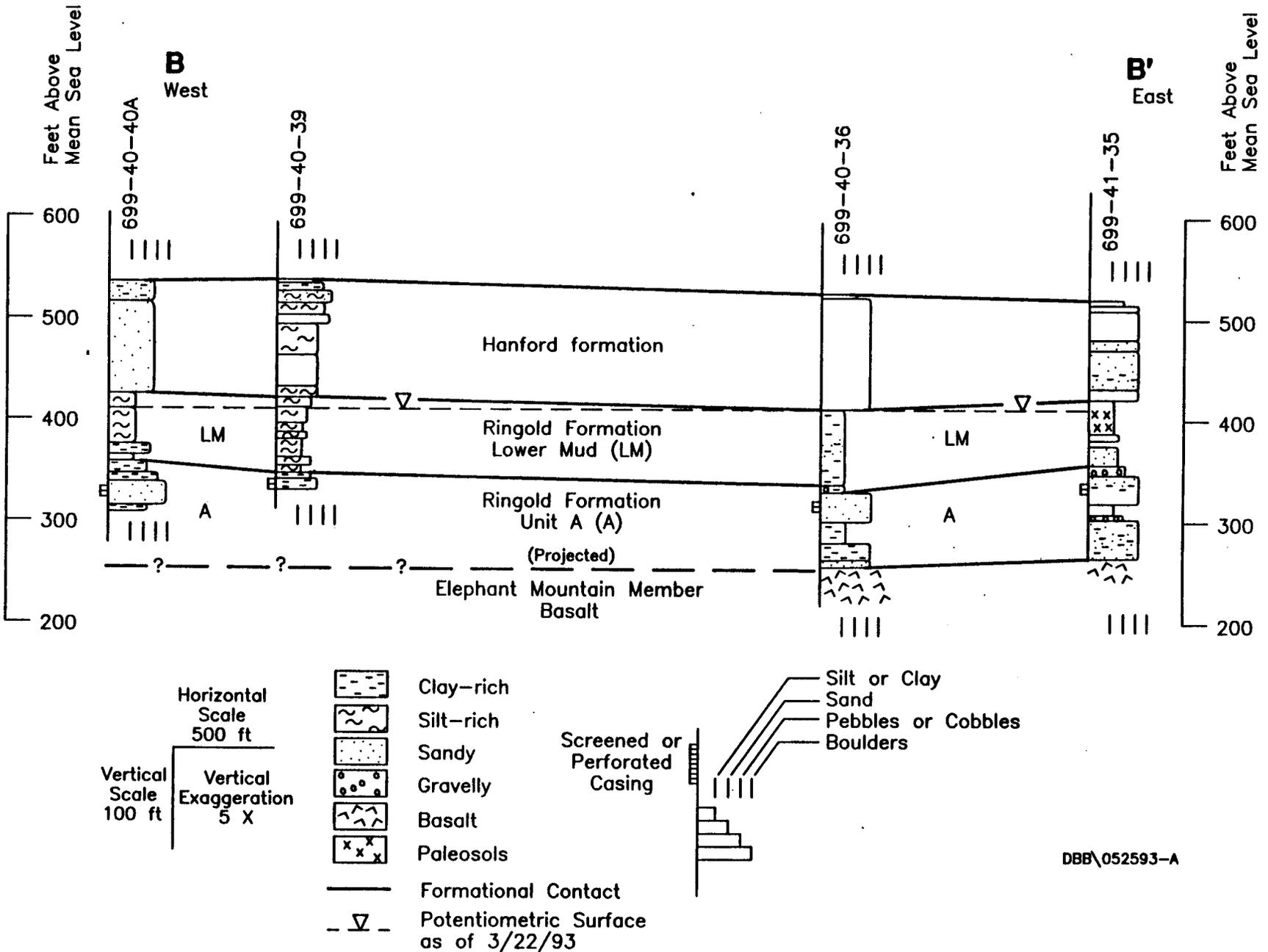
Unit or Sequence Contact

Legend

- Secondary Features**
- Gravelly
 - Sandy
 - Silty or Clayey
 - Pedogenic Carbonate
 - Paleosols
 - Basalt
 - Thin, coarser-grained Interbeds
- ▽ Potentiometric Surface
As of 3/93
- ? Problematic Relationship
- Hug - upper gravel sequence, Hanford formation
- Hs - sandy sequence, Hanford formation
- Hlg - lower gravel sequence, Hanford formation
- Hun - undifferentiated Hanford formation
- LM - lower mud sequence, Ringold Formation
- A - Unit A, Ringold Formation

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Figure 8. Geologic Cross Section B-B'



3.2.1 Unit A

In the vicinity of the 200 East Area and the proposed TEDB, unit A of the Ringold Formation is fluvial gravel with interbedded lenses of sand and silt from overbank deposition (Lindsey 1991, Lindsey et al. 1992).

3.2.1.1 Stratigraphy and Structure. Unit A becomes thicker from the southeast corner (~75 ft) to the northwest corner (~120 ft) of the proposed site. As Figure 9 indicates, unit A becomes progressively thinner to the north and pinches out immediately north of the B Pond complex. The plane of contact between unit A and the overlying lower mud sequence beneath the proposed TEDB was calculated to dip ~1.5° (3.3% slope), in a direction 10° east of south (Figure 10).

3.2.1.2 Lithology. The geologic logs of the three site characterization wells indicate that unit A is predominantly clast-supported gravel, with subordinate interbedded silt and sand. Where penetrated by well 699-42-37, unit A gravel is more than three times as thick and contains relatively more silt than in wells 699-41-35 and 699-40-36.

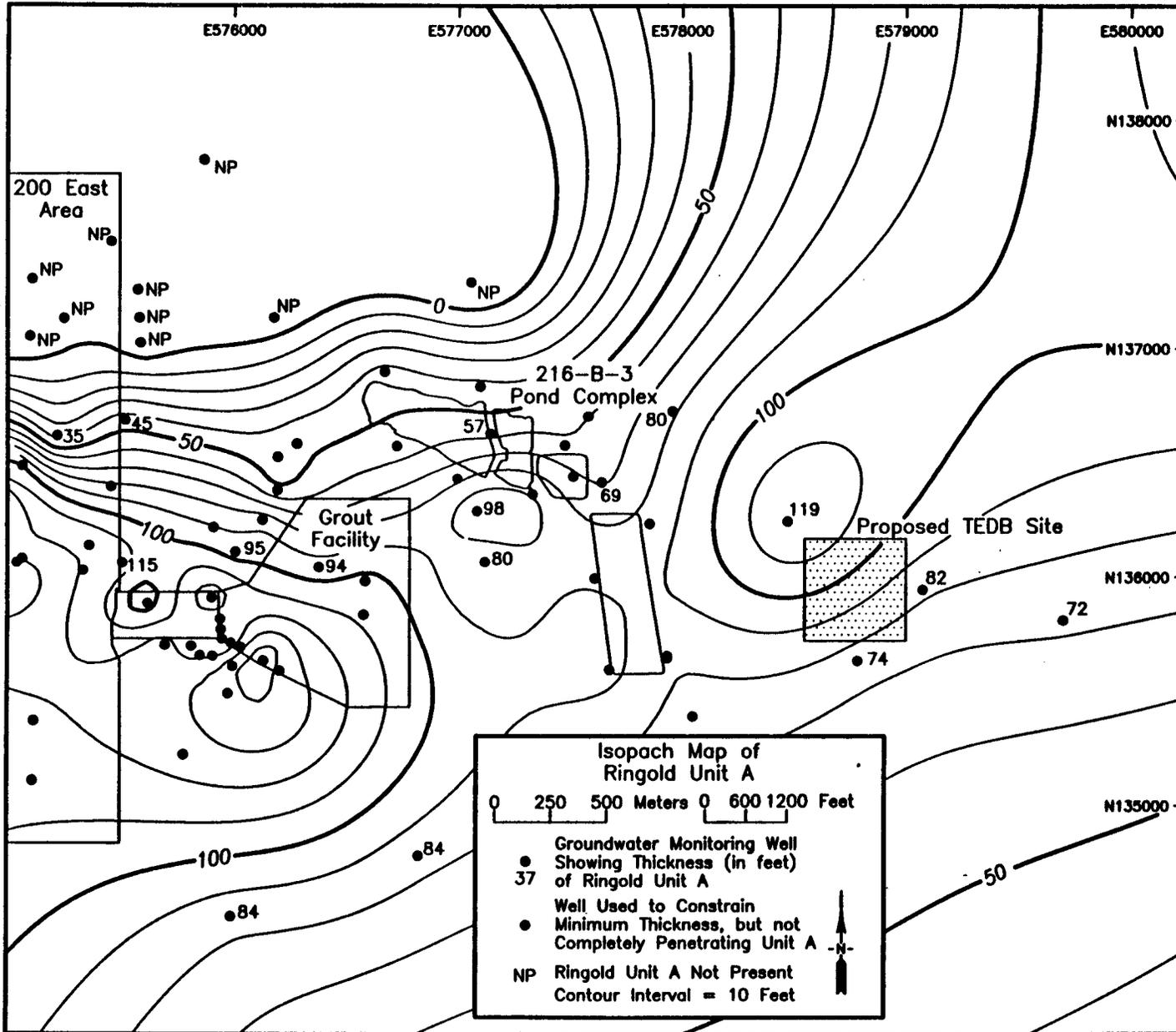
A bed of clay and silt is conspicuously present near the middle of unit A in all three site characterization wells. The thickness of this relatively fine-grained stratum ranges from 15 ft in well 699-42-37 to 23 ft in well 699-40-36. No caliche horizons or zones with significant amounts of CaCO₃ were noted in unit A of the Ringold Formation for any of the three wells. However, minor amounts of CaCO₃ were locally detected within unit A.

3.2.2 Lower Mud Sequence

The lower mud sequence of the Ringold Formation directly overlies unit A in the vicinity of the proposed TEDB and, in turn, is overlain by the Hanford formation. The lower mud sequence is a fluvial overbank deposit comprised of clay and silt (Lindsey et al. 1992).

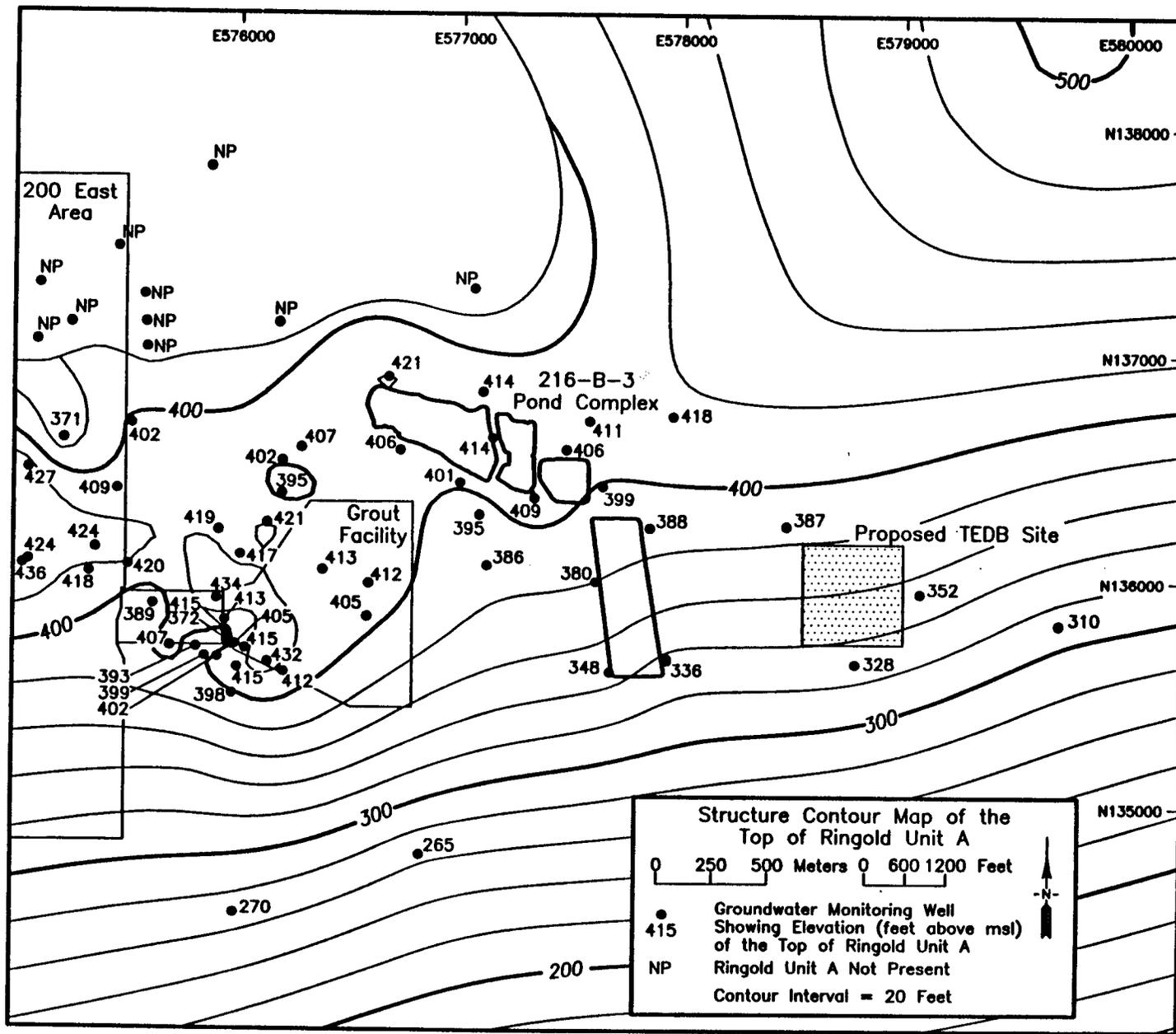
3.2.2.1 Stratigraphy and Structure. In contrast to unit A of the Ringold Formation, the lower mud sequence becomes thicker from north to south across the proposed TEDB site (Figure 11). Its thickness increases from ~40 ft in the northwest corner to ~80 ft in the southeast corner of the proposed site. The lower mud sequence pinches out northwest of the site, immediately north and northwest of the B Pond complex. North of the B Pond complex, the lower mud sequence is known based on well data to occur only locally and sporadically as isolated, discontinuous lenses (Lindsey et al. 1992).

The plane of the contact between the lower mud sequence and the overlying Hanford formation beneath the proposed TEDB site was calculated to dip at ~0.3° (0.7% slope) in a direction 20° east of south (Figure 12).



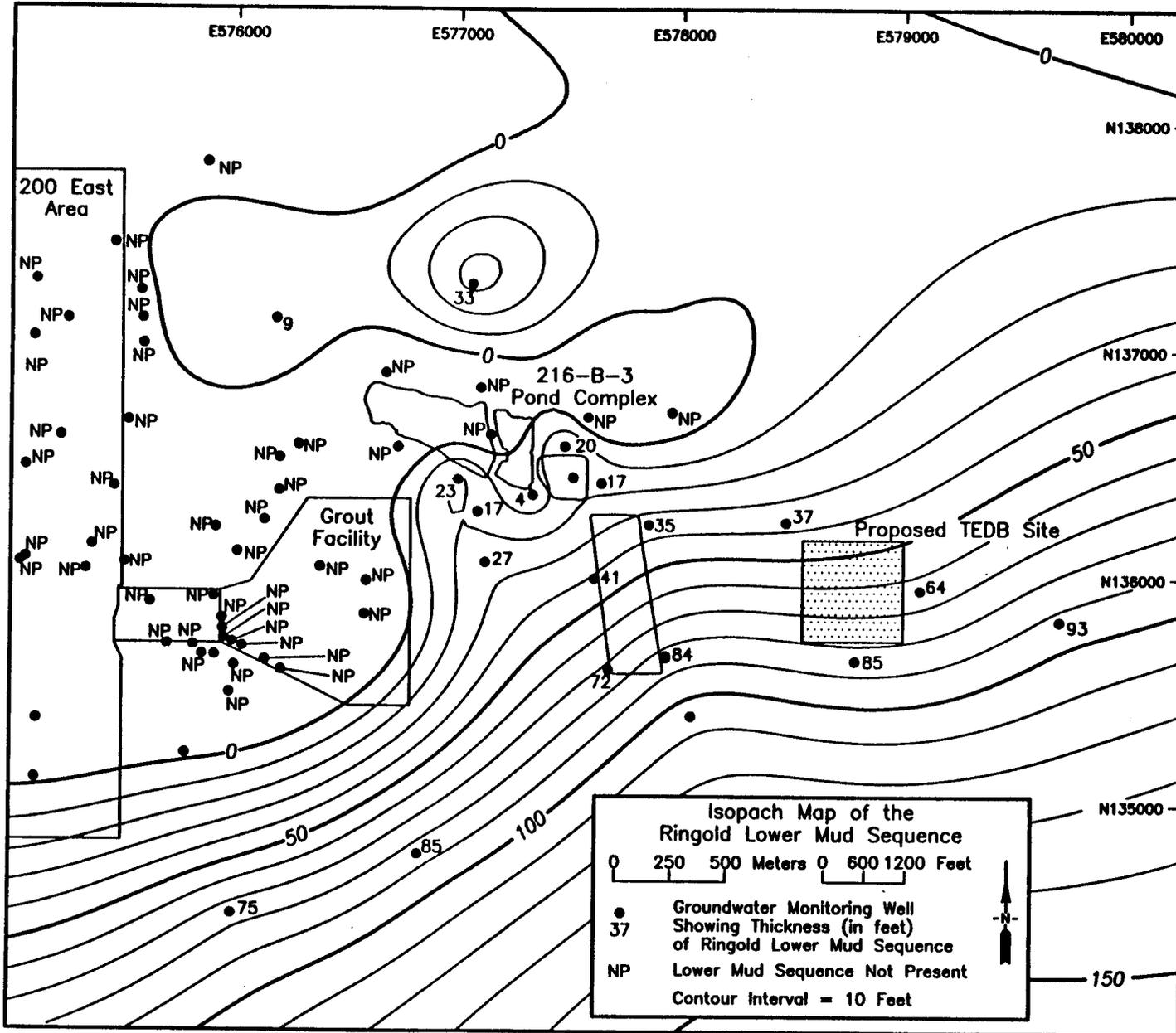
DBB\051993-E

Figure 9. Isopach Map of Ringold Formation Unit A.



DBB\052493-B

Figure 10. Structure Contour Map of Ringold Formation Unit A.



DBE\052093-E

Figure 11. Isopach Map of Ringold Formation Lower Mud Sequence.

3.2.2.2 Lithology. The lower mud sequence is dominantly clay and silt. Of the three site characterization wells, well 699-40-36 encountered the largest content of clay and the most uniformity of the lower mud sequence. Interbedded sand lenses occur near the middle of the lower mud sequence and are particularly evident in wells 699-40-36 and 699-41-35. Gravelly clay occurs in the bottom 5 ft of the lower mud sequence in well 699-40-36.

Cementitious calcium carbonate and zones of caliche are more abundant in the lower mud sequence of the Ringold Formation than in either unit A or the Hanford formation. In well 699-41-35, 4% CaCO_3 was visually estimated by the well-site geologist to be present in the top of the lower mud sequence. In wells 699-40-36 and 699-42-37, 3% CaCO_3 was estimated to be present in the lower mud sequence near its contact with unit A.

3.3 HANFORD FORMATION

Hanford formation sediments underlying the proposed TEDB site are the coarse-grained facies. The relatively fine-grained facies of the Hanford formation that locally separates the lower and upper gravels of the Hanford formation elsewhere is absent from the 200 East Area and vicinity (Lindsey et al. 1992). Hence, distinguishing the lower from the upper Hanford gravel is problematic at the TEDB site (see Figures 7 and 8). At the proposed TEDB site, the Hanford formation is overlain by 2 to 4 ft of dune sand and loess.

3.3.1 Stratigraphy and Structure

Based on extrapolation of data from the three site characterization wells, the thickness of the Hanford formation increases from north-northeast to south-southwest (Figure 13). Data from the three wells indicate that the formation is ~100 ft thick beneath the proposed TEDB site and ranges from 90 ft in well 699-42-37 to 109 ft in well 699-40-36.

3.3.2 Lithology

The composition of Hanford formation sediments encountered in the three site characterization wells is dominated by gravel and silty sandy gravel. In well 699-40-36, the unit is almost entirely gravel, with only 3 ft of silty sandy gravel at the top of the well. In wells 699-41-37 and 699-42-35, respectively, the lower half and lower two-thirds of the unit are silty sandy gravel. Based on this observation, the degree of sorting of the gravel appears to increase in a south to southwest direction (i.e., toward well 699-40-36).

With one exception, significant CaCO₃ cement in the Hanford formation was not observed by the well-site geologist to occur in the three wells. Near the top of well 699-42-37, as much as 4% CaCO₃ was estimated to be present as gravel coatings.

3.4 PHYSICAL PROPERTIES DATA

Split-spoon samples were collected from each of the three site characterization wells for evaluation of the physical properties of sediments encountered by drilling. Eleven samples were collected; four from well 699-42-37, three from well 699-40-36, and four from well 699-41-35. Tests were made to determine specific gravity, moisture content, grain size distribution, hydraulic conductivity, CaCO₃, and porosity.

Table 5 summarizes the results of these tests. The results are arranged according to well number and sample depth. Specific details of each test method are given by the sources previously listed in Table 2.

Table 5. Summary of Data for Physical Properties of Sediments. (sheet 1 of 2)

Sample no.	Stratigraphic unit	Sample depth (ft)	Specific gravity (g/cm ³)	Moisture (%)	Grain size distr. classif.	Hydraulic conductivity	CaCO ₂ (%)	Porosity (%)
Well 699-42-37								
2-3088	Hanford formation	11.6-17.3	2.72	6.79	Sandy gravel	1.3x10 ⁻³	<1.0	28.68
2-3089	Ringold lower mud	91.65-94.0	2.62	19.30	Silty sand	3.2x10 ⁻⁷	<1.0	36.32
2-2865	Ringold lower mud	126.8 ^a -128.8	2.66	25.82	Silty sand	2.3x10 ⁻⁶	2.7	40.41
2-3053	Ringold unit A	135.39 ^a -136.69	2.63	7.60	Sandy gravel	6.4x10 ⁻⁷	1.1	24.38
Well 699-40-36								
3-0001	Hanford formation	95.5-97.0	2.72	6.47	Silty sandy gravel	1.8x10 ⁻⁴	<1.0	18.32
3-0002	Ringold lower mud	114.5 ^a -116.5	2.46	26.52	Silty sand	9.3x10 ⁻⁸	<1.0	31.32
3-0003	Ringold unit A	215.0 ^a -217.0	2.57	11.02	Silty sandy gravel	6.3x10 ⁻⁷	<1.0	22.16

Table 5. Summary of Data for Physical Properties of Sediments. (sheet 2 of 2)

Sample no.	Stratigraphic unit	Sample depth (ft)	Specific gravity (g/cm ³)	Moisture (%)	Grain size distr. classif.	Hydraulic conductivity	CaCO ₂ (%)	Porosity (%)
Well 699-41-35								
2-3084	Hanford formation	80.8-81.8	2.80	6.46	Gravel	1.3x10 ⁻¹	<1.0	33.12
2-3085	Ringold lower mud	102.7-104.7	2.71	20.72	Silty sand	1.4x10 ⁻⁸	2.5	38.48
2-3086	Ringold lower mud	146.1 ^a -147.6	2.65	15.59	Silty sand	7.5x10 ⁻⁹	<1.0	28.73
2-3087	Ringold unit A	207.2 ^a -208.8	2.65	45.38	Silty sand	9.2x10 ⁻⁹	<1.0	55.8

^a Sample from saturated zone.

3.4.1 Specific Gravity

Specific gravity values range from 2.46 g/cm³ for a sample collected from a 2-ft interval within the Ringold lower mud sequence in well 699-40-36 to 2.80 g/cm³ for a sample collected from a 1-ft interval from the gravel facies of the Hanford formation in well 699-41-35.

3.4.2 Moisture Content and Moisture Retention

Moisture content has been found typically to be highest for samples collected from the Ringold lower mud sequence. The average moisture content of the five samples from this facies (three of which were collected from below the potentiometric surface) is 21.59%. The highest moisture content measured, 45.38%, is for a sample of silty sand from unit A of the Ringold Formation. This sample was taken from the saturated zone intercepted by well 699-41-35. The remaining two samples from unit A were of silty sandy gravel from the saturated zone. These samples have moisture contents of 7.60% and 11.02%. The least moisture was measured in three samples of the gravel facies from the Hanford formation. All three samples are from the vadose zone and average 6.57% moisture.

Moisture retention data were determined for the vadose zone samples listed in Table 5. These data are presented as moisture retention curves and are provided as a part of the borehole data package (WHC 1993b).

3.4.3 Grain Size Distribution

Grain size distributions were determined by sieve analysis of the sediment samples. The data were plotted as distribution curves which, in turn, were used to classify the sediments in accordance with a modified Folk Classification System (WHC 1989). The results of the classifications are shown in the 6th column of Table 5. Data on grain size distribution are in a published data package (WHC 1993b). Hanford formation sediments encountered by the site characterization boreholes are classified as gravel, sandy gravel, silty sandy gravel, and silty sand. Ringold lower mud unit samples are classified as silty sand. Ringold unit A samples are classified as sandy gravel, silty sandy gravel, and silty sand.

3.4.4 Hydraulic Conductivity

Calculations used to derive the hydraulic conductivity values in Table 5 are provided as a part of the borehole data package (WHC 1993b). Hydraulic conductivities measured for the sediments underlying the 200 Areas TEDB range from 1.3×10^{-1} cm/sec for a sample of Hanford formation gravel to 7.5×10^{-9} cm/sec for a sample of the Ringold lower mud sequence. Both samples are from well 699-41-35. Five samples of silty sand from the Ringold lower mud sequence have an average hydraulic conductivity of 5.5×10^{-7} cm/sec and range from 2.3×10^{-6} cm/sec to 7.5×10^{-9} cm/sec. The three samples of sandy gravel to silty sand from Ringold unit A range from 6.3×10^{-7} cm/sec to 9.2×10^{-9} cm/sec. Local cementation and poor sorting may contribute to low hydraulic conductivities in the Ringold unit A. The three samples of gravel to silty sandy gravel from the Hanford formation range from 1.3×10^{-1} to 1.8×10^{-4} cm/sec.

3.4.5 Calcium Carbonate

The CaCO_3 content in the sample fractions that passed through a #10 sieve was measured for the samples listed in Table 5. Details of the methods and calculations used to derive the values shown in the table are in WHC (1993b).

Only three of the samples contained more than 1% CaCO_3 . One sample of silty sand from the Ringold lower mud sequence in well 699-41-35 had 2.5% CaCO_3 . One sample of silty sand from the Ringold lower mud sequence in well 699-42-37 had 2.7% CaCO_3 . One sample of sandy gravel from the Ringold unit A had 1.1% CaCO_3 .

3.4.6 Porosity

Porosities of the samples listed in Table 5 were determined by the methods given in WHC (1993b). The highest porosity of those listed, 55.8%, is for the sample of silty sand from Ringold unit A in well 699-41-35. This is the sample listed in Table 5 with

the lowest hydraulic conductivity. The lowest porosity, 18.32%, is for a sample of silty sandy gravel of the Hanford formation from well 699-40-36.

The five samples of the Ringold lower mud sequence have the highest average porosity (35.05%) of samples listed in Table 5. The six samples of the Hanford formation have porosity values that consistently are the lowest, 18.32%-33.12%, of those in the table. Porosities of Ringold unit A samples are of intermediate value.

3.5 RESULTS OF CHEMICAL ANALYSES OF SEDIMENTS

To determine whether the sediments underlying the proposed TEDB Site are free of contamination, 20 split-spoon samples (including two duplicates) from the three site characterization wells were analyzed. Rationale for the analyte selection is discussed in Davis and Delaney (1992). Sample collection methods are stipulated by WHC (1989). All analytical data and documentation of data validation are in WHC (1993c). The 20 samples are identified in Table 6 by well, sample number, stratigraphic unit, and depth. Samples were analyzed for the constituents and by the methods that previously were listed in Table 3.

Table 6. Inventory of Chemically Analyzed Sediment Samples.

Lab. sample #	Stratigraphic unit	Sample depth (ft)
Well 699-42-37 (see Table 7)		
B075C2	Hanford formation	5
B075C3	Hanford formation	10
B075C4	Hanford formation	15
B975C5	Hanford formation	20
B075C8	Ringold lower mud	92
B075D6	Ringold unit A	131
Well 699-41-35 (see Table 8)		
B075D2	Hanford formation	5
B075D3	Hanford formation	10
B075D4	Hanford formation	10 (dupl.)
B075D5	Hanford formation	15
B075D7	Hanford formation	21
B075D9	Ringold lower mud	103
B075F2	Ringold lower mud	103 (dupl.)
B075F3	Ringold unit A	188.5
Well 699-40-36 (see Table 9)		
B075C6	Hanford formation	5
B075C7	Hanford formation	10
B075C9	Hanford formation	15
B075D0	Hanford formation	20
B075F4	Ringold lower mud	115
B07HG0	Ringold unit A	202

Tables 7 through 9 list the results of chemical analyses of the inorganic constituents of sediments from the three site characterization wells. Analytical results for the inorganic constituents are discussed in Sections 3.5.1 through 3.5.3. Results of analyses for volatile and semi-volatile organic chemical compounds are discussed in Section 3.5.4. Where applicable, analytical results are compared with cleanup standards imposed by WAC 173-340, *Model Toxics Control Act -- Cleanup* (see Section 3.5.6). The analytical results are also compared with recently published background values for the Hanford Site (DOE-RL 1993). Analyte detection limits varied from sample to sample because of differences in relative moisture contents of the samples.

3.5.1 Metals

Except for mercury and chromium⁺⁶, all metals in the sediment samples were analyzed by the inductively coupled plasma (ICP) method. The results indicate that aluminum, beryllium, chromium, lead, nickel, potassium, selenium, and zinc concentrations are within the ranges that can be expected for uncontaminated Hanford Site sediments (DOE-RL 1993). As was anticipated, the concentrations of these naturally occurring elements are consistently higher in the clay-rich Ringold lower mud sequence than in the generally coarser-grained, clay-poor Ringold unit A and Pasco gravels facies of the Hanford formation. In the same samples of the lower mud unit, arsenic, cobalt, iron, sodium, and vanadium are generally less abundant than in samples of Ringold unit A and the Pasco gravels. The results of the ICP analyses are below the detection limits for cadmium, chromium⁺⁶, mercury, and thallium, for all 20 samples.

Mercury and chromium⁺⁶ were analyzed by cold vapor atomic absorption (AA) and colorimetry, respectively. Contract laboratory results for chromium⁺⁶ are not usable because of matrix-spike failure. All concentrations reported for mercury are below the instrument detection limit.

Analytical results from all 20 sediment samples, for all five metals included in the WAC 173-340 hazardous substance list (i.e., arsenic, cadmium, chromium⁺², lead, and mercury), indicate concentrations that are below required cleanup levels. The maximum concentrations detected in the 20 sediment samples for these five metals are:

- Arsenic -- 3.2 mg/kg
- Cadmium -- not detected
- Chromium (total) -- 24.7 mg/kg
- Lead -- 15.5 mg/kg
- Mercury -- not detected.

Table 7. Results of Chemical Analyses of Inorganic Constituents of Sediment Samples -- Well 699-42-37. All results are in units of mg/kg unless otherwise noted. (sheet 1 of 2)

SAMPLE NUMBER	B075C2	B075C3	B075C4	B075C5	B075C8	B075D6
METALS						
aluminum	6360	5940	5270	5910	9770	4770
antimony	4.0	6.4	3.5	4.5	3.2u	4.1
arsenic	3.2	2.8	2.0	1.8	1.0	1.5
barium	75.4	75.4	70.8	73.7	33.8	54.0
beryllium	0.37	0.33	0.33	0.29	0.60	0.38
cadmium	0.29u	0.31u	0.31u	0.30u	0.33	0.33u
calcium	6910	6750	6260	6800	3780	5000
chromium	9.3	17.0	4.7	24.7	9.5	8.8
hexavalent Cr	<0.49 [*]	<0.50 [*]				
cobalt	12.8	12.4	11.2	13.0	5.3	8.6
copper	19.6	15.3	13.4	16.2	10.0	10.7
iron	23800	24400	22200	22700	8070 ^e	12200
lead	9.1	3.6	3.4	3.6	6.7	2.9
magnesium	4570	4130	3680	4090	3700	2980
manganese	297	288	275	304	193	200
mercury	0.05u	0.05u	0.05u	0.05u	0.05u	0.06u
nickel	8.8	12.3	5.8	16.1	5.4	8.9
potassium	882	925	842	805	1860	730
selenium	0.55u	0.58u	0.58u	0.60u	0.82	0.65u
silver	2.1	1.8	1.7	2.2	0.78u	1.5
sodium	291	352	323	478	89.4	226
thallium	0.25u	0.26u	0.26u	0.27u	0.88u	0.86u
vanadium	58.2	62.6	57.4	60.0	13.9	36.6
zinc	43.7	42.1	39.8	41.5	19.2	28.4

Table 7. Results of Chemical Analyses of Inorganic Constituents of Sediment Samples -- Well 699-42-37. All results are in units of mg/kg unless otherwise noted. (sheet 2 of 2)

SAMPLE NUMBER	B075C2	B075C3	B075C4	B075C5	B075C8	B075D6
ANIONS						
chloride	11	10	13	17	15	7
fluoride	3	2	3	2	2	2
phosphate	<4	<4	<4	<4	<4	<4
sulfate	30	35	34	38	54	25
nitrate/nitrite (as N)	<2.50	<2.49	<2.42	<2.40	<2.44	<2.42
OTHER CONSTITUENTS						
cyanide	0.51u	0.52u	0.49u	0.49u	0.59	0.56u
pH	8.10	8.28	8.29	8.50	7.27	8.67
RADIONUCLIDES (picocuries/gram)						
gross alpha	5.5 *	1.9 *	7.4 *	5.2 *	3.5 *	7.8 *
gross beta	11	6.8	9.4	15	16	17
⁴⁰ K	7.7	6.6	8.0	7.0	10	6.5
²²⁶ Ra	0.28	0.27	0.40	0.27	0.45	0.48
²²⁸ Th	0.45	0.38	0.48	0.55	0.93	0.99
²³² Th	0.74	0.45	0.73	0.35	1.0	0.90

u - The constituent was analyzed for, but not detected. The value shown is the method detection limit or the sample quantitation limit.

* - Reported value is designated unusable (see text).

e - The value given is suspected of error.

Table 8. Results of Chemical Analyses of Inorganic Constituents of Sediment Samples -- Well 699-41-35. All results are in units of mg/kg unless otherwise noted. (sheet 1 of 2)

SAMPLE NUMBER	B075D2	B075D3	B075D4 ^d	B075D5	B075D7	B075D9	B075F2 ^d	B075F3
METALS								
aluminum	6160	5540	5530	5260	4900	12700	16600	4210
antimony	4.6	4.4	3.6u	4.4	5.6	3.7u	3.7u	3.9u
arsenic	2.9	2.8	2.6	2.1	1.1	0.69	0.90	1.3
barium	64.9	60.3	57.3	72.3	64.7	30.5	32.6	67.9
beryllium	0.30	0.36	0.33	0.30	0.33	0.86	0.87	0.09u
cadmium	0.30u	0.32u	0.31u	0.31u	0.28u	0.22u	0.22u	0.23u
calcium	14500	7890	8400	5750	5830	10600	14400	2290
chromium	7.1	6.2	6.4	6.5	10.3	15.9	19.4	10.6
hexavalent Cr	<0.50 [*]	<0.50 [*]	<0.50 [*]	<0.50 [*]	<0.50 [*]	<0.50 [*]	<0.50 [*]	<0.50 [*]
cobalt	12.1	12.2	12.2	12.8	13.8	8.2	8.7	4.9
copper	17.3	16.4	16.3	16.6	15.0	14.1	17.1	9.7
iron	22500	22700	22700	21900	23300	12300	17600	10100
lead	3.5	3.8	3.9	3.4	2.5	15.5	14.9	2.4
magnesium	4720	4480	4830	3950	3870	7220	8260	2110
manganese	331	289	288	260	284	302	326	159
mercury	0.05u	0.05u	0.05u	0.05u	0.05u	0.06u	0.06u	0.06u
nickel	7.9	7.5	7.5	7.4	9.9	19.3	21.6	6.5
potassium	911	956	887	785	764	1480	1700	786
selenium	0.60u	0.60u	0.60u	0.59u	0.57u	0.70	1.3	0.82
silver	1.2	1.5	1.7	1.1	1.2	0.55	0.64	0.57u
sodium	399	318	320	459	446	117	143	178
thallium	0.79u	0.78u	0.79u	0.77u	0.74u	0.30u	0.29u	0.29u
vanadium	58.2	55.3	56.0	58.9	67.9	13.7	18.2	28.1
zinc	43.3	44.8	45.1	41.1	43.7	48.3	56.7	19.4

Table 8. Results of Chemical Analyses of Inorganic Constituents of Sediment Samples -- Well 699-41-35. All results are in units of mg/kg unless otherwise noted. (sheet 2 of 2)

SAMPLE NUMBER	B075D2	B075D3	B075D4 ^d	B075D5	B075D7	B075D9	B075F2 ^d	B075F3
ANIONS								
chloride	5	5	5	6	5	10	10	6
fluoride	3	2	3	3	3	5	4	2
phosphate	<4u	<4u	<4u	<4u	<4u	<4u	<4u	<4u
sulfate	26	23	23	33	28	63	60	22
nitrate/nitrite (as N)	3.66	<2.58u	<2.46u	<2.53u	<2.47u	<2.53u	<2.51u	NR
OTHER CONSTITUENTS								
cyanide	0.50u	0.50u	0.50u	0.50u	0.50u	0.58u	0.60u	0.59u
pH	8.80	8.80	8.87	8.79	8.91	8.36	8.31	8.91
RADIONUCLIDES (picocuries/gram)								
gross alpha	4.0 *	6.0 *	3.1 *	4.8 *	0.87 *	14 *	6.4 *	3.8 *
gross beta	1.0	16	6.3	3.6	4.4	25	21	17
⁴⁰ K	5.9	8.3	8.8	9.3	7.0	15	13	7.2
²²⁶ Ra	0.28	0.39	0.28	0.38	0.34	0.34	0.65	0.33
²²⁸ Th	0.45	0.44	0.39	0.63	0.37	1.1	1.4	0.28
²³² Th	0.34	0.46	0.70	u	0.29	1.2	1.0	0.33

u - The constituent was analyzed for, but not detected. The value shown is the method detection limit or the sample quantitation limit.

* - Reported value is designated unusable (see text).

NR - Analysis not requested.

^d - Duplicate sample

Table 9. Results of Chemical Analyses of Inorganic Constituents of Sediment Samples -- Well 699-40-36. All results are in units of mg/kg unless otherwise noted. (sheet 1 of 2)

SAMPLE NUMBER	B075C6	B075C7	B075C9	B075D0	B075F4	B07HG0
METALS						
aluminum	5110	5580	5630	4960	16500	5280
antimony	7.0	7.2	3.6	3.7	3.7u	3.5u
arsenic	2.7	2.5	2.9	2.4	1.3	1.3
barium	60.7	59.9	61.9	64.3	110e	68.6
beryllium	0.22	0.26	0.33	0.24	1.2	0.57
cadmium	0.31u	0.31u	0.30u	0.29u	0.38u	0.21u
calcium	9450	7010	6720	7030	5300	6740
chromium	7.5	8.3	6.4	6.7	19.1	8.7
hexavalent Cr	<0.50 *	<0.50 *	<0.50 *	<0.50 *	<0.50 *	<0.50 *
cobalt	13.6	12.9	12.3	12.0	5.6	7.6
copper	18.9	16.8	15.8	14.0	26.3	16.4
iron	24400	22900	23800	23300	20200	13200
lead	3.6	3.6	4.1	3.9	14.0	4.5
magnesium	4280	3760	4040	4120	4700	2990
manganese	293	303	288	291	417	210
mercury	0.05u	0.05u	0.05u	0.05u	0.06u	0.06u
nickel	7.8	8.0	6.3	7.2	8.0	7.6
potassium	769	827	899	783	1760	639
selenium	0.56u	0.64	0.71	0.67	0.87u	0.76u
silver	1.4	1.2	1.2	1.5	0.90u	0.52u
sodium	441	490	394	332	176	296
thallium	0.33u	0.33u	0.76u	0.77u	0.31u	0.36u
vanadium	68.0	67.8	65.4	59.2	25.5	32.7
zinc	45.8	45.1	43.0	41.1	51.8	29.4

Table 9. Results of Chemical Analyses of Inorganic Constituents of Sediment Samples -- Well 699-40-36. All results are in units of mg/kg unless otherwise noted. (sheet 2 of 2)

SAMPLE NUMBER	B075C6	B075C7	B075C9	B075D0	B075F4	B07H60
ANIONS						
chloride	14	11	11	14	11	3.7
fluoride	4	3	3	3	3	0.8
phosphate	<4u	<4u	<4u	<4u	<4u	<1u
sulfate	40	30	29	38	53	9
nitrate/nitrite (as N)	<2.48u	<2.47u	<2.42	<2.52	<2.45	<2.46
OTHER CONSTITUENTS						
cyanide	0.52	0.52u	0.50u	0.51u	0.63u	0.54u
pH	8.62	8.81	8.27	8.35	7.93	8.84
RADIONUCLIDES (picocuries/gram)						
gross alpha	2.6 [*]	2.9 [*]	11 [*]	4.7 [*]	8.9 [*]	5.0 [*]
gross beta	11	2.8	14	4.2	14	14
⁴⁰ K	8.5	8.0	10	7.3	16	8.4
²²⁶ Ra	0.36	0.33	0.31	0.35	0.85	0.52
²²⁸ Th	0.54	0.46	0.38	0.49	1.7	0.80
²³² Th	0.46	0.50	0.45	u	1.3	0.58

u - The constituent was analyzed for, but not detected. The value shown is the method detection limit or the sample quantitation limit.

* - Reported value is designated unusable (see text).

e - The value given is suspected of error.

3.5.2 Cyanide

Analyses for cyanide were by colorimetry. The maximum concentrations of cyanide in all samples are below the detection limit. Allowable contract laboratory holding times for colorimetric analysis of cyanide were exceeded for all samples; nevertheless, the data are considered to be usable.

3.5.3 Anions and pH

Anions analyzed for the 20 sediment samples were chloride, fluoride, phosphate, sulfate, and nitrate/nitrite (as elemental nitrogen). All except nitrate/nitrite were analyzed by the ion chromatography method.

Three samples (and one duplicate) of the clay-rich Ringold lower mud sequence were determined to consistently have the highest sulfate concentrations of the 20 samples (53 to 63 mg/kg). The highest fluoride concentrations (5 mg/kg) in the sampled sediments are also within the lower mud sequence.

The average pH of all 20 sediment samples (including the two duplicates) is 8.48, with a standard deviation of 0.41. The highest pH detected, from Ringold unit A sample B075F3, is 8.91. The lowest pH measured, from sample B075C8 of the Ringold lower mud sequence, is 7.27.

3.5.4 Volatile and Semi-volatile Organic Compounds

Volatile and semi-volatile organic compounds are present in concentrations that are below detection limits in nearly all samples. The exceptions are all below applicable cleanup levels specified by WAC 173-340.

3.5.4.1 Volatile Organic Compounds. Low concentrations of the following volatile organic compounds were measured:

- Methylene Chloride. Detected in several samples. The highest concentration reported is 91 µg/kg (sample B075F4). This value is far below the WAC 173-340 cleanup level of 500 µg/kg.
- Acetone. Detected in several samples. Concentrations are on the order of 130 µg/kg (sample B075F3).
- 4-Methyl-2-pentanone. Detected in several samples. Concentrations are on the order of 36 µg/kg (sample B075D6).
- Unknown hydrocarbon. Tentatively identified compound(s) with a concentration of 81 µg/kg (sample B075D4).

3.5.4.2 Semi-volatile Organic Compounds. Low concentrations of the following semi-volatile organic compounds were measured:

- Di-n-butylphthalate. Detected in several samples. Concentrations are less than 110 µg/kg (sample B075F4).
- Diethylphthalate. Detected in only one sample (B075F4; 80 µg/kg).
- Tentatively identified compounds. Semi-volatile organic compounds tentatively identified in the samples include:
 - 2-pentanone, 4-hydroxy-4-methyl.
Up to 48,000 µg/kg in sample B07HG0.
 - 3-pentanone-2-one, 4 methyl.
Up to 1,800 µg/kg in sample B075G0.
 - furan, 2, 5-dimethyl.
Up to 1500 µg/kg in sample B07HG0.
 - formamide, N, N-dimethyl.
370 µg/kg in sample B07HG0.

3.5.5 Radionuclides

As expected, the highest radionuclide activities are in clay-rich samples of the Ringold lower mud sequence and appear to be from naturally occurring radionuclides. Of the 20 samples analyzed, the highest gross beta activity is 25 pCi/L in sample B075D9. The highest gamma activities were measured in sample B075F4 and are as follow: $^{40}\text{K} = 16$ pCi/L, $^{226}\text{Ra} = 0.85$ pCi/L, $^{228}\text{Th} = 1.7$ pCi/L, and $^{232}\text{Th} = 1.3$ pCi/L. Measured gross alpha values were not usable because the analyses were inadvertently performed by the contract laboratory without a matrix spike.

In addition to the radionuclides listed in Tables 7 through 9, the following isotopes were also sought by measurement of gamma activities, but were undetected in all samples: ^{59}Fe , ^{51}Cr , ^{60}Co , ^{65}Zn , ^{106}Ru , $^{134,137}\text{Cs}$, and $^{152,154}\text{Eu}$.

3.5.6 Comparison of Results to Other Studies

Results of the chemical analyses of sediments at the TEDB site are not strictly comparable to results from recent analyses of the background composition of Hanford Site sediments or to WAC 173-340 cleanup levels because of differences in sample collection and preparation methods. For the study of *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes* (DOE-RL 1993), only that portion of samples that passed through a 2-mm sieve (i.e., sand-sized or smaller), as recommended by WAC 173-340-740 (Ecology 1992), was analyzed. This fraction was then digested or leached, analyzed, and reported according to Contract Laboratory Program (CLP) protocol (EPA 1989).

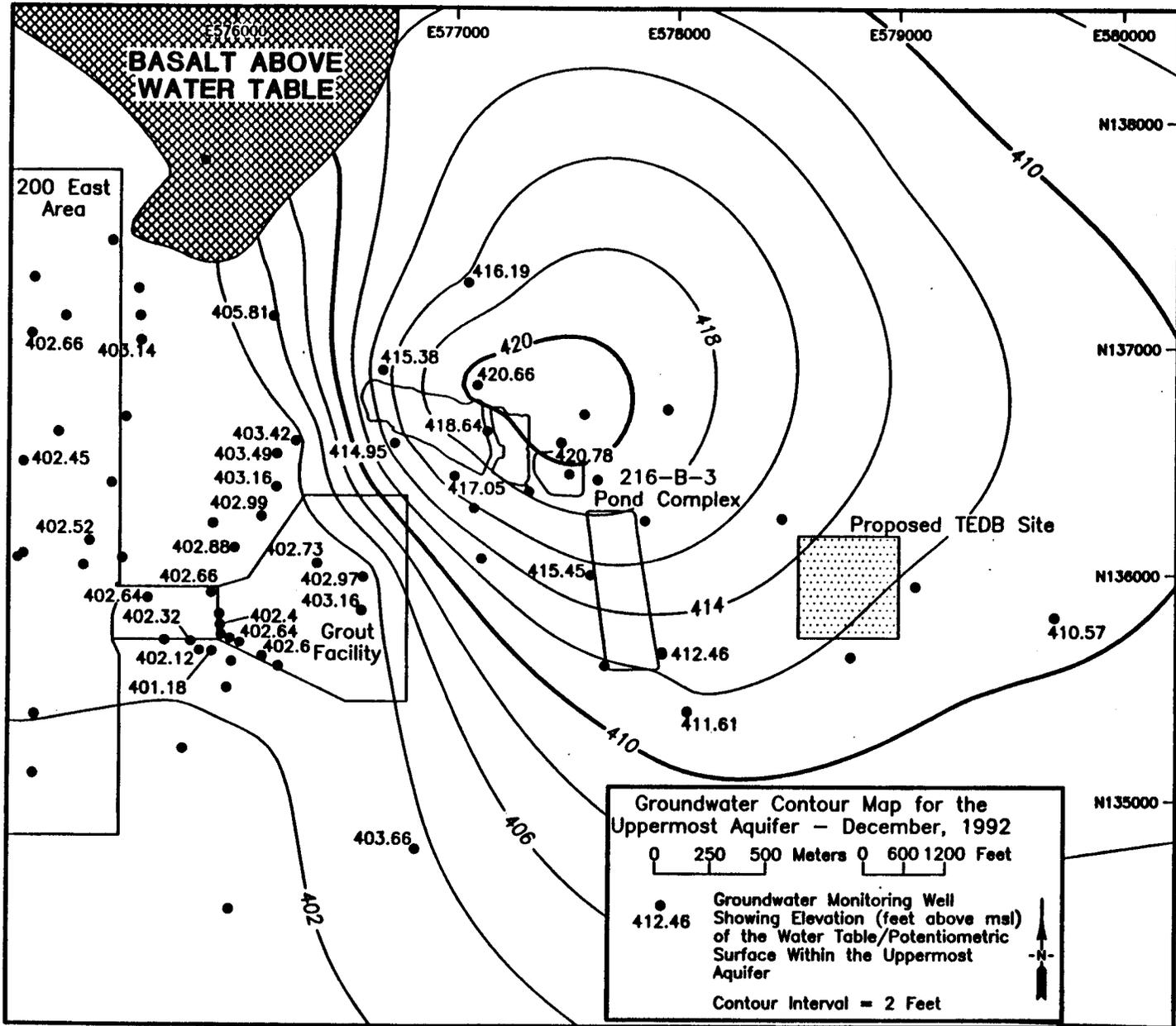
In contrast, samples from the TEDB were analyzed essentially *in toto*, irrespective of grain size. The remainder of the sample preparation and analysis protocol was the same as the WAC-173-340-740 and CLP protocols. Hence, results for samples of predominantly fine-grained sediments (e.g., Ringold lower mud) from the TEDB site are more comparable to Hanford Site background results than are results for samples of coarser-grained sediments (e.g., Hanford or Ringold gravels). Neither can the TEDB analyses properly be termed "bulk composition" analyses because the samples were not completely dissolved in acid prior to their analysis. All sediment samples that were chemically analyzed for the Hanford Site background study (DOE-RL 1993) were taken from the vadose zone. In contrast, some samples from the TEDB site were taken from saturated zone sediments of the Ringold Formation (compare sample intervals with lithologic logs in Appendix A).

With the above differences of sample collection and preparation in mind, analytical results for the proposed TEDB site were compared with ranges for the same analytes reported for Hanford Site background in DOE-RL (1993). For analytes common to the two studies, the following were observed:

- Results for the TEDB samples are below the upper limits of the background ranges for the same analytes.
- Except for potassium and silver, analyte concentrations in TEDB samples are within the background concentration ranges reported for the same analytes in DOE-RL (1993). Potassium and silver in TEDB samples are mostly lower than the respective lower limits for Hanford Site background. Analytes of the background study with detection limits that are higher than those for the TEDB study (e.g., antimony) were not compared.
- Two samples (B075C8 and B075F3) of the Ringold Formation from the proposed TEDB site are notable with respect to the number of analytes present in amounts that are below the lower end of the background ranges given by DOE-RL (1993).

4.0 CANDIDATE SITE HYDROLOGY

Groundwater in the uppermost aquifer beneath the TEDB occurs under confined or semi-confined conditions, and as isolated bodies of perched water. These findings were confirmed by the (1) observed potentiometric head, (2) presence of a continuous Ringold Formation lower mud sequence immediately above the aquifer and (3) substantial responses to barometric changes. The semi-confined conditions and perched water are a result of the relatively low-permeability lower mud sequence and the proximity of a mound in the water table caused by past and present effluent discharges to the B Pond complex. The configuration of this mound and the potentiometric surface near the TEDB as of December 1992 are shown in Figure 14.



DBB\052193-C

Figure 14. Contour Map of the Top of the Uppermost Aquifer, December 1992.

4.1 HYDROSTRATIGRAPHIC RELATIONSHIPS

In the vicinity of the B Pond complex, effluent water has infiltrated into an area in which the lower mud sequence is not continuously present (see Figures 7 and 11). Comparison of the potentiometric surface and the spatial distribution of the Ringold lower mud sequence indicates that the uppermost aquifer is progressively more confined by the lower mud sequence from the B Pond Complex southeastward to the TEDB. Hydraulic conditions as measured in the three TEDB site characterization wells are detailed in Section 4.5

Groundwater intercepted during the drilling of well 699-40-36 established the existence of perched water in the vicinity of the proposed TEDB site. Because natural recharge is probably insignificant at this location (PNL 1991, DOE-RL 1993), the regional inflow of groundwater or artificial recharge are the likely sources of the perched water. As a consequence of the relatively low permeability of the lower mud sequence, part of the water currently infiltrating into the ground from the B Pond complex likely remains above the lower mud sequence as it flows downgradient to the southeast (see Figures 7, 8 and 14). It is also possible that some of this perched groundwater is remnant from past effluent discharges to the B Pond complex that were much larger than current discharges. If this is the case, the perched groundwater may be residual pockets of groundwater that became trapped in low areas along the surface of the Ringold lower mud sequence when the higher groundwater elevations that prevailed in the past receded.

4.2 HYDRAULIC GRADIENT, FLOW DIRECTION AND FLOW VELOCITY

The magnitude of the hydraulic gradient in the vicinity of the TEDB is 0.002 ft/ft, as calculated from water levels measured in the three site characterization wells on March 22, 1993. The groundwater flow direction, calculated using the same information, is 20° east of south. Using this gradient, estimates of porosity (n) obtained from the physical properties tests (Table 5) and hydraulic conductivities (K) derived from the constant-discharge aquifer tests (Section 4.5.3, Table 15), a range of average linear flow velocities for groundwater in unit A of the Ringold Formation was calculated. Recognizing that the porosity estimates are affected by local heterogeneities and by sampling and measurement processes, the smallest quotient (K/n) of K and n ($K = 1.3$ ft/day, $n = 0.56$) yields a flow velocity of 0.005 ft/day. The largest quotient of K and n ($K = 8.9$ ft/day, $n = 0.22$) results in an estimated flow velocity of 0.08 ft/day.

4.3 GROUNDWATER QUALITY

Although a large quantity of data related to groundwater quality has been evaluated for specific Hanford Site facilities and the Hanford Site in general, no data previously existed for the proposed TEDB site. To determine current groundwater quality at the TEDB site and thereby establish a baseline from which any future

changes can be measured, groundwater in the three newly drilled site characterization wells (see Figure 1) is being monitored in conjunction with groundwater monitoring at the nearby B Pond complex.

Constituents to be analyzed in groundwater being monitored at the B Pond complex and the TEDB site were determined by means of:

- RCRA background interim-status requirements (40 CFR 265 Subpart F and WAC 173-303-400)
- Knowledge of constituents with potential site-specific concern
- Requirements of the WAC-173-216 permit application for the TEDB.

All samples for determination of groundwater chemistry were collected, processed, analyzed, and the results reported in accordance with applicable provisions of the Quality Assurance Plan for RCRA Groundwater Monitoring Activities (Jackson 1990) and the site characterization work plan (Davis and Delaney, 1992).

4.3.1 Historical Trends

Davis and Delaney (1992) evaluated site-specific aspects of current groundwater quality and groundwater monitoring in the vicinity of the TEDB site. The TEDB site characterization wells are located within the area in which the elevation of the water table and gradient of the uppermost aquifer are influenced by past and current discharges of effluent to the B Pond complex (see Figure 14). This effluent, now essentially raw water from the Columbia River (Johnson 1993), may be diluting and causing the renewed movement of contaminants from earlier effluent discharges to the B Pond complex and nearby facilities. Because no other waste management units are located between the B Pond complex and the site of the proposed TEDB, any contaminants detected in groundwater beneath the downgradient TEDB would likely have originated within or near the B Pond complex.

Contaminants present in past effluent discharges to the B Pond complex included hydrazine, ammonium, tritium, organic carbon, and organic halogens (WHC 1993c). With the exception of tritium, constituents common to Hanford Site effluents have not been detected in groundwater in the vicinity of the B Pond complex (DOE-RL 1990b; Johnson 1993).

Total organic halogens (TOX) were determined to be elevated in wells adjacent to the B Pond complex. These elevated values subsequently decreased and are believed (Johnson 1993) to be unrelated to discharged effluents because of their absence in other, older wells nearby. Similar elevation of TOX was detected by the initial two consecutive quarters of groundwater quality monitoring in newly drilled site characterization wells 699-40-36 and 699-41-35.

4.3.2 Analytical Results

When this report was issued, analytical results for two consecutive quarters of groundwater sampling from the site characterization wells were available for evaluation. Appendix C lists the results of these analyses by well and constituent. Results not available when this report was issued will be included in forthcoming quarterly reports of RCRA groundwater monitoring for the Hanford Site. Also listed in Appendix C are the sample collection dates, field sample numbers, and notes denoting specific quality control circumstances associated with a result or sample. These qualifiers are discussed in detail in the *Quarterly Report of RCRA Groundwater Monitoring Data for the Period of January 1, 1993 through March 31, 1993* (WHC 1993d). An abbreviated explanation of data qualifiers is included in Appendix C.

Iron and manganese (in both filtered and unfiltered samples) are the only constituents of groundwater samples from the three wells that exceeded EPA Drinking Water Standards (DWS) during the 4th quarter of 1992 and the 1st quarter of 1993. When analytical results were compared with criteria listed in *Water Quality Standards for Groundwaters* (WAC-173-200, Table 1), only iron and manganese exceeded the criteria. The WAC criteria for these constituents are the same as RCRA standards. Other authors (WHC 1993e) have suggested that the elevated concentrations of iron and manganese, especially in unfiltered samples, are artifacts of well construction. Table 10 summarizes the analytical results for these constituents and the date the sample was collected. Complete results are in Appendix C. The DWS for iron is 300 ppb; for manganese, 50 ppb. The concentrations of iron and manganese in these

Table 10. Groundwater Constituents that Exceed Drinking Water Standards in Site Characterization Wells.

Well	Constituent	Result (ppb)	Date of sample collection
699-40-36	iron	550.00	12/21/92
		580.00	02/22/93
	manganese	120.00	12/21/92
		170.00	02/22/93
	manganese ^a	110.00	12/21/92
	150.00	02/22/93	
699-41-35	manganese	180.00	12/21/92
		150.00	02/22/93
	manganese ^a	170.00	12/21/92
		170.00	02/22/93
699-42-37	iron	1200.00	12/22/92
		870.00	02/23/93
	manganese	140.00	12/22/92
		130.00	02/23/93
	manganese ^a	120.00	12/22/92
	120.00	02/23/93	

^afiltered sample

samples are similar to those observed in samples from elsewhere throughout the Hanford Site. Reasons for the elevated concentrations of these elements in Hanford Site groundwater are currently under investigation (WHC 1993a, d).

Apparent concentration of TOX (see Appendix C) in wells 699-40-36 and 699-41-35 is high compared to concentrations in wells at the nearby B Pond complex. Thus far, no correlation has been established between the TOX values observed and a specific constituent or group of constituents. Continuing analytical laboratory problems (WHC 1993a, d) have hampered attempts to date to identify which constituent(s) are related to the TOX values.

4.3.3 Perched Groundwater

During the drilling of well 699-40-36, perched groundwater was found at the top of the Ringold lower mud sequence 112 ft below the surface. This groundwater was sampled by a bailer and analyzed for specific conductance, pH, anions, TOC, TOX, gross alpha and gross beta activities, and tritium. No constituent was found to be present in elevated concentrations. Details of the analytical methods and qualifying information are in WHC (1993c). Analytical results for the perched groundwater are in Table 11.

Table 11. Results of Analyses of Perched Groundwater from Well 699-40-36.

Constituent	Analytical result
Specific conductance	215 μ MHOS/cm
pH	8.0
Anions	
Chloride	4.2 mg/L
Fluoride	0.50 mg/L (non-detect)
Phosphate	0.25 mg/L (non-detect)
Sulfate	15.6 mg/L
Nitrate/Nitrite (as N)	0.29 mg/L
TOC	2.0 mg/L
TOX	20.0 μ g/L (non-detect)
Radionuclides	
gross alpha	3.40x10 ¹ pCi/L
gross beta	3.80x10 ¹ pCi/L
tritium	None detected (3.10x10 ² pCi/L detection limit)

Note: Laboratory sample identification numbers for perched groundwater analyses are B075F5 and B075F6.

4.3.4 Additional Data

In addition to the constituents listed in Appendix C, the complete suite of analyses specified in Appendix IX of 40 CFR 264 were made for groundwater samples taken from the three site characterization wells in May 1993. The results of these analyses will be reported in future quarterly reports of RCRA groundwater monitoring results for the B Pond complex.

Because of ambiguous results for analyses of total petroleum hydrocarbons (TPH) and total oil and grease (TOG) in samples from well 699-40-36, samples were collected from all three wells in May 1993 and were additionally analyzed for TPH, TOG and volatile organic compounds (VOC). Results of these analyses will also be reported in future quarterly reports of RCRA groundwater monitoring for the B Pond complex.

4.4 BASELINE INFILTRATION RATES

Infiltration tests were conducted at a 4-ft-deep trench excavated in the bottom of a 9-ft-deep borrow pit at the proposed TEDB site (see Figure 2). The tests were done to determine the vertical hydraulic conductivity at that location. Details of the tests and analytical methods are in Appendix D. Results of the tests are summarized in Section 4.4.2 and Table 12.

4.4.1 Description of Tests

The sediments that were intersected by the trench are Hanford formation gravels. Initially, a 4-ft-diameter culvert was placed on end in the trench and a bentonite seal was placed around the outside of its bottom edge. The annulus around the culvert was then backfilled with Hanford formation gravels. Water was added to the culvert until a relatively constant head was obtained for constant-flow conditions. Because the infiltration was sufficiently large through the 4-ft culvert that a steady-state condition was not achieved before the water supply was exhausted, a smaller 20-in-diameter casing was then installed inside the culvert and the annulus between them sealed with bentonite and backfilled with sand. The smaller casing extended the duration of the test by reducing the volume of water per unit time that needed to be discharged to the casing to achieve essentially steady-state flow.

4.4.2 Results

Results of the one falling-head and the two constant-head infiltration tests are in Table 12. The results indicate that a hydraulic conductivity range of 1 to 10 gal/min/ft² can be expected for the Hanford formation at a 13-ft depth. This depth approximates the projected bottom of the effluent disposal basins. These values are subject to an unquantified amount of error because of lateral divergence of flow due to lithologic

Table 13. General Hydrogeologic Conditions and Well Configurations During Aquifer Tests.

Well	Aquifer Interval	Aquifer thickness	Confining bed thickness	Potentiometric level	Screened interval	Pump intake
699-40-36	201.3-230.8	29.5	84.5	177.7	213.02-223.02	200
699-41-35	163.8-206.8	55	37	108.22	193.85-203.85	202.64
699-42-37	132.8-179.8	47	37	104.35	148.13-158.40	157.19

Note: All intervals and depths were measured in feet from the top of the casing.

4.5.1 Testing Approach

Water levels were monitored for 4 to 5 days prior to testing at each well. Downhole pressure transducers and a barometric pressure transducer at the surface relayed pre-test and test data to a data logger. The depth to water was measured by an electric tape to confirm that the transducers were operating satisfactorily. Following the period of baseline monitoring, instantaneous slug injection and withdrawal tests were conducted. After the water level had equilibrated (usually ~1 day), a single-well constant-discharge test was initiated. The drawdown phase was terminated after 5 to 7 hr of pumping. Recovery monitoring then continued for several days.

Flow rates during the constant-discharge tests were measured with rotometers mounted on a panel. The measured rates were confirmed using a stop watch and a bucket of known volume. Discharge rates were 3.3 gal/min for wells 699-41-35 and 699-42-37, and 0.85 gal/min for well 699-40-46. All purgewater was contained as a precautionary measure because of the presence of an oily sheen observed at well 699-40-36 when the monitoring pump was pulled and the test pump was installed. Based on retesting of the water quality of the well, the sheen subsequently was indicated to be a local, temporary artifact of the well drilling process.

4.5.2 Analysis Approach

Prior to applying the methods of hydraulic analysis discussed below, the drawdown and recovery data were corrected for long-term water-level trends and fluctuations due to barometric pressure changes. Table 14 lists the barometric efficiencies and the water-level trends calculated for each well. Example analyses are shown in Figures 15 and 16. The remaining hydraulic analyses and plots are in Appendix E.

Table 14. Barometric Efficiencies and Long-Term Trends Observed During Aquifer Testing.

Well	Barometric efficiency ^a	Monitoring periods	Long-term trend (ft/day) ^b	Monitoring period
699-40-36	20% to 23%	3/18-3/22/93; 4/26-5/3/93	-0.0267	3/18-3/22/93
699-41-35	30% to 39%	3/18-3/22/93; 4/26-5/3/93	-0.0176	3/18-3/22/93
699-42-37	54% to 65%	3/18-3/22/93; 4/26-5/3/93	-0.0229	3/18-3/22/93

^aCalculated using the Clark (1967) method.

^bEstimated using a regression analysis.

Barometric efficiencies were estimated using water-level data measured during two separate monitoring periods, March 18 through 22 and April 26 through May 3, 1993. Hence, two values of barometric efficiency are reported for each well. Differences in barometric efficiency are noted for the two monitoring periods; the differences between values reported for the two monitoring periods are relatively larger at wells 699-42-37 and 699-41-35.

Downward water-level trends were insignificant over the short duration of the drawdown portion of the pumping test; the values ranged from -0.02 to -0.03 ft/d. A correction for the downward trend during the recovery phase was applied to water-level data prior to the hydraulic analysis.

The test data for the instantaneous slug tests were analyzed using the confined aquifer method developed by Cooper et al. (1967) for a finite-diameter well. Data were analyzed for both the injection and withdrawal phases of the tests.

Data were analyzed for the single-well constant-discharge tests by using the Bourdet et al. (1989) pressure derivative method to determine when radial flow occurred, then applying the Cooper and Jacob (1946) straight-line method to calculate the transmissivity for the applicable portion of the data. The recovery data were plotted and evaluated using the traditional t/t' residual drawdown method (Freeze and Cherry 1979) and the Agarwal (1980) equivalent-time method. These methods are described in Appendix E.

Barometric Efficiency Analysis Well 42-37; April 1993 Data

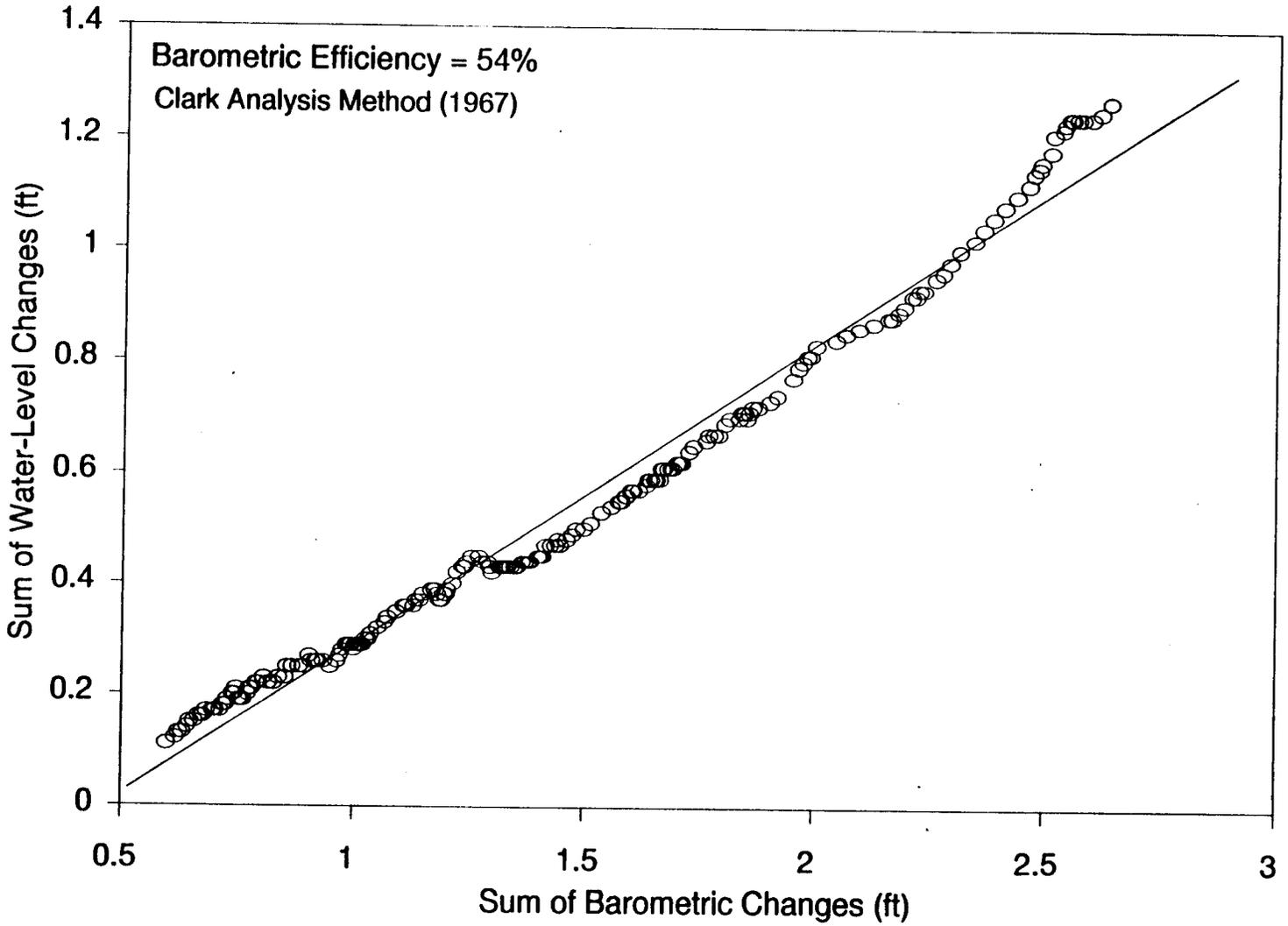


Figure 15. Barometric Efficiency Analysis for Well 699-42-37, April 1993 Data.

Trend Analysis

Well 42-37; March 18-22, 1993

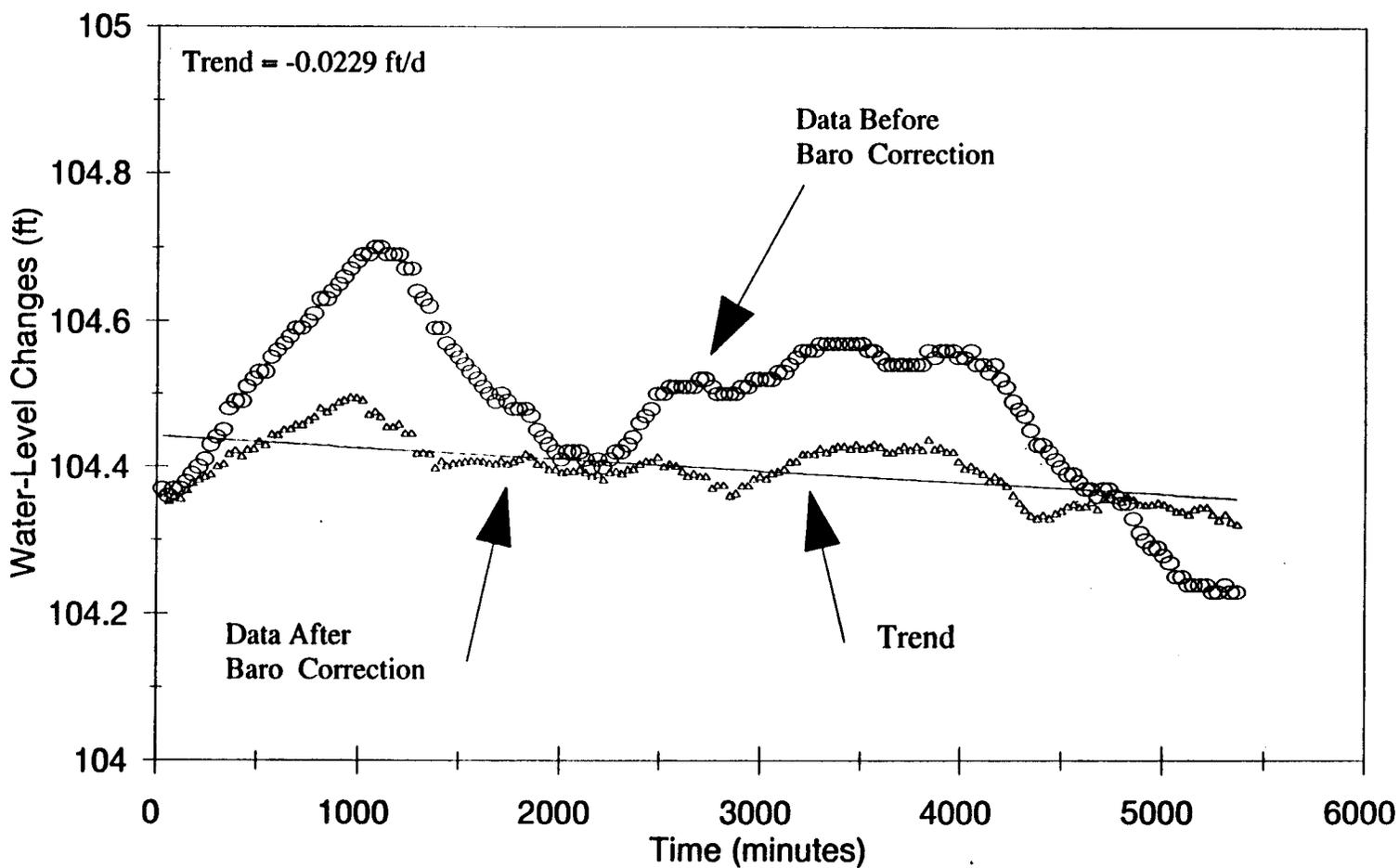


Figure 16. Water-Level Trend Analysis for Well 699-42-37.

4.5.3 Analysis Results

This section describes the aquifer test results for slug and constant-discharge methods. Tables 15 and 16 summarize the calculated hydraulic properties and other relevant test information. Additional analysis plots and a brief discussion of the analysis methods are in Appendix E.

Table 15. Transmissivities and Hydraulic Conductivities.

Well	Type of test	Date of test	Duration of test ^a (min)	Slug rod vol. or flow rate (cu. ft or gal/min)	Transmissivity (ft ² /d)	Hydraulic conductivity ^b (ft/d)
699-40-36	Slug	3/22/93	23i	0.194	22	2.2
			26w		13	1.3
	Constant discharge	3/29/93 3/30/93	425d 1095r ^c	0.85	23 —	2.3
699-41-35	Slug	3/22/93	21i	0.194	29	2.9
			23w		23	2.3
			26i	0.388	37	3.7
			25w		30	3
	Constant discharge	3/26/93	330d 4200r ^c	3.3	100 200	1.8 3.6
699-42-37	Slug	3/23/93	21i	0.194	38	3.8
			11w		32	3.2
			15i	0.388	65 ^d	6.5
			14w		34	3.4
	Constant discharge	3/24/93 3/25/93	420d 1050r ^c	3.3	160-500 420	3.4-10.6 8.9

- ^a i = injection portion of slug test
- w = withdrawal portion of slug test
- d = drawdown portion of constant-discharge test
- r = recovery portion of constant-discharge test.

^b Hydraulic conductivity was calculated using the mathematical relation $K = T/b$, where K = hydraulic conductivity, T = transmissivity, and b = screen length or aquifer thickness.

^c Best calculated value for constant-discharge test.

^d Considered an outlier (see discussion in text).

Table 16. Storativities and Specific Capacities.

Well	Storativity from slug tests ¹	Maximum drawdown (ft)	Specific capacity ² (gal/min/ft)
699-40-36	7.4E-4i 4.2E-4w	9.6	0.089
699-41-35	4.6E-4i 1.4E-03w 1.6E-5i 1.2E-4w	16.5	0.2
699-42-37	1.1E-3i 2.0E-3w 2.9E-6i 5.4E-4w	10.7	0.31

¹ i = injection portion of slug test; w = withdrawal portion of slug test; d = drawdown portion of constant-discharge test; r = recovery portion of constant-discharge test.

² The specific capacity was calculated at the end of the pumping phase of each test.

The best overall estimates of transmissivity are 23 ft²/d, 200 ft²/d, and 420 ft²/d for wells 699-40-36, 699-41-35, and 699-42-37, respectively. Figures 17 and 18 show typical drawdown and recovery analyses. These best-estimate values are based on data from the recovery phase of the constant-discharge tests. The recovery data are considered more reliable than the drawdown data because testing irregularities (e.g., variations in the pumping rate) are dampened during the recovery period. This dampening effect results in a more consistent data set for evaluation.

At well 699-40-36, the recovery data were not analyzed because of the rapid return to the static water level (Figure 19). The rapid recovery may have been due to a check valve that leaked during the recovery period; or alternatively, it may have been the result of formational heterogeneities that affected the recovery response.

The best estimates of transmissivity from the slug tests were 18 ft²/d, 30 ft²/d, and 35 ft²/d at wells 699-40-36, 699-41-35, and 699-42-37. Figure 20 shows an example slug-test analysis for well 699-42-37. These values were calculated by averaging the slug-test transmissivities for each well. The transmissivity estimates are similar to those calculated from infiltration tests described in Section 4.4, although the infiltration test transmissivities are slightly lower (12-16 ft²/d; Delaney 1993). The values reported by Delaney, however, consistently are significantly lower than the pumping test results from the three wells. The consistency of this discrepancy may suggest a factor such as incomplete well development that is common to the three wells.

Data from the slug tests should be used with caution because they do not closely match the type curve for early and late test stages. The observed initial heads (maximum water-level change) do not correspond to the theoretical maximum head displacement for a 4-in. well. These discrepancies may result from the finite storage

Drawdown Analysis
Well 42-37; March 24, 1993

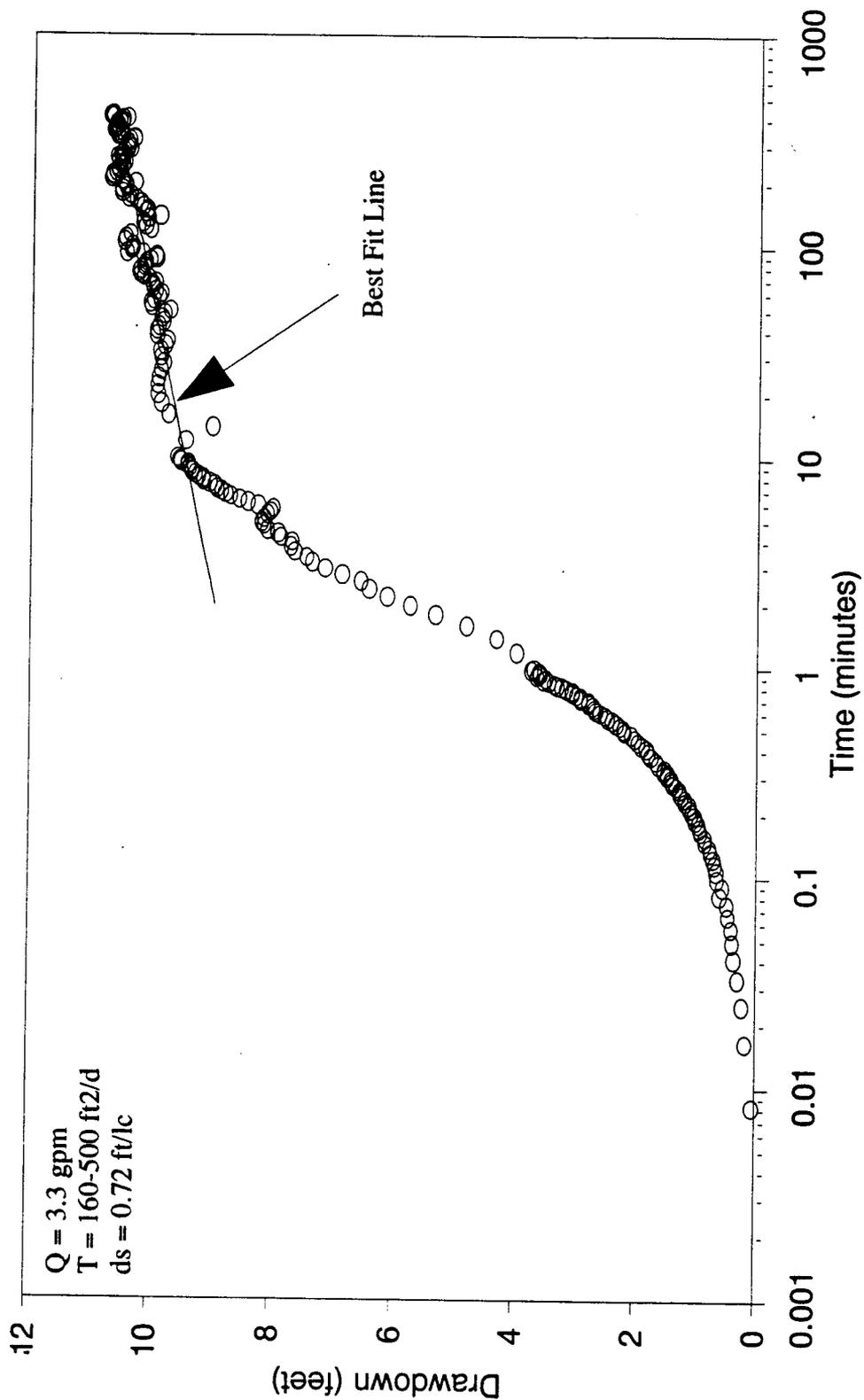


Figure 17. Straight-Line Analysis of Drawdown Data for Well 699-42-37.

Recovery Analysis
Well 42-37; March 24, 1993

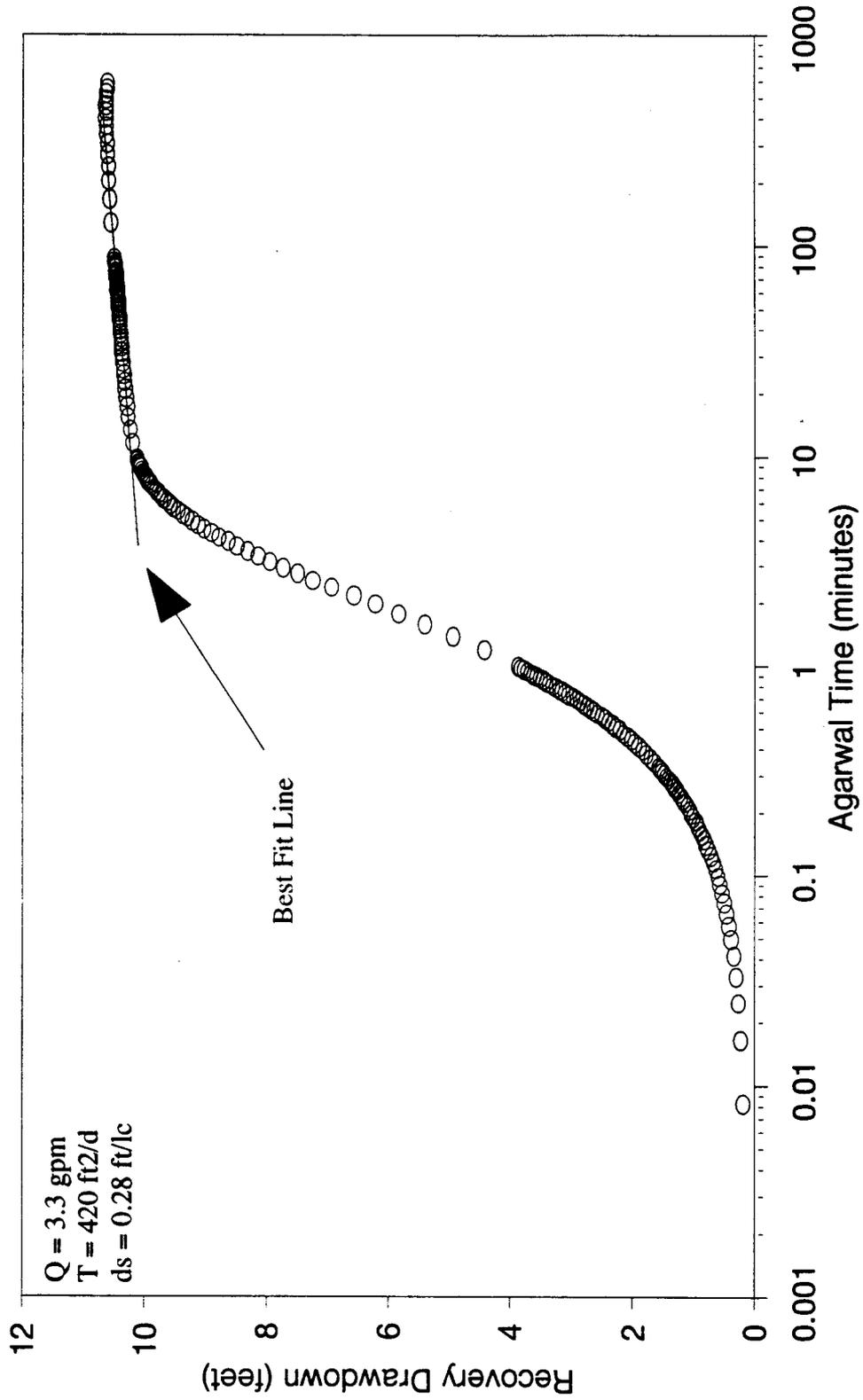


Figure 18. Straight-Line Agarwal Analysis of Recovery Data for Well 699-42-37.

Residual Drawdown Plot
Well 40-36; March 29-30, 1993

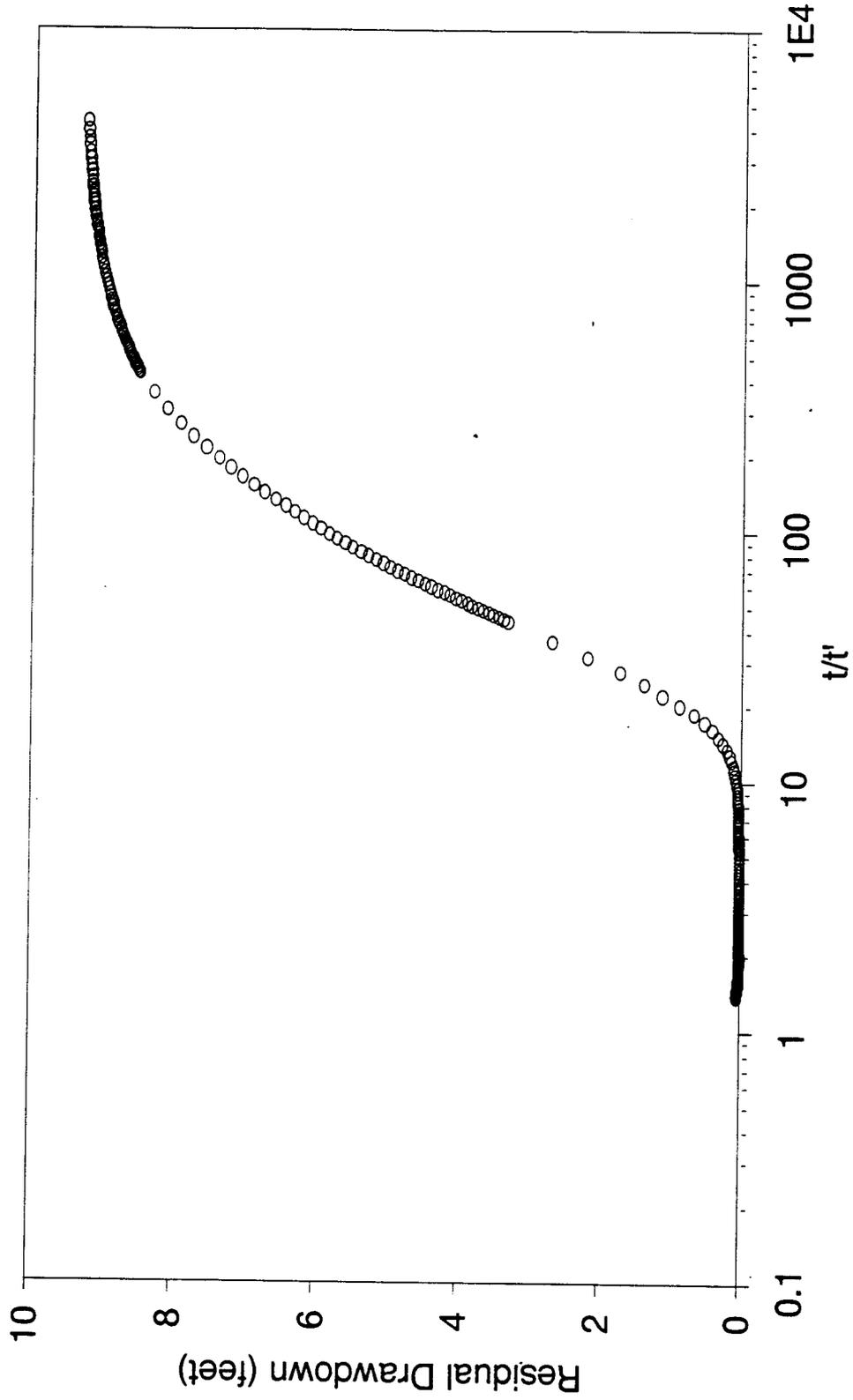


Figure 19. Residual Data for Well 699-40-36, Showing Very Rapid Recovery to the Static Water Level.

$T = 32 \text{ ft}^2/\text{d}; S = 2.0\text{E}-3$
 $rc = 0.167 \text{ ft}; r_w = 0.333 \text{ ft}; H_o = 2.22 \text{ ft}$

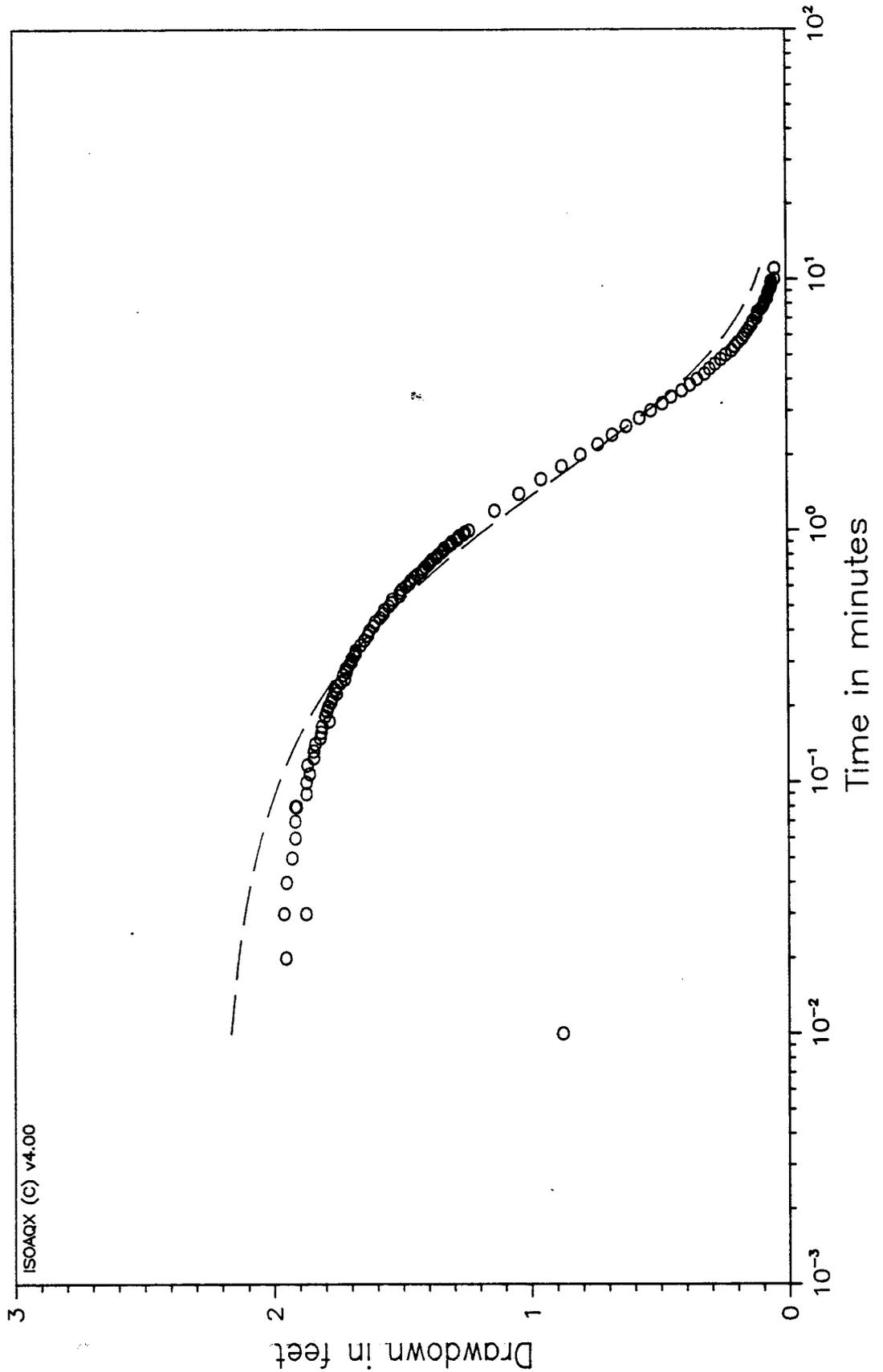


Figure 20. Slug Withdrawal Analysis for Well 699-42-37.

capacity of the filter pack. To minimize influence of the filter pack on the analysis, the initial head was held constant at its theoretical value during the analysis. When the initial head was set equal to the observed displacement in the well, a better match with the type curve resulted (Figure 21). However, the analysis was biased by the hydraulic properties of the filter pack. These calculated transmissivities are believed to be too high and the storativities too low.

Lohman (1972) cautions against overreliance on storativities calculated from slug tests determined from the Cooper et al. (1967) analysis method. Nevertheless, most of the calculated storativities appear to be reasonable estimates for confined aquifers (see Table 15). According to Freeze and Cherry (1979), storativities of most confined aquifers range from 10^{-3} to 10^{-5} .

For the aquifer tests at two of the three site characterization wells, there was good agreement between slug and constant-discharge test results when the comparisons were made in terms of equivalent hydraulic conductivities (see Table 14). For well 699-42-37, the hydraulic conductivity results for the slug tests were two to three times lower than those for the constant-discharge tests, but still in reasonable agreement.

4.6 PREDICTED EFFECTS OF FACILITY OPERATION ON THE UPPERMOST AQUIFER

The potential effects on the uppermost aquifer of operating the TEDB at the proposed site were simulated using the VAM3DCG finite-element numerical model. The modeling effort focused on the question of whether operation of the facility at the proposed site would result in a rise in the present water table sufficient to potentially remobilize known vadose zone contamination that is associated with parts of the 200 East Area and the B Pond complex. VAM3DCG was developed by HydroGeoLogic, Inc., for single or multidimensional modeling of groundwater flow and contaminant transport. The model employs a finite-element scheme to solve Darcy's flow equation. The finite-element grid of the numerical model was configured to comply with the shapes and dimensions of hydrogeologic units in the area of interest.

4.6.1 Conceptual Model

Information on the uppermost aquifer and overlying vadose zone that was derived from B Pond monitoring activities and the TEDB site investigation work provided the basis for the conceptual model of the area of hydrologic interest. Noticeable mounding of the water table resulting from the disposal of effluent at the B Pond complex can readily be detected as far as ~5,000 m from the complex. However, because the regional hydraulic gradient in the area of interest is relatively flat, the hydrologic effects of the B Pond complex extend well beyond 5,000 m. The area of influence of the B Pond complex on the elevation of the uppermost aquifer is asymmetric. Although the top of the groundwater mound resulting from discharges of effluent to the B Pond complex is immediately north of the complex, the effluent

$T = 92 \text{ ft}^2/d$; $S = 3.9E-9$
 $rc = 0.167 \text{ ft}$; $rw = 0.333 \text{ ft}$; $H_o = 2.22 \text{ ft}$

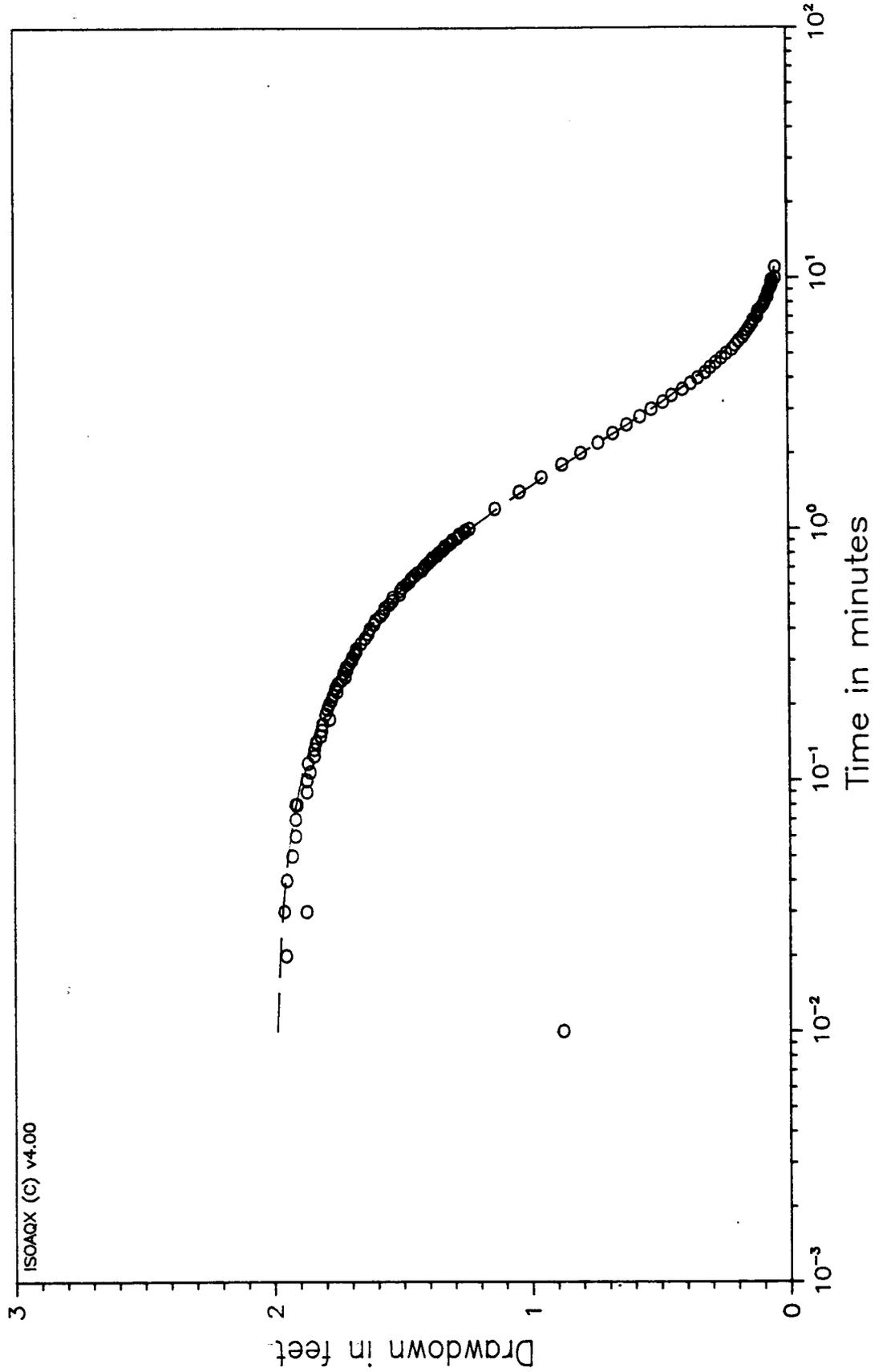


Figure 21. Slug Withdrawal Analysis Showing Filter Pack Effects for Well 699-42-37.

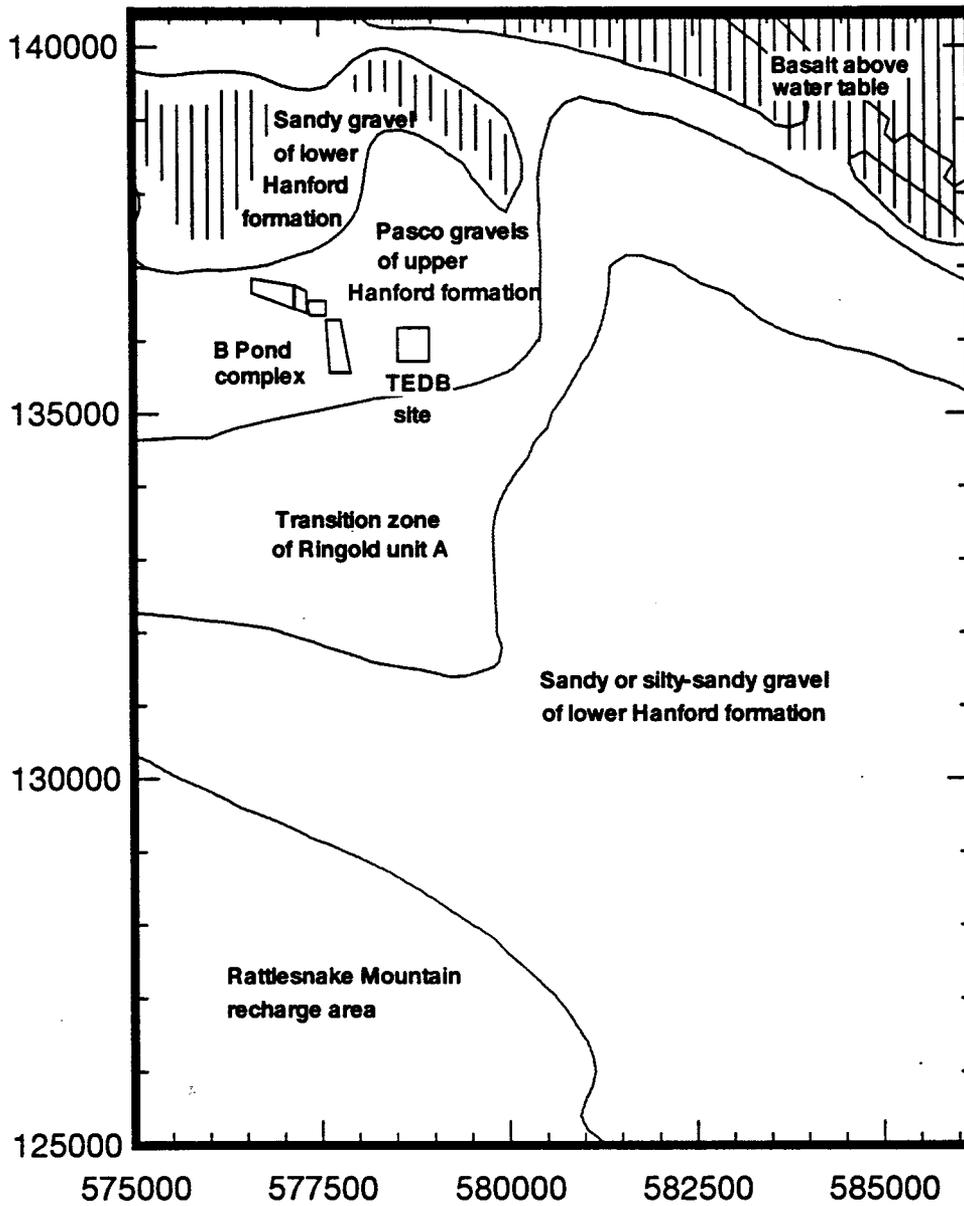
migrates principally to the east and southeast, toward the Columbia River. In the immediate vicinity of the proposed TEDB site, groundwater flow in unit A of the Ringold Formation is principally 20° east of south at a gradient of 0.002 m/m.

The model domain covered an area of ~17,200 hectares; its dimensions were 15,400 m north-south and 11,200 m east-west. In addition to accounting for unconfined flow in the Pasco gravels of the Hanford formation in the immediate vicinity of the B Pond complex, the conceptual model accounted for confined or semi-confined flow in unit A of the Ringold Formation and unconfined flow in the Hanford formation in the areas to the south and east of the proposed TEDB site (Figure 22). In these areas to the south and east of the proposed site, the uppermost aquifer is in the sandy or silty sandy gravel of the Hanford formation immediately above the lower mud unit of the Ringold Formation. Unit A of the Ringold Formation was accounted for in the model domain as part of a "transition zone" between the bedrock basalt and the Pasco gravels of the Hanford formation (Figure 22). In the conceptual model, the Ringold lower mud unit separated the Ringold unit A aquifer from the overlying Pasco gravels.

The basalt comprising Gable Mountain and Gable Butte (see Figure 3) blocks the northward flow of groundwater from the B Pond complex and the TEDB, except at Gable Gap. To the east, the Columbia River is a discharge boundary for the uppermost aquifer; however, to limit the size of the model to a manageable size, its eastern boundary was terminated at the eastern tip of the basalt outcrop that comprises Gable Mountain. Including the area from Gable Mountain to the Columbia River in the model was found to introduce numerical problems because of the configurations and disparities between the hydraulic contours on opposite sides of Gable Mountain. West of the proposed TEDB site, groundwater of the uppermost aquifer occurs as a hydrologic plateau. To the south, basalt comprising Rattlesnake Mountain forms the closest natural hydrologic boundary to the area of interest, although Rattlesnake Mountain is well beyond the southern extent of the model. The model domain was, however, within the area influenced by recharge from Rattlesnake Mountain.

The location of the bottom of the model depended on the elevations of the tops of the Elephant Mountain Basalt and lower mud unit of the Ringold Formation. The top of the basalt served as the bottom of the model in those areas where the elevation of the basalt exceeded mean sea level. Where neither the elevation of the top of the basalt nor the top of the Ringold lower mud exceeded mean sea level, the top of the Ringold lower mud served as the bottom of the model. Where the elevation of the top of the basalt was less than mean sea level but the elevation of the Ringold lower mud unit exceeded mean sea level, the bottom of the model was defined to be mean sea level. This criterion was an artifact of accounting in the conceptual model for both the May Junction Fault (see Figure 3), where the elevation of the Elephant Mountain Basalt abruptly changes from above to below mean sea level, and other areas in which the elevation of the top of the basalt is far below mean sea level.

Another hydrogeologic feature included in the conceptual model is the apparent absence of the Ringold lower mud unit beneath much of the B Pond complex. The



Axes are in Lambert east and north coordinates. Dimensions are in meters.

Figure 22. Plan View of the Model Domain, Showing Modeled Hydrogeologic Units.

absence or discontinuous presence of the lower mud unit in this area facilitates the downward flow of water from the B Pond complex to Ringold unit A. Once this water reaches unit A, it moves laterally downgradient, principally to the east and southeast. To the east and southeast, flow in the uppermost aquifer is confined or semi-confined by the presence of the Ringold lower mud unit. This interpretation is consistent with geologic logs of monitoring wells near the B Pond complex. These data indicate that no water is present in wells in this area until the lower mud unit is penetrated. Penetration of the lower mud unit permits groundwater to rise in the well bore to above the elevation of the lower contact of the lower mud unit, indicating the presence of artesian conditions.

Within the domain of the conceptual model, the effects of the May Junction Fault on groundwater flow east of the proposed TEDB site are not known. Vertical stratigraphic offset by the fault has been inferred to be from 30 to 100 m. The fault is not exposed at the surface and definitive information on how the fault may affect groundwater flow is not available. For purposes of the conceptual model, the May Junction Fault was assumed to hydraulically connect groundwater from the semi-confined aquifer in unit A of the Ringold Formation west of the fault with the unconfined aquifer of the Hanford formation east of the fault. Two pieces of evidence support this assumption. First, data from monitoring wells indicate no sharp change in the elevation of the water table in the vicinity of the fault, even though the wells are screened above and below the lower mud unit. Second, the mound in the water table in Ringold unit A beneath the B Pond complex continues into the uppermost aquifer in the Hanford formation to the east of the fault. Because discharges to the B Pond complex appear not to locally accumulate above the lower mud unit, the uppermost aquifer to the east of the May Junction Fault must receive water from unit A of the Ringold Formation in order to display effects resulting from the B Pond complex.

Five geologic strata were included in the conceptual model. From top to bottom of the model domain these are: the Pasco gravels of the Hanford formation, sandy or silty sandy gravel of the Hanford formation, the lower mud unit and unit A of the Ringold Formation, and the Elephant Mountain Basalt.

For purposes of the conceptual model, the geologic strata of interest were generally considered to be continuous throughout the model domain unless information was available that indicated otherwise. The elevations of the top of the two Ringold Formation units and the Elephant Mountain Basalt were determined from their respective structure contour maps. Data for precisely locating the contact between the Pasco gravels and the sandy or silty sandy gravel of the Hanford formation were not available for most of the model domain. In general, the unconfined aquifer above the Ringold lower mud unit was initially assumed to occur in the Pasco gravels sequence of the Hanford formation where the top of the basalt served as the bottom of the model. Elsewhere, the unconfined aquifer was initially assumed to occur in the sandy or silty sandy sequence of the Hanford formation. Refinements of these thicknesses and top and bottom contact locations subsequently were made based on results from the numerical model calibration.

4.6.2 Finite Element Mesh

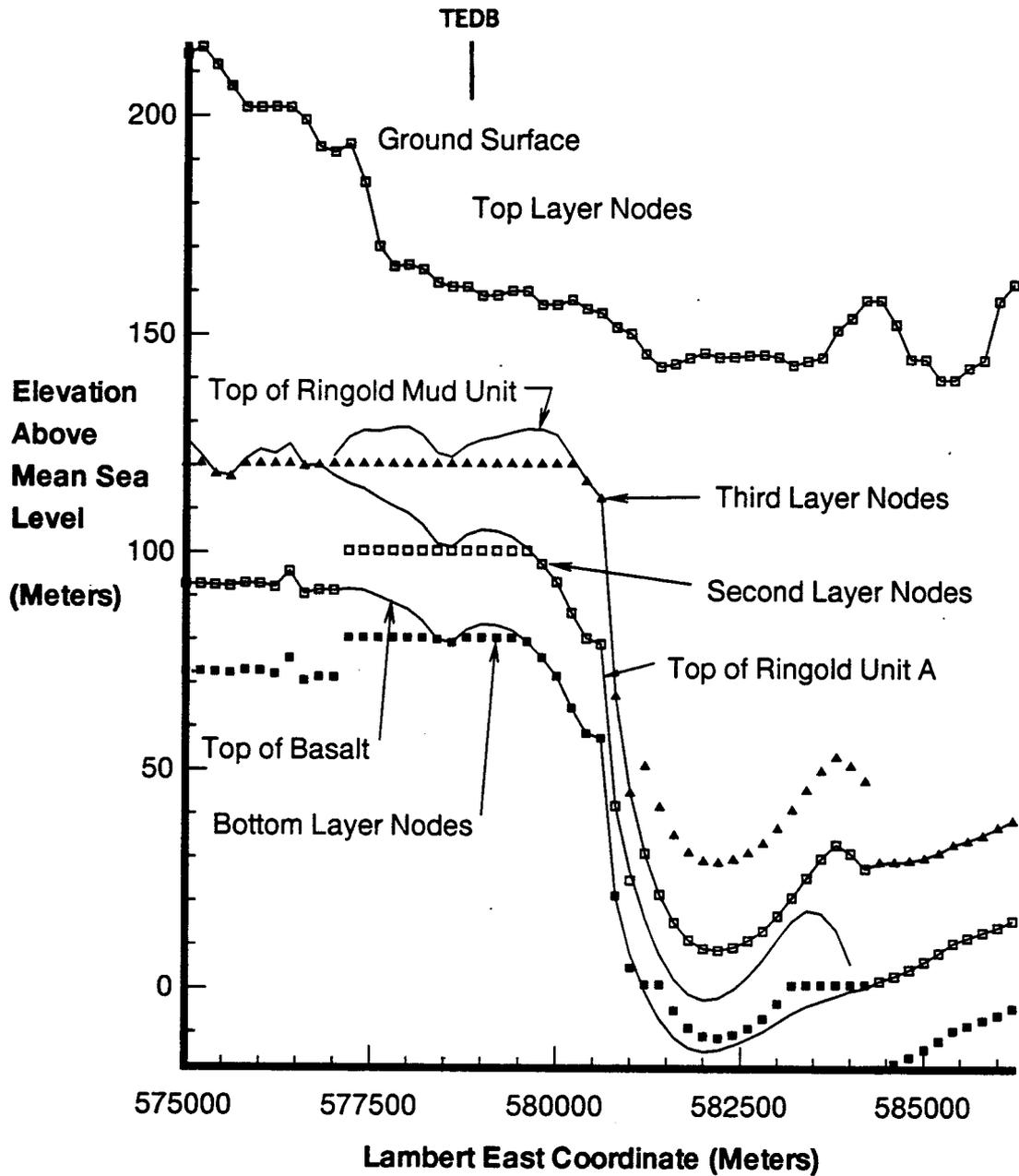
The 3-dimensional finite-element mesh was constructed from the nodal grid imposed on the conceptual model. The nodes were distributed in four horizontal layers to portray the four transmissive strata. The planar (horizontal or x-y) coordinates were consistently 200 m apart and were spaced consistently from layer to layer. The 200-m spacing and four layers of nodes resulted in the maximum number of nodes that could be accommodated by the VAM3DCG code in a reasonable amount of time using the available computing resources. The location of the vertical (z) coordinate of each node depended on the stratigraphy.

Structure contour elevations of the top of the basalt, the two Ringold Formation units, and the ground surface were digitized for use in Interactive Surface Modeling (ISM) software (copyrighted by Dynamic Graphics, Inc.). The ISM software interpolated elevations for the contacts between stratigraphic units. The interpolated elevations were derived from the elevations indicated by the respective structure contour maps. The vertical coordinate of each node at a specified x-y coordinate was then computed based on these interpolated values (Figure 23).

The distance between two vertically adjacent nodes represented the thickness of the specified stratigraphic unit between that pair of nodes. For the sake of convention and clarity, the four layers of the model depicting the four transmissive strata were consecutively numbered from bottom to top of the model domain. Hence, the first layer of nodes defined the bottom surface and the fourth layer depicted the top surface of the model. Where geologic units were depicted to locally not be present as, for example, in the vicinity of the B Pond complex where the Ringold lower mud unit is absent, the nodal grid was modified as described below. The lower mud or A units of the Ringold Formation were considered by the model to be present only if the thickness of each unit was more than 6 m.

To prevent introducing aspect-ratio instabilities into the numerical model due to the thinning or absence of the lower mud and A units of the Ringold Formation, each vertical coordinate was assigned a numerical value such that the minimum distance between two vertical nodes was 20 m. If the actual vertical distance between nodes was more than 6 but less than 20 m, the value of the z coordinate of the lower node was reduced by the difference between 20 m and the actual distance. Based on results of several model-calibration runs, this criterion provided the best compromise between accurate depiction of the geology and numerical model capability.

The four vertically aligned nodes corresponding to each planar coordinate location were assigned elevations (z-coordinate values) based on the elevation of the top of the basalt and the top of the Ringold lower mud unit at that location. The assignments were in terms of three categorizations: (1) the elevation of the top of the basalt was above mean sea level, (2) the elevations of both the top of the basalt and the top of the Ringold lower mud unit were below sea level, and (3) the elevation of the top of the basalt was below mean sea level but the elevation of the top of the Ringold lower mud unit was above mean sea level. These categorizations helped define the



Structure contours are represented by the solid lines; the nodes by geometric symbols. The Lambert north coordinate of the line of section is 136000 m.

Figure 23. Cross-Sectional View Showing Schematic of Modeled Elevations and Placement of Finite-Element Nodes.

bottom of the model domain. Once the category was specified, the elevation of the four vertically aligned nodes corresponding to each planar coordinate location was determined. In areas where the elevation of the top of the basalt was above sea level (i.e., Category 1), the elevation of the bottom node was assigned that value. The elevation of the two nodes above the bottom depended on the presence and thicknesses of the Ringold lower mud and A units. In general, the elevation of the second-layer node was set equal to the elevation of the top of the Ringold unit A and the elevation of the third-layer node was set equal to the elevation of the top of the Ringold lower mud unit (e.g., see the segment between the east coordinates 577500 and 579000 in Figure 23). If either unit was not present, the elevation of the second-layer node was assigned the elevation of the top of the basalt, and the bottom-layer node elevation was reduced by 20 m.

The elevation of the top of the third layer was then assigned the elevation of whichever Ringold unit was present in that area (e.g., see the segment between the east coordinates 575000 and 576500 in Figure 23 where the Ringold lower mud unit is absent, or the segment from 585000 to 586200 where the Ringold unit A is absent). If neither Ringold unit was present, the third-layer node was assigned the elevation of the top of the basalt, and the elevations of the two underlying nodes were each reduced from this value by 20 m.

Where the elevations of the top of the basalt and the top of the Ringold lower mud unit were below mean sea level (Category 2), the bottom-layer grid node was assigned an elevation equal to the top of the Ringold lower mud unit. The two nodes above it were then assigned elevations that were each 20 m higher than the underlying node. The vertical segments of grid elements between the nodes above the Ringold lower mud unit represented the thickness of the sandy or silty sandy gravel sequence of the Hanford formation.

In the transition zone (see Figure 22) between the area where the elevation of the top of the basalt served as the bottom of the model and the area where the top of the Ringold lower mud unit served as the bottom, Category 3 applied. Within this transition zone, the bottom-layer grid node was assigned the elevation of the top of the Ringold lower mud unit (e.g., see the segment between east coordinates 583000 and 584000 in Figure 23). The third-layer node was then assigned an elevation that was 20 m higher than the second-layer node. Again, the vertical segments of grid elements between the nodes above the Ringold lower mud unit represented the thickness of the sandy or silty sandy gravel sequence of the Hanford formation.

The elevation of the node in the fourth (top) layer of the grid, regardless of the categorization, was made equal to the elevation of the topographic surface of the Hanford formation. A final check ensured that the minimum distance between any two vertically adjacent nodes was 20 m. If two nodes were found to be vertically less than 20 m apart, the elevation of the lower of the two nodes was reduced to preserve the 20-m minimum (e.g., see the segment between 577500 and 578500 in Figure 23).

The finite elements were then constructed from the horizontal and vertical lines that connected adjacent nodes. All elements were defined by the eight line segments connecting eight nodes (four per layer) that formed the corners of each element. The elements were then assigned material properties according to the stratigraphic units present in the area defined by the four vertical-line segments of each element. Elements defined by nodes that were located below the top of the basalt were identified as no-flow elements.

Several opportunities presented themselves to refine the node elevations. In some instances, the back-interpolation routine of the ISM software resulted in anomalous upward or downward spikes in the surface defined by the structure contour elevations. Where this occurred, the data points were adjusted to the average of their nearest neighbors.

Completely desaturated elements often introduced numerical solution instabilities at the elements defining areas of no-flow, and the TEDB and B Pond complex. Furthermore, the sharp contrast in hydraulic conductivities between the Ringold lower mud unit the Pasco gravels member of the Hanford formation caused non-converging oscillations in the solution iterations when a change in the hydraulic head moved across the mud-gravel interface in the vicinity of the proposed TEDB site. To prevent this, the elevation of any node on the third layer of the grid was not allowed to exceed 120-m above mean sea level (e.g., see the segment between east coordinates 577500 and 579000 in Figure 23). This specification resulted in an initial condition of at least partial saturation for every active element in the model domain. Although this stipulation may have resulted in overestimation of lateral flow in the vicinity of the proposed TEDB site for the early portion of the duration simulated, these effects were assumed to be insignificant in view of the 30-yr duration of the modeled discharges.

4.6.3 Travel Time Determinations

Travel time from the TEDB to the Columbia River was determined in two steps. First, the travel time from the TEDB site to the model boundary was calculated. The hydraulic gradient across this distance after 20 yr of facility operation was determined from the numerical modeling. After 20 yr the hydrology of the area was assumed to have stabilized sufficiently to provide a reasonable and conservative estimate of the gradient from the TEDB to the boundary of the model domain. Second, the travel time from the model boundary to the Columbia River was calculated using the prevailing regional hydraulic gradient (Kasza et al., 1992). This procedure was consistent with the assumption that the water table at the eastern boundary of the model domain remained undisturbed by discharges at the B Pond complex and proposed TEDB site.

For the travel time calculations, the aquifer was assumed to consist of the Pasco gravels of the Hanford formation. The purpose of this assumption was to provide conservatism to the analysis by using the highest feasible hydraulic conductivity. Summing the travel times from the proposed TEDB site to the downgradient edge of the model domain and from the model boundary to the Columbia River yielded the

time estimated for treated effluent discharged at the TEDB to reach the Columbia River.

4.6.4 Boundary Conditions

The northern boundary of the model domain was treated as a no-flow boundary because of the presence of basalt above the water table along the Gable Mountain-Gable Butte anticline. Other areas in which basalt is locally present above the water table are immediately north of the 200 East Area and north and northeast of the B Pond complex (e.g., see Kasza et al. 1992). These areas were assigned hydraulic properties that resulted in their model elements being depicted as no-flow. The extent of the area in which the water table currently is markedly affected by past and present discharges to the B Pond complex was inferred from Figure 14. Those boundaries of the model domain that were beyond this affected area and that were not otherwise defined as no-flow boundaries because of the presence of basalt above the water table were defined as constant-head boundaries.

4.6.5 Hydraulic Input Parameters

Hydraulic input parameters required for each of the four transmissive geologic units of the conceptual model were the vertical and horizontal hydraulic conductivities, the water contents of saturated strata, and storativities. The sources of the hydraulic data used in the model were discussed in Section 3.4 and 4.0. The hydraulic conductivities of the Ringold and Hanford units were determined by a combination of laboratory analyses, field determinations of near-surface infiltration rates, and aquifer testing. These values were subsequently adjusted during the model calibration. The water content of the saturated strata was determined in the laboratory. Storativity was determined by aquifer testing.

Hydraulic conductivities of the silty sandy gravel and sandy gravel facies of the Hanford formation were measured in the laboratory (see Section 3.4, Table 5). The respective values measured were 1.8×10^{-4} cm/sec (0.15 m/day) and 1.3×10^{-1} cm/sec (112 m/day). Infiltration tests of the Pasco gravels member of the Hanford formation at the proposed TEDB site (see Section 4.4) yielded hydraulic conductivities that ranged from ~300 ft/day (91.5 m/day) to ~3,350 ft/day (1,020 m/day), with a median value of ~1,700 ft/day (520 m/day). Prior estimates have ranged as high as 3,000 m/day (Davis and Delaney, 1992). The model calibration results indicated values of 1.2 m/day for the silty sandy gravel and 685 m/day for the Pasco gravels.

Aquifer tests performed at the three site characterization wells screened in silty sandy gravels or silty gravelly sands of unit A indicated a hydraulic conductivity on the order of 3.5 ft/day (1.1 m/day). After model calibration, this value was adjusted to 0.8 m/day. Laboratory measurements of hydraulic conductivities of the Ringold lower mud unit indicated values averaging 5.5×10^{-7} cm/s (4.7×10^{-4} m/day). Because this value is decidedly lower than the hydraulic conductivities of the other modeled strata, it

was not adjusted during model calibration.

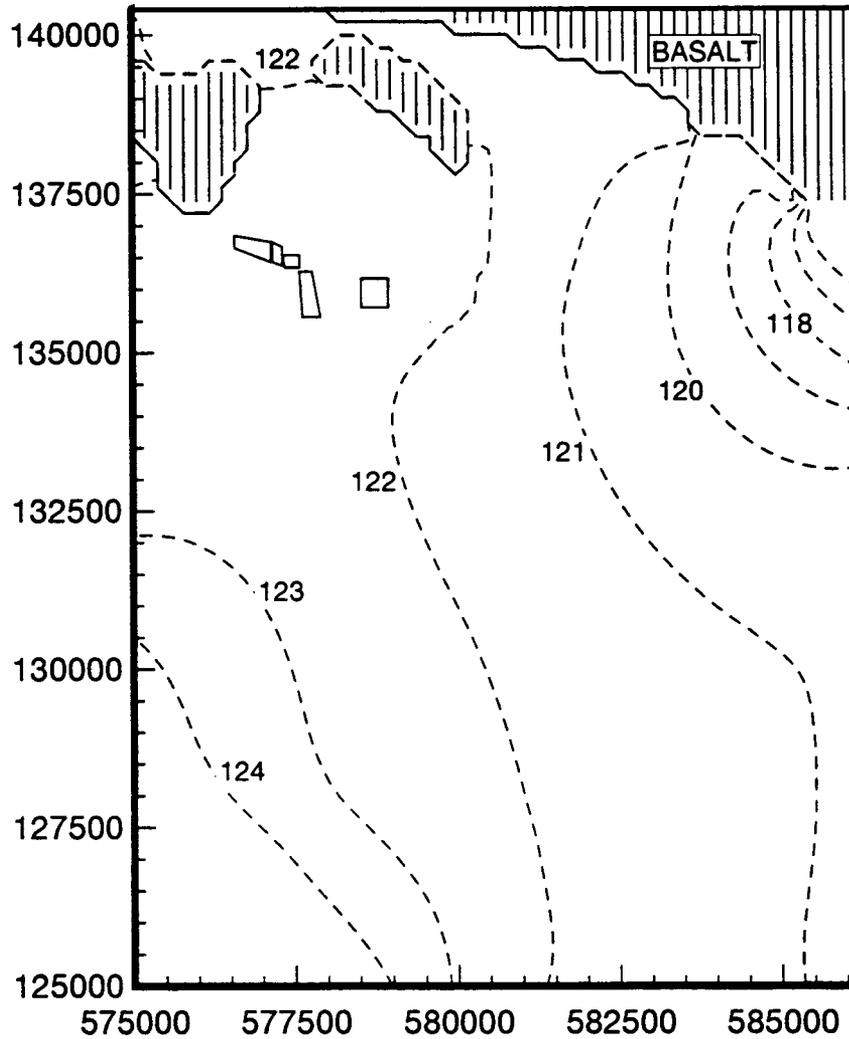
The saturated volumetric water content of each unit was determined in the laboratory. These values, based on the averages of the porosities for the tests performed, were 0.235 for the Pasco gravels member of the Hanford formation, 0.287 for the silty sandy member of the Hanford formation, 0.351 for the Ringold lower mud unit, and 0.339 for unit A of the Ringold Formation. The storativity of the Ringold unit A gravel, as determined from the aquifer tests, is on the order of 1×10^{-4} . The Hanford formation sequences and the Ringold lower mud unit were also assigned this value because data were unavailable and storativity is of negligible importance in simulating flow through unconfined aquifers.

4.6.6 Model Calibration

The primary objective of the model calibration was to evaluate whether the values and distribution of hydraulic properties used in the model adequately represented the flow system, and to adjust the model as needed to achieve adequate representation. A secondary objective was to facilitate discrimination between the effects of TEDB discharges and the effects of model geometry or boundary conditions on the uppermost aquifer. Because of the relatively large size of the model domain and the scale-dependent uncertainties in the hydraulic input parameters and hydrogeology, the calibration was focused toward demonstrating general agreement between model-generated results and results from monitoring well measurements.

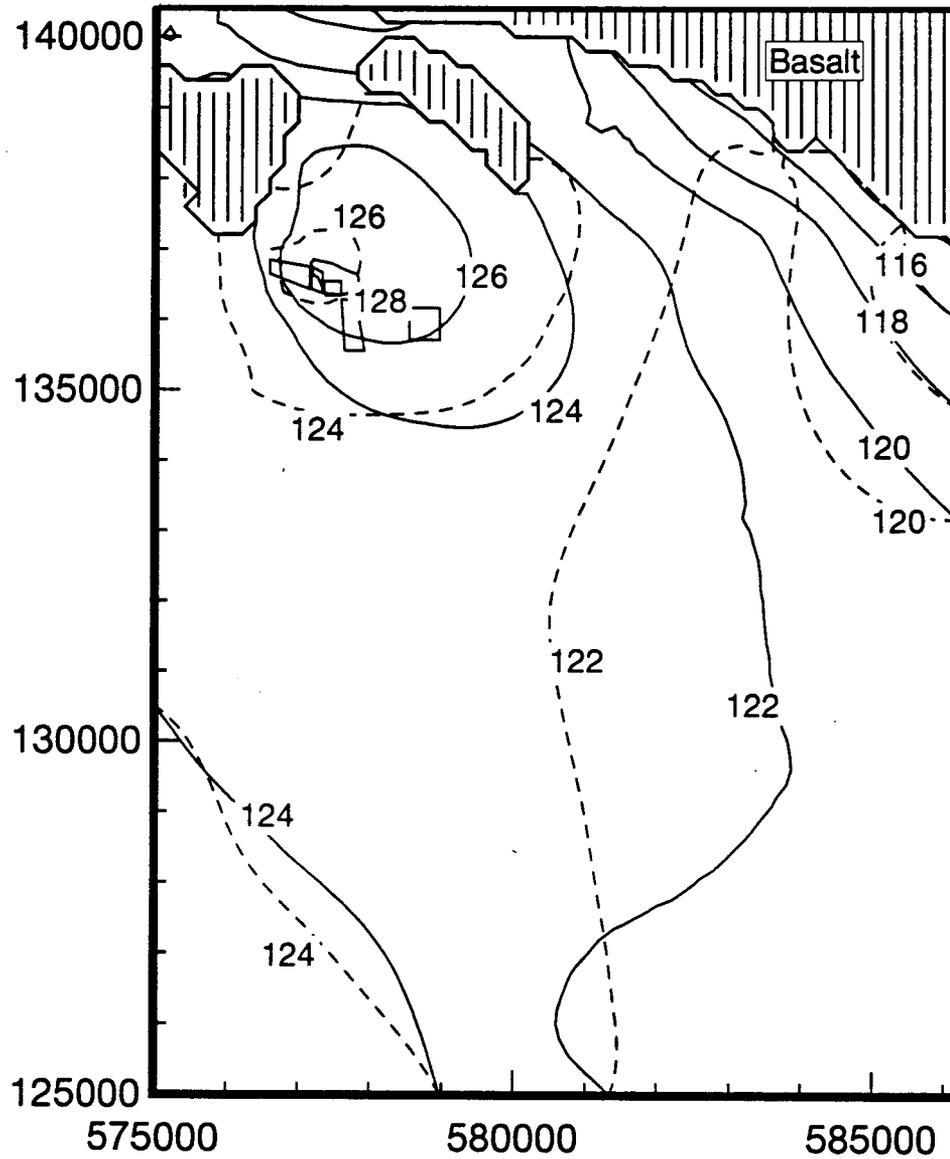
First, VAM3DCG was run for steady-state model conditions using only the boundary conditions. The result was a simulation of the hydrologic conditions within the model domain prior to the initiation of effluent discharges to the B Pond complex. These results were compared (Figure 24) to the hindcast water table map (Figure II.3-D-14 in ERDA 1975) to determine if the boundary conditions used for the model were suitable. The comparison indicated that the boundary conditions being used were suitable; hence, the calibration continued to a second step that simulated the transient effects of discharging 1.6 billion gal/yr of effluent to the B Pond complex during a 45-yr period.

Results from the second step of the calibration were then compared (Figure 25) to the water table map of Kasza et al. (1992). The comparison indicated that the model-generated water table appeared to adequately depict the map of the water table derived from measurements in monitoring wells, except in the northeast corner of the model domain. Because the conceptual model assumed that the basalt in this area creates a no-flow boundary, the contour lines generated by the simulation necessarily terminated perpendicular to the area of basalt above the water table. Hence, the discrepancy between the mapped and modeled contour lines in this area was expected and unavoidable, and was considered not to be an indicator of inadequate model calibration. The calibrated output from this step was used for the initial conditions of subsequent simulations to predict the transient effects on the uppermost aquifer of operating the TEDB at the proposed site for different rates of discharge.



Contour elevations are in meters above mean sea level.
Grid axes are in Lambert coordinates. Dimensions are in meters.
The patterned areas denote basalt above the water table.

Figure 24. Model-Generated Map of the Top of the Uppermost Aquifer Prior to Any Effluent Discharges.



Contour elevations are in meters above mean sea level.
Contours generated by the model are dashed lines.
Contours based on measurements in monitoring wells are solid lines.
The patterned areas denote basalt above the water table.

Figure 25. Comparison of the Simulated Versus Measured Top of the Unconfined Aquifer after Forty-Five Years of Discharges to the B Pond Complex.

4.6.7 Results

Predictive simulations were made of a 40-yr period to determine the effects on the uppermost aquifer of operating the TEDB and to estimate the time required for the treated effluent to travel to the Columbia River. The duration simulated included a 30-yr period of effluent discharge and a 10-yr period of reequilibration. Simulations were made for four discharge scenarios (Table 17).

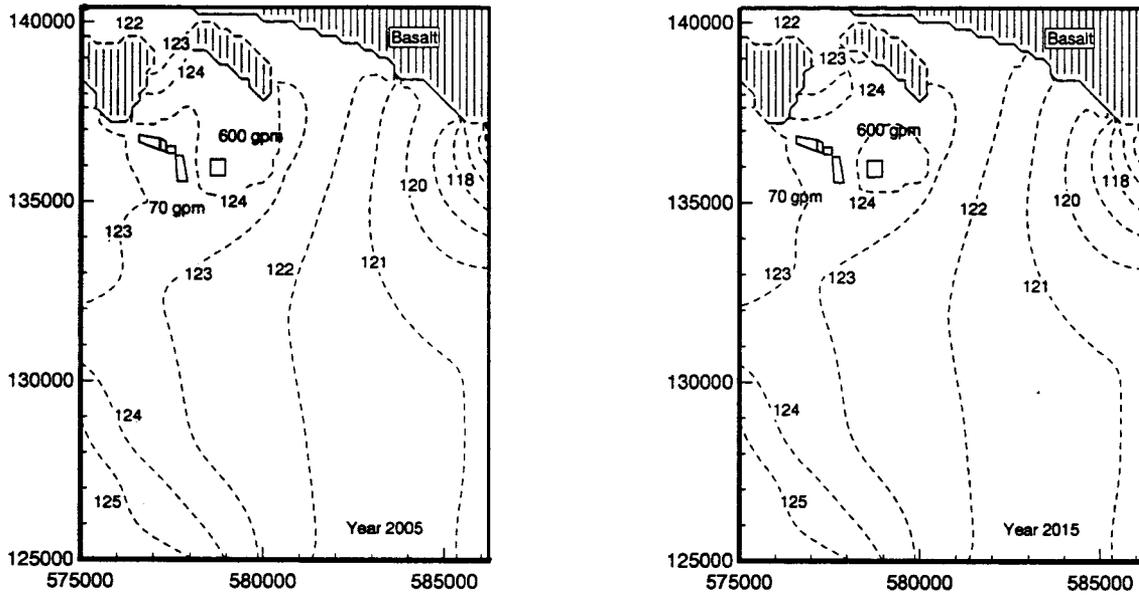
For the 30-period of treated effluent disposal, the TEDB was assumed to discharge an average of 600 gpm and a maximum peak discharge of 2,300 gpm (Crane 1992). The B and C Lobes of the B Pond complex were assumed to have been clean closed, and to continue operating for 30 yr at an average discharge of 70 gpm and a maximum peak discharge of 210 gpm (Crane 1992).

Table 17. 200 Areas Treated Effluent Discharge Scenarios.

Scenarios	30-yr discharge to the TEDB	30-yr discharge to the B Pond complex
1	600 gpm	70 gpm
2	600 gpm	210 gpm
3	2,300 gpm	70 gpm
4	2,300 gpm	210 gpm

Because of the heterogeneity of hydraulic properties, the variations in thickness or continuity of modeled strata within the model domain, and the assumed hydraulic interconnection between the Ringold unit A and the sandy or silty sandy gravels of the Hanford formation along the May Junction Fault, the hydrologic system was categorized for purposes of modeling in terms of an "upper" and a "lower" aquifer. The upper aquifer was defined to include the Pasco gravels of the Hanford formation and the upper portion of the Hanford formation sandy or silty sandy gravels. The lower aquifer was defined to include the Ringold unit A and the lower portion of the Hanford formation sandy or silty sandy gravels.

At the anticipated average rate of treated effluent discharge to the two facilities during the 30-yr period that was simulated (Scenario 1), the hydraulic head appeared to reach an approximate steady state between 10 and 20 yrs after discharges began. The results of the simulation additionally indicate that the mound in the water table beneath the B Pond complex rapidly recedes from the current level, becoming unrecognizable within 10 yr while a new but much smaller mound develops beneath the proposed TEDB site (Figures 26 and 27).



Simulated rate of discharge to the B Pond complex is 70 gpm.
Simulated rate of discharge to the TEDB is 600 gpm.

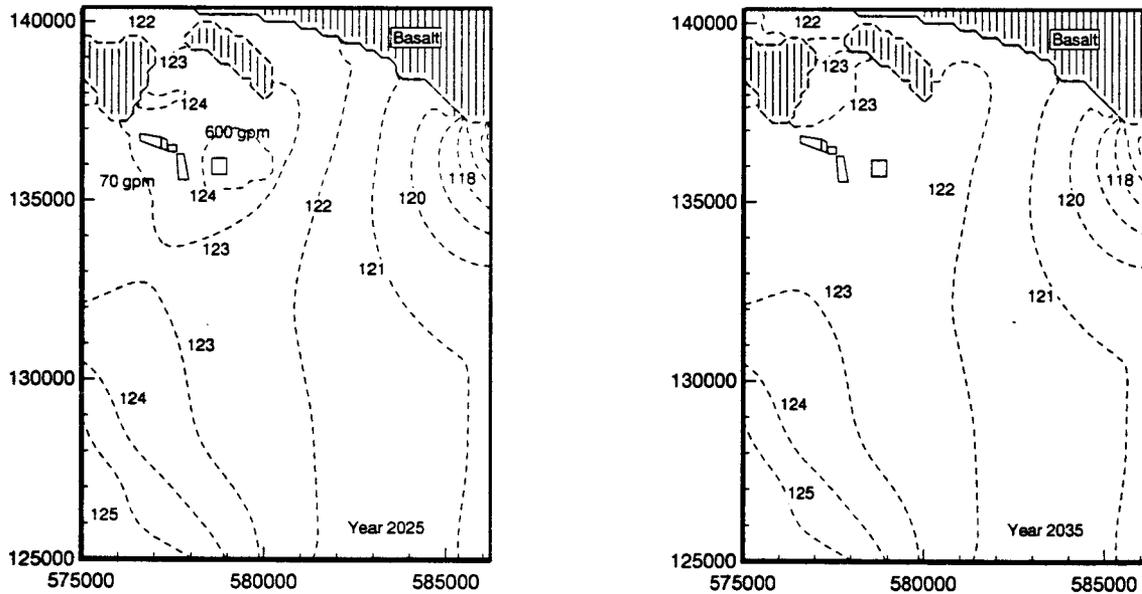
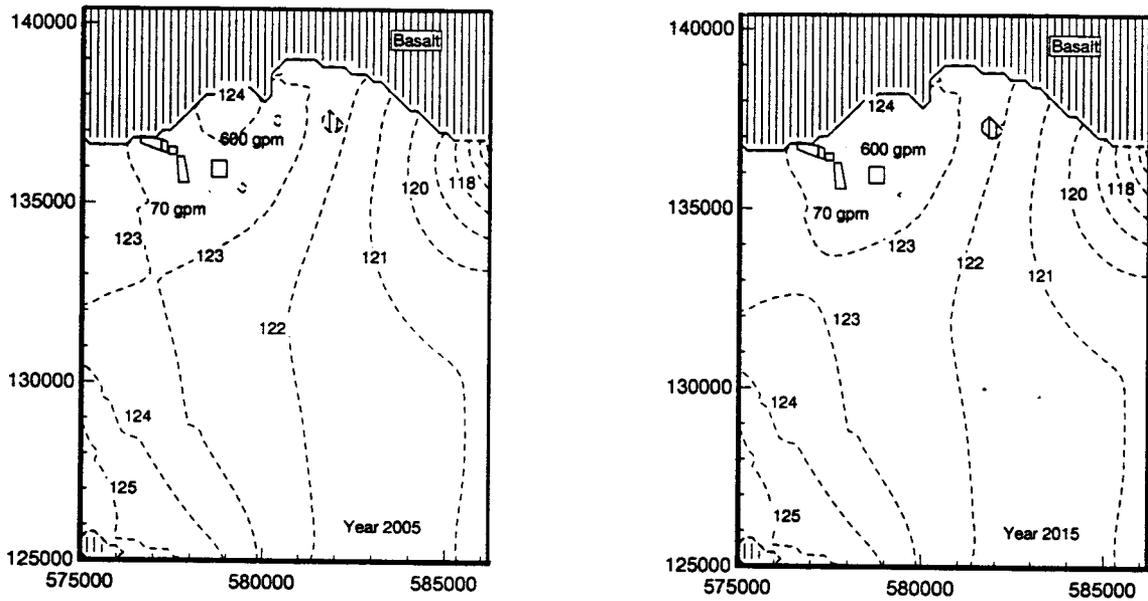


Figure 26. Elevation of the Top of the Upper Aquifer System after Ten-Year Intervals from the Initiation of Discharges for Scenario 1.



Simulated rate of discharge to the B Pond complex is 70 gpm.
Simulated rate of discharge to the TEDB is 600 gpm.

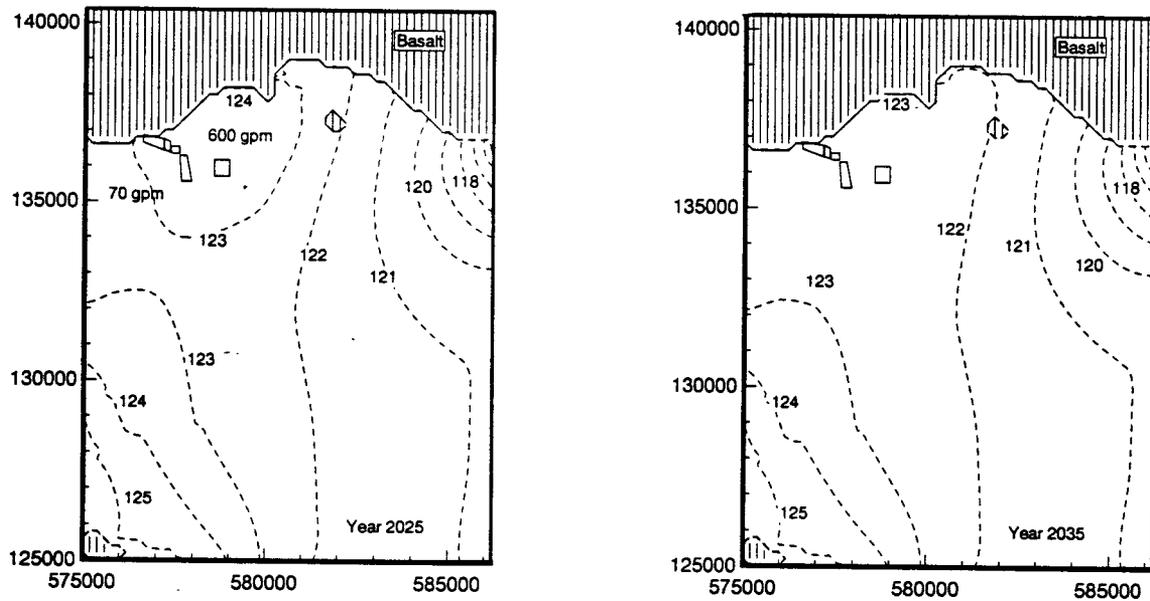


Figure 27. Elevation of the Top of the Lower Aquifer System after Ten-Year Intervals from the Initiation of Discharges for Scenario 1.

Intervals from the Initiation of Discharges for Scenario 1.

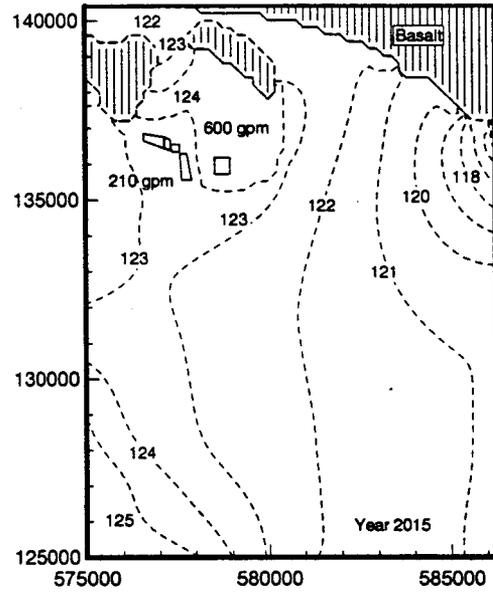
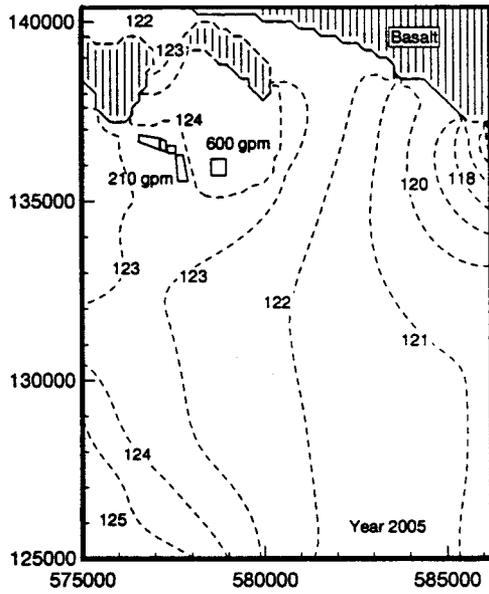
The maximum elevation of the new mound appears to remain at approximately the present elevation of the top of the water table; the mound-like configuration of the simulated surface of the water table beneath the TEDB results from the decrease in elevation of the water table in the surrounding area due to contraction of the mound resulting from past and current discharges to the B Pond complex. In the vicinity of the two treated effluent disposal facilities, simulation results suggest that the increase in elevation of the water table in the Ringold unit A is not as large as it is in the Pasco gravels of the Hanford formation, even though the base of the mound extends laterally outward the same distance in both formations.

For Scenario 1, the time required for treated effluent to travel from the proposed TEDB site to the Columbia River was computed to be 9.7 yr. Except for a slight increase in elevation of the water table in the sandy or silty sandy gravel of the Hanford formation between the two areas of basalt north of the B Pond complex, the results indicate that the water table returns to the steady-state condition of the modeled hindcast (see Figure 25) within 10 yr of the end of discharges to the facilities. For the anticipated average rate of treated effluent discharge to the TEDB and the maximum peak rate of discharge to the B Pond complex (Scenario 2), the uppermost aquifer required more than 20 yr, and perhaps in excess of 30 yr, to reach a steady-state condition. The current mound in the elevation of the water table is indicated by the simulation results to recede while a new mound forms beneath the proposed TEDB site (Figures 28 and 29). In general, the results suggest that the hydraulic head decreases in the area adjoining the TEDB while the hydraulic head immediately beneath the proposed TEDB site remains at the 1992 level.

For Scenario 2, the hydraulic head near and to the south of the B Pond complex is indicated to be slightly elevated, but no well defined mounding of the water table beneath the B Pond complex is evident. In the Ringold unit A in the vicinity of the proposed TEDB site, a new mound in the water table is predicted to develop adjacent to the areas north of the proposed TEDB site where basalt occurs above the water table. This mound extends laterally and vertically about the same distance in unit A as in the overlying Hanford formation.

The time required for treated effluent to travel from the proposed TEDB site to the Columbia River for Scenario 2 was calculated to be 9.6 yr. Except for the gaps between the areas of basalt above the water table to the north of the TEDB where a slight increase in elevation of the water table is evident, the water table is indicated by the simulation results to return to the steady-state conditions of the modeled hindcast (see Figure 25) within 10 yr of the cessation of discharges to the facilities.

For the maximum peak rate of treated effluent discharge to the proposed TEDB site and the average anticipated rate of discharge to the B Pond complex (Scenario 3), the maximum rise of the water table in the Pasco gravels of the Hanford formation is immediately north of the proposed TEDB site and approximates the elevation of the mound currently beneath the B Pond complex (Figures 30 and 31). The simulation results additionally suggest that the water table is likely to be relatively flat in the Pasco



**Simulated rate of discharge to the B Pond complex is 210 gpm.
Simulated rate of discharge to the TEDB is 600 gpm.**

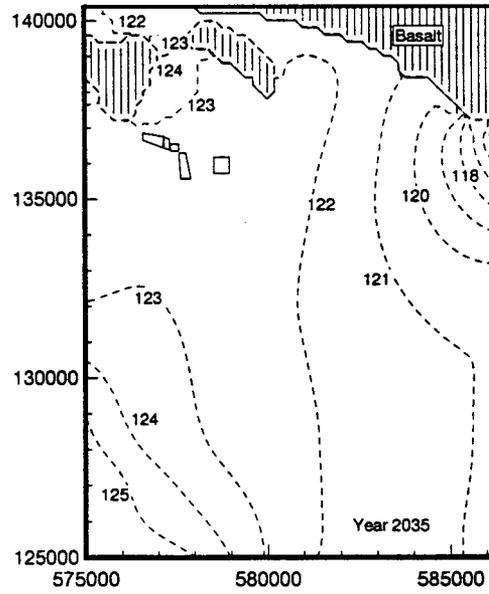
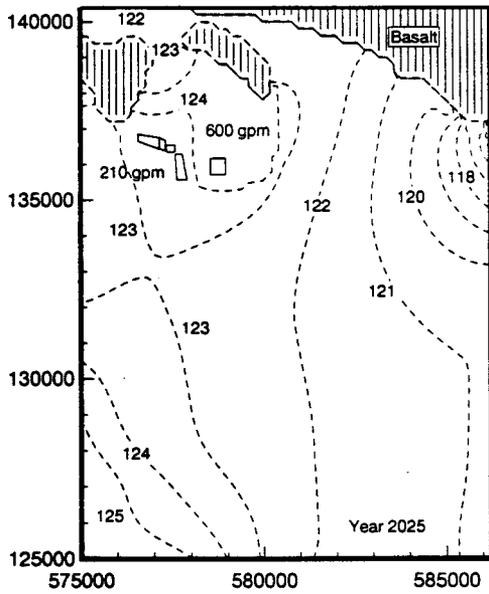
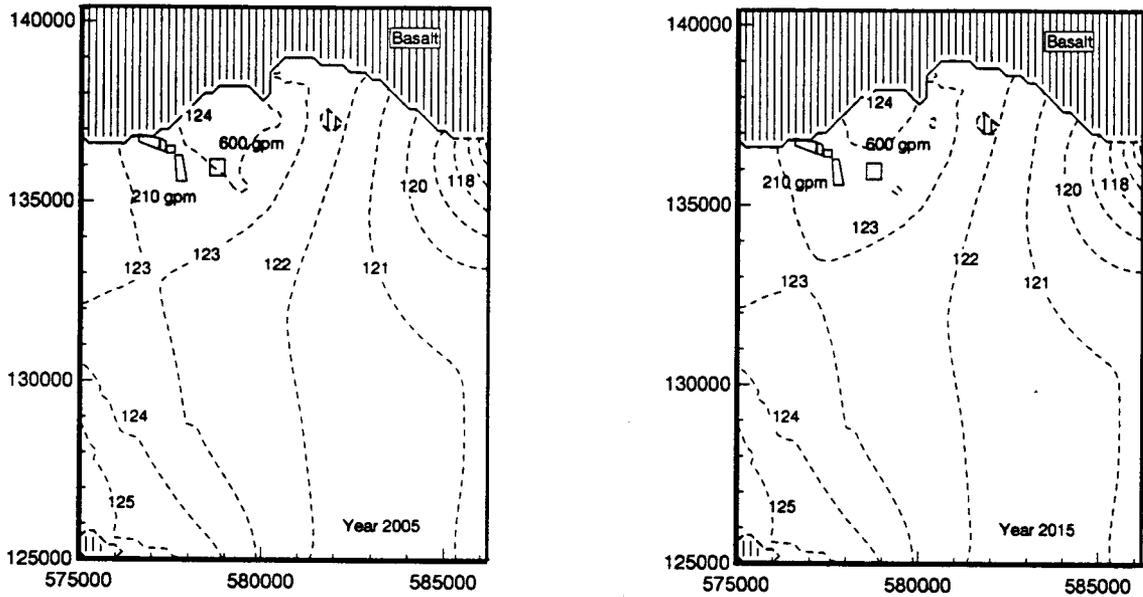


Figure 28. Elevation of the Top of the Upper Aquifer System after Ten-Year Intervals from the Initiation of Discharges for Scenario 2.



**Simulated rate of discharge to the B Pond complex is 210 gpm.
Simulated rate of discharge to the TEDB is 600 gpm.**

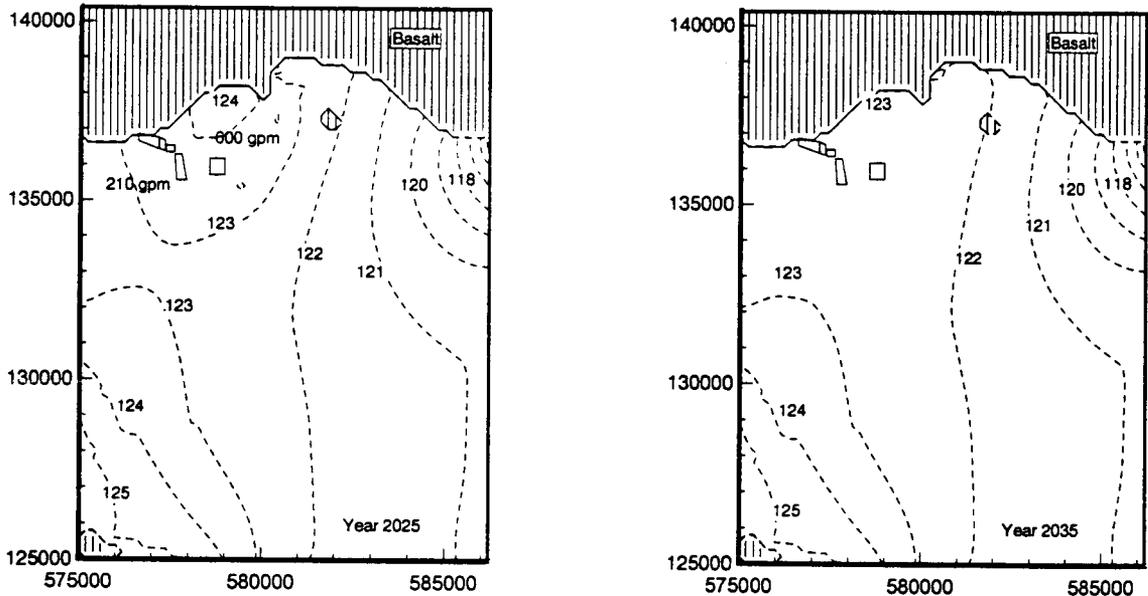
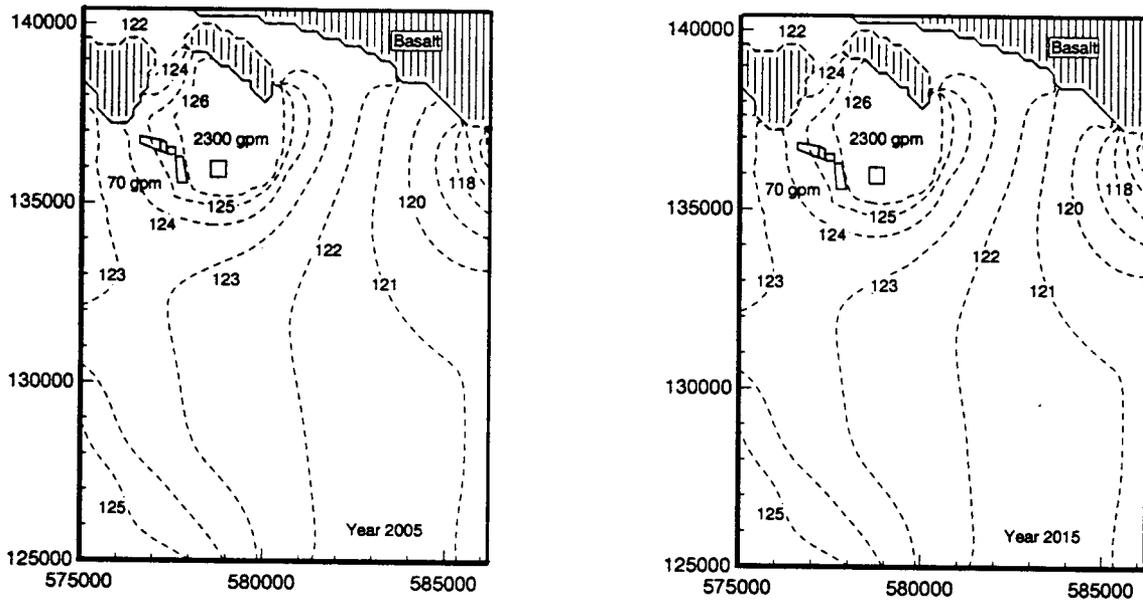


Figure 29. Elevation of the Top of the Lower Aquifer System after Ten-Year Intervals from the Initiation of Discharges for Scenario 2.



**Simulated rate of discharge to the B Pond complex is 70 gpm.
Simulated rate of discharge to the TEDB is 2,300 gpm.**

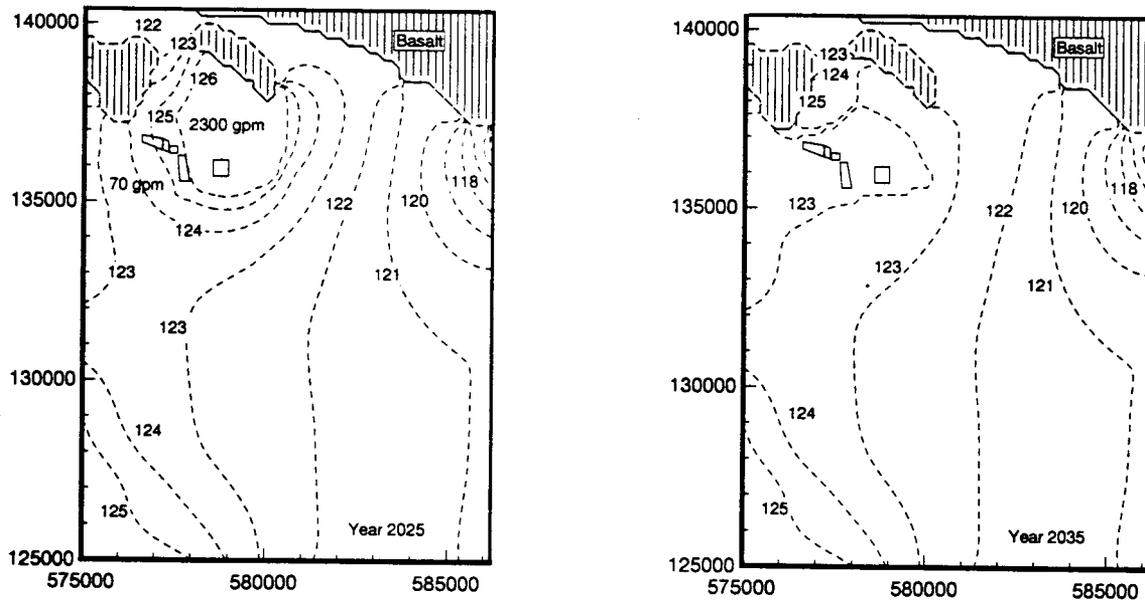
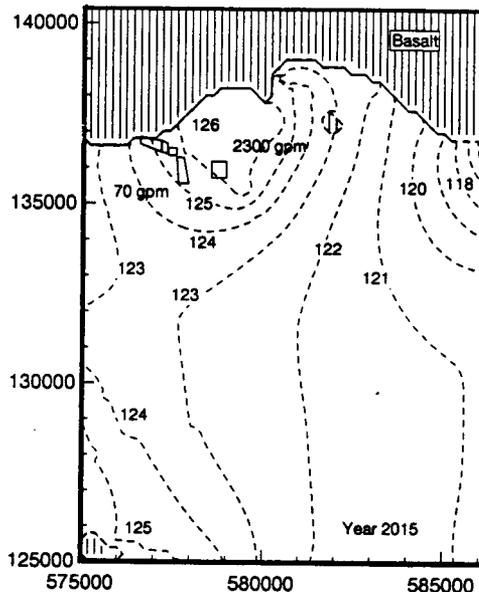
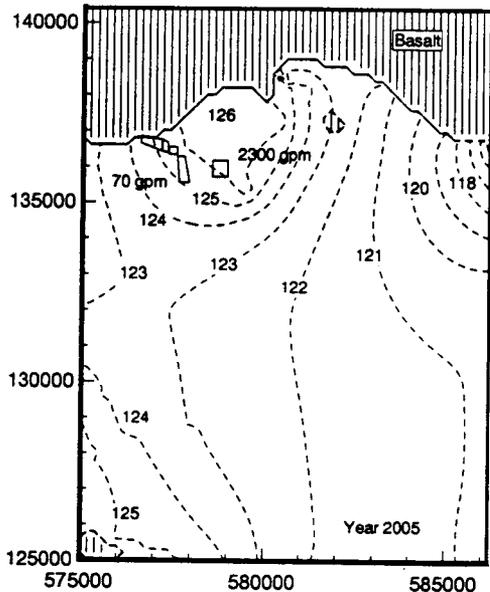


Figure 30. Elevation of the Top of the Upper Aquifer System after Ten-Year Intervals from the Initiation of Discharges for Scenario 3.



Simulated rate of discharge to the B Pond complex is 70 gpm.
 Simulated rate of discharge to the TEDB is 2,300 gpm.

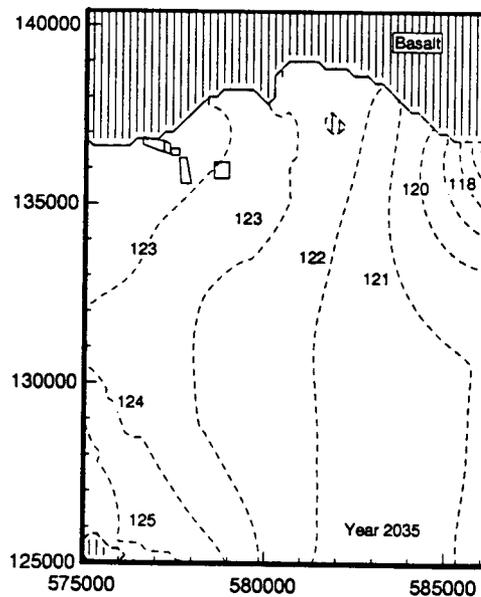
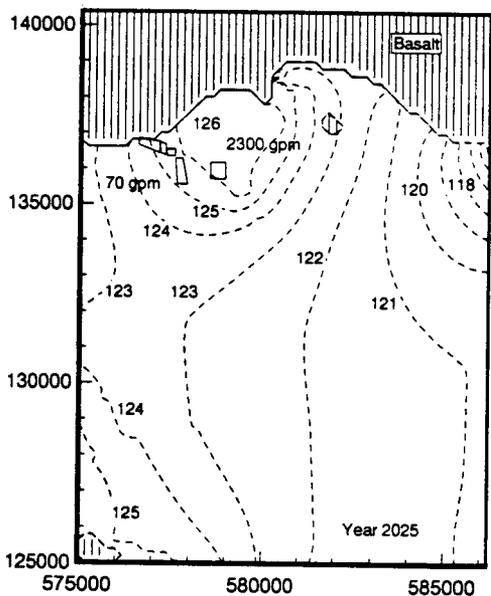


Figure 31. Elevation of the Top of the Lower Aquifer System after Ten-Year Intervals from the Initiation of Discharges for Scenario 3.

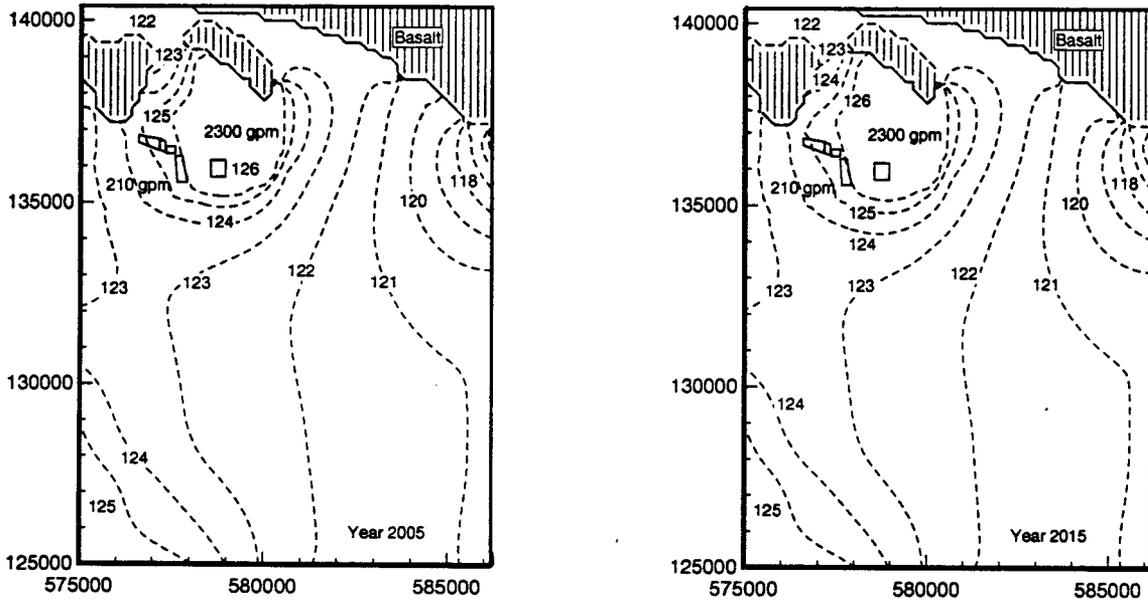
base of the mound in the water table approximates that in the Hanford formation, but the mound-like shape is much more pronounced. In addition, the center of the maximum rise of the water table in the Ringold Formation is further north than it is in the Hanford formation. For this scenario, the elevation of the water table is indicated by the simulation results to rapidly reach a steady state; the plots of the top of the uppermost aquifer at 10, 20, and 30 yr are virtually the same.

The time required for treated effluent to travel from the proposed TEDB site to the Columbia River for Scenario 3 is calculated to be 8 yr. The results of the simulation indicate that the rise in the water table is likely to rapidly recede after treated effluent discharges end, although residual effects remain evident after 10 yr. Throughout much of the model domain, the water table in the Ringold Formation remains somewhat elevated at conditions that approximate steady-state after 10 yr. In the Hanford formation after 10 yr, a small mound remains in the water table for conditions approximating steady state. This mound is between the areas of basalt that are above the water table to the north of the B Pond complex. Elsewhere in the model domain, the water table in the Hanford formation appears to completely reequilibrate to the modeled hindcast steady-state conditions (see Figure 25).

The results for Scenario 4, with the maximum peak flow rates to both the TEDB and the B Pond complex (Figures 32 and 33), were indistinguishable from the results for Scenario 3. The results indicate that the hydrologic system appears to quickly achieve a steady-state condition, with the maximum rise in the water table in the Pasco gravels immediately north of the proposed TEDB site. The maximum rise in the water table in the underlying Ringold unit A is also offset to the north of the proposed site. The simulated rise in the water table in the Ringold formation is of approximately the same lateral and vertical extent as that in the Hanford formation, but the rise is more uniformly distributed in the Hanford formation.

The time required for treated effluent to travel from the proposed TEDB site to the Columbia River for Scenario 4 is computed to be 8 yr. The results of the travel time calculations for all 4 scenarios are summarized in Table 18.

The results of the simulation for Scenario 4 indicate that the residual effects on the water table 10 yr after the end of treated effluent disposal are essentially the same as those for Scenario 3. Immediately north of the B Pond complex, a small mound in the water table remains in the Hanford formation between the two areas of basalt above the water table. Near the treated effluent disposal facilities, the water table in the Hanford formation remains elevated at conditions approximating steady state, 10 yr after treated effluent disposal ceases. Elsewhere, the elevation of the water table has returned to the modeled hindcast steady-state conditions.



**Simulated rate of discharge to the B Pond complex is 210 gpm.
Simulated rate of discharge to the TEDB is 2,300 gpm.**

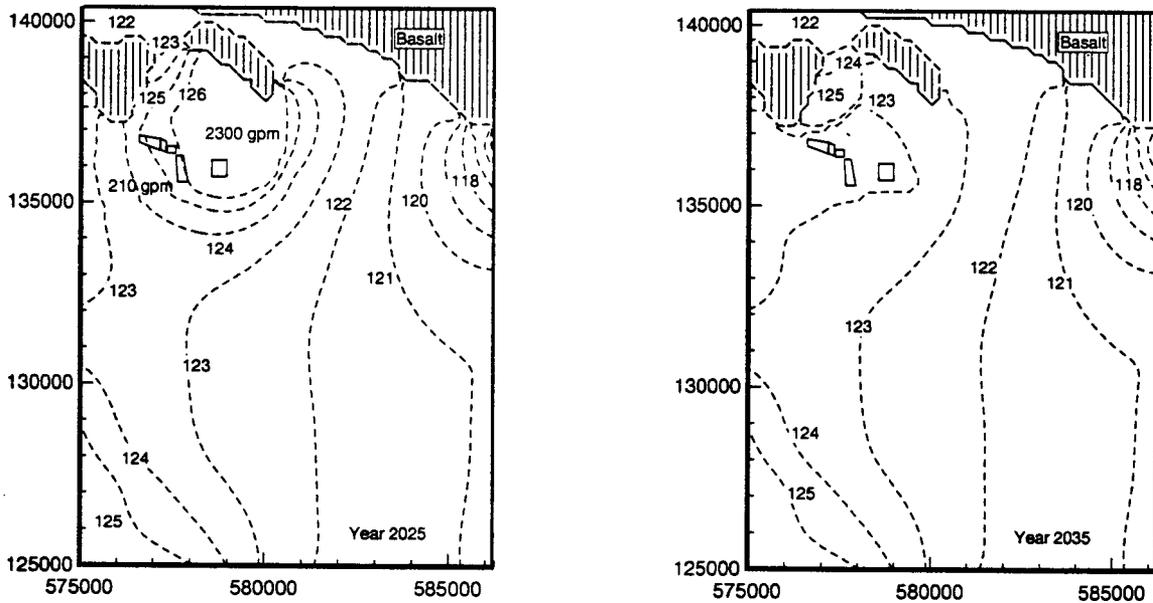
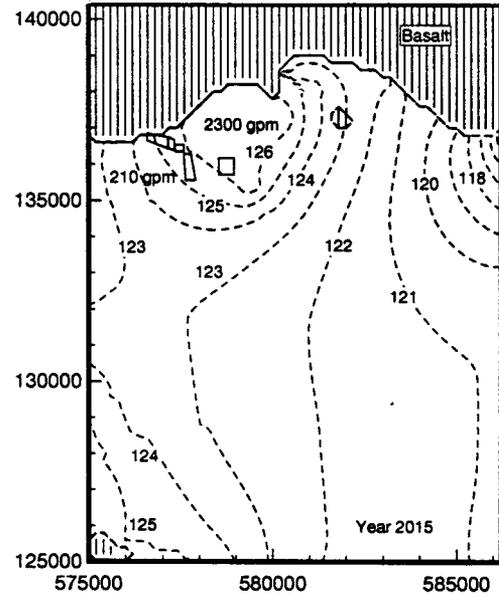
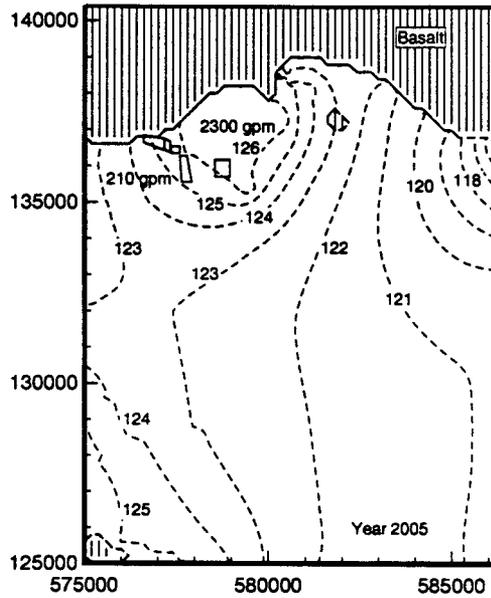


Figure 32. Elevation of the Top of the Upper Aquifer System after Ten-Year Intervals from the Initiation of Discharges for Scenario 4.



**Simulated rate of discharge to the B Pond complex is 210 gpm.
Simulated rate of discharge to the TEDB is 2,300 gpm.**

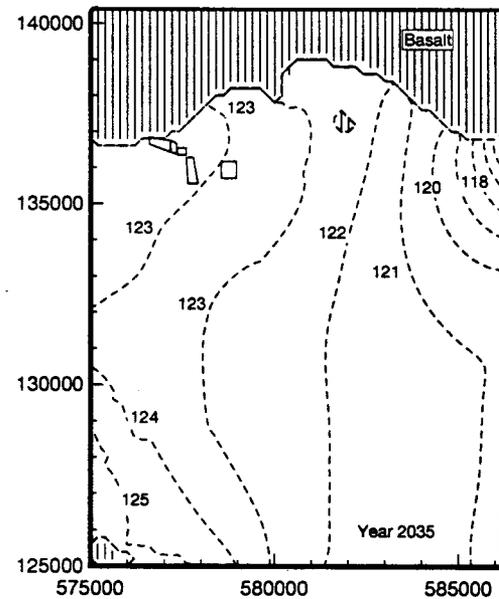
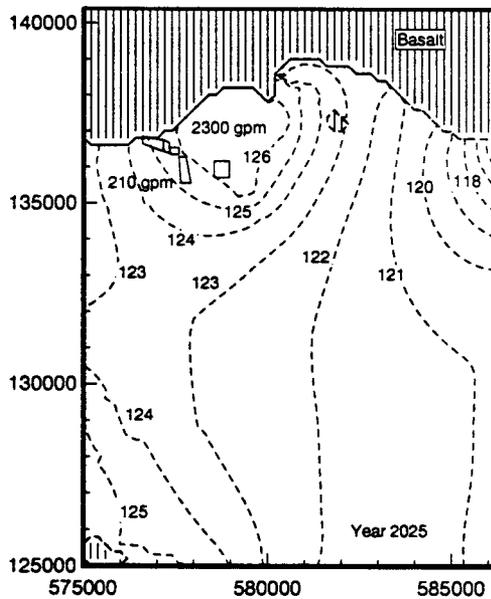


Figure 33. Elevation of the Top of the Lower Aquifer System after Ten-Year Intervals from the Initiation of Discharges for Scenario 4.

Table 18. Summary of Time Required for Treated Effluent to Travel from the Proposed Site to the Columbia River.

Scenarios	Water table elevation at TEDB site (meters)	Water table elevation at model boundary	Travel time from TEDB site to model boundary (yr)	Travel time from TEDB site to model boundary (yr)	Travel time from TEDB site to Columbia River (yr)
1	124.34	116.07	6.2	3.5	9.7
2	124.46	116.07	6.1	3.5	9.6
3	127.46	116.07	4.5	3.5	8.0
4	127.54	116.07	4.5	3.5	8.0

4.6.8 Discussion

The results of the simulations indicate that the anticipated average rate of discharge of treated effluent to the TEDB will not sustain the currently elevated condition of the potentiometric surface beneath the B Pond complex. If the TEDB discharges the expected 600 gpm (315 million gal/yr), the results indicate that the current elevation of the water table or potentiometric head will return to the modeled hindcast levels (see Figure 25), except in the immediate vicinity of the proposed TEDB site.

Neither of the two modeled discharge rates to the B Pond complex (70 and 210 gpm) appear likely to maintain an appreciable mound in the water table beneath that facility. However, at the maximum peak rate rate of discharge to the B Pond complex, the mounding of the water table beneath that facility, which occurs in the Pasco gravels sequence is relatively broader, and the peak in the Ringold unit A is more elevated than at the lower rate of discharge.

Model results indicate that within 10 yr of discontinuing the expected average rate of discharge to the TEDB, the hydraulic head within the model domain will return to the modeled hindcast condition, except for the gap between the areas of basalt above the water table to the north of the B Pond complex.

The maximum peak rate of discharge to the TEDB (2,300 gpm; 1.2 billion gal/yr) is shown to additionally elevate the water table in the Pasco gravels of the Hanford formation. The potentiometric level remains elevated in the Ringold unit A. Model results indicate that the mound in the water table beneath the B Pond complex decays while a new mound of approximately the same height as the current mound beneath the B Pond complex grows in the Pasco gravels to the immediate north of the proposed TEDB site. Hydraulic head profiles are indicated to be different for the Pasco gravels than for the Ringold unit A. Although the area affected by the

discharges extends outward to same radius in all directions and the location of the peak elevation is approximately the same in the Pasco gravels as in the Ringold unit A, the mound in the water table in the Hanford formation is indicated to be flatter than that in the Ringold unit A.

The residual effects for the maximum peak rate of discharge to the TEDB are still apparent 10 yr after the discharges cease, particularly in the Hanford formation. A small mound is indicated to remain in the Hanford formation in the gap between the two areas of basalt above the water table north of the B Pond complex. Within the model domain the water table generally remains elevated by at least a meter compared to the modeled hindcast steady-state conditions. No residual mounding is indicated to be present in the Ringold Formation unit A, but the potentiometric elevation around the TEDB is also elevated by ~1 m compared to the modeled hindcast steady-state conditions.

The Ringold lower mud unit beneath the proposed TEDB site prevents the modeled discharge at that facility from moving vertically downward into the Ringold unit A. Above the lower mud unit, water is indicated by the model to accumulate in the Pasco gravels, but the high transmissivity of this unit prevents a prominent mound in the water table from forming by rapidly conveying the water laterally. Flow from the TEDB, as well as flow from the B Pond complex, is shown by model results to continue laterally until the Ringold lower mud unit is not present and the water has the opportunity either to recharge the Ringold unit A or the sandy or silty sandy gravels of the Hanford formation underlying the Pasco gravels.

In the vicinity of the B Pond complex, the water table is above the contact between the Ringold lower mud unit and the Hanford formation at the beginning of the time simulated. Only as much water as could laterally be conveyed through the Ringold unit A was allowed to enter from the top of the model domain; i.e., no storage occurred within unit A. The simulation results indicate that any water not immediately moving downward into the Ringold unit A accumulates until it is able to travel laterally through the Pasco gravels. This water then merges with that discharged to the proposed TEDB and either eventually enters the Ringold unit A or the sandy or silty sandy gravel of the Hanford formation.

Model results indicate that continued operation of the B Pond complex at the simulated rates of discharge would not result in the perpetuation of a well defined mound in the water table beneath that facility, but that its operation would have a discernable effect on the discharges to the TEDB. Comparison of the effects of the two simulated discharge rates to the B Pond complex (70 gpm and 210 gpm) showed that a significant fraction of effluent discharged at the higher rate is likely to travel north and recharge the Ringold unit A near the areas of basalt that rise above the water table. The lower rate of discharge to the B Pond complex appears to have no discernable effect on the water table, either in the Hanford formation or in Ringold unit A.

The simulations indicate that when 210 gpm of treated effluent is discharged to the B Pond complex, a laterally much more extensive mound forms in the Pasco

gravels in the vicinity of the proposed TEDB, particularly in the gap between the areas of basalt to the north of the TEDB. In unit A of the Ringold Formation, the lateral and vertical dimensions of the simulated mound are also relatively larger. At the maximum peak rate of discharge to the B Pond complex, the capacity of the Ringold unit A to convey the water away from the point of recharge is exceeded. Consequently, the water accumulates and moves laterally outward through the overlying Pasco gravels. Water entering the deeper sandy or silty sandy gravels of the Hanford formation near the areas of basalt to the north of the TEDB site also recharges the Ringold unit A. It is this water that causes the hydraulic mound in unit A to be centered immediately to the north of the proposed TEDB, rather than directly beneath it.

The simulations for Scenarios 3 and 4 predict water table and potentiometric elevations that are similar to those for current conditions, but with two exceptions. One exception is that the Hanford formation stores comparatively more of the discharged water, with the top of the mound in the water table remaining at approximately the currently observed elevation. The second exception is that the mound in Ringold unit A appears to be broader than that currently observed beneath the B Pond complex, with the new mound centered near the areas of basalt above the water table to the north of the proposed TEDB site. Both changes are the direct consequence of the discharge at the TEDB site occurring where the Ringold lower mud unit separates the Hanford formation from the Ringold unit A. The changes are not sensitive to whether the rate of discharge to the B Pond complex is 70 or 210 gpm; both of these simulated discharge rates are less than one tenth of the 2,300 gpm discharge rate simulated for the proposed TEDB.

Because of the presence of the Ringold lower mud sequence, discharges to the proposed TEDB are unable to flow directly downward and form a steep-flanked mound in the water table. The mound becomes fairly evenly distributed through the Pasco gravels. Flow to the north encounters the areas of basalt above the water table where the Ringold lower mud unit is absent. In these areas, the water recharges the Ringold unit A. The resultant mound in the Ringold unit A appears broader than the current mound beneath the B Pond complex for two reasons. One is that water in the Ringold formation beneath the B Pond complex emanates from the discharge point and flows radially in all directions down the hydraulic gradient. In contrast, at the peak of the new mound induced by discharges to the proposed TEDB, the basalt aquitard blocks flow further to the north. A second reason is that the transmissive unit north of the TEDB thins as it approaches the basalt, resulting in decreased transmissivity. Both of these factors greatly reduce the aquifer's ability to transmit water, thus producing a relatively broad-flanked mound in the Ringold unit A.

Along the May Junction Fault and where the elevation of the top of the basalt is below mean sea level, groundwater flow originating from the TEDB is indicated by the simulations to continue eastward or southward, bypassing the Ringold unit A and feeding water from the Pasco gravels directly into the relatively deeper sandy or silty sandy gravels of the Hanford formation. Only the flow reaching discontinuities in the lower mud unit around B Pond complex and the areas of basalt above the water table to the north of the TEDB site appears to directly recharge the Ringold unit A. Water

from the simulated discharges to the B Pond complex does not form a discernable mound in the water table because of the high transmissivity of the Pasco gravels. Near the areas of basalt above the water table that partially block flow to the north, the Hanford formation consists of sandy or silty sandy gravels that do not transmit water as readily as the Pasco gravels. Consequently, the flow blocked by the basalt accumulates, creates a peak in the hydraulic head, and recharges the Ringold unit A.

The calculations of time required for the treated effluent to reach the Columbia River are believed to be conservative. Previous estimates of the travel time from the B Pond complex to the Columbia River range from 10 to 20 yr (USGS 1987). All travel time estimates for the area of interest depend on knowledge of the hydraulic characteristics of the Pasco gravels and the sandy to silty sandy gravels sequence of the Hanford formation from the discharge area to the Columbia River. These characteristics are not well known for the entire length of the flow pathway. The high infiltration capacity and the lack of a substantial saturated thickness of the Pasco gravels hinders hydraulic testing of that unit (Davis and Delaney, 1992). Thorne and Newcomer (1992) report that results of previous constant-discharge tests performed in the uppermost aquifer of the Hanford Site (four wells of which are within the model domain) ranged from 190 ft/day (58 m/day) to 7,100 ft/day (2,165 m/day). Without better delineation of the distribution of hydraulic conductivity throughout the uppermost aquifer, more accurate estimates of travel time cannot be made.

The contour plots of the results of the model simulations show many of the effects of modeling a heterogeneous system. These effects are particularly evident in the Hanford formation. For example, the location and configuration of the mound in the water table that remains 10 yr after maximum peak discharges to the TEDB end are dependent on the hydraulic properties and thickness of the uppermost aquifer.

Specifically, a remnant of the mound is indicated to be present in the Hanford formation near the areas of basalt above the water table after discharges end. The mound remains because the modeled aquifer in this area was assigned the properties for sandy or silty sandy gravel instead of those for the Pasco gravel sequence. Consequently, the aquifer between the areas of basalt above the water table retains more of the water and thus maintains a higher hydraulic head than the neighboring highly transmissive area. In addition, the hydraulic properties and thickness of the uppermost aquifer affects the location of contour lines. The convergence of contours of water table elevation along the Gable Mountain-Gable Butte anticline is the most obvious result of these effects. The contour lines converge where the Hanford formation thins near the base of the anticline and its hydraulic properties change from the Pasco gravels sequence to the sandy or silty sandy sequence.

4.6.9 Conclusions

Discharge of treated effluent to the proposed TEDB site at the projected average rate of 600 gpm and continued discharge to the B Pond complex at a projected average rate of 70 gpm is indicated to likely result in conditions that approximate those

of the modeled hindcast (compare Figures 25 and 26). A small mound in the water table is likely to remain in the Hanford formation in the vicinity of the TEDB; the size of the mound is dependent on the continuation of discharges to the B Pond complex.

At the projected average rates of discharge to the TEDB and the B Pond complex, the size of the mound in the water table in Ringold unit A is likely to contract from that currently observed. The mound presently centered beneath the B Pond complex almost disappears, with a new, smaller mound centered north of the TEDB near the areas of basalt above the water table. At the anticipated average rate of discharge, treated effluent is indicated to require at least 9.6 yr to reach the Columbia River. Ten years after all discharges end, the water table is likely to return to a steady-state that approximates that of the modeled hindcast.

At maximum peak rates of discharge to the proposed TEDB and the B Pond complex, the elevation of the water table approximates that currently observed except for two changes. The mound in the water table in the Hanford formation is likely to flatten out at approximately the same elevation as is currently observed. The mound in the water table in Ringold unit A is likely to be broader than that currently observed. The present mound in the water table beneath the B Pond complex in Ringold unit A is likely to contract, while a new mound grows to the north of the TEDB.

The simulation results indicate that there is no discernable difference in the water table elevation that is attributable to a change in the rate of discharge to the B Pond complex from 70 to 210 gpm. At maximum peak rates of discharge, 8 yr is indicated to be required for discharges to reach the Columbia River. Ten years after discharges cease, the effect of the discharges on the elevation of the water table is still apparent in the immediate vicinity of the TEDB and the B Pond complex. However, in the remainder of the model domain, the water table has essentially returned to the modeled hindcast steady-state condition.

5.0 CONCLUSIONS ON SITE SUITABILITY

Two kinds of criteria were used to choose a tentative site for construction and operation of the 200 Areas TEDB: screening criteria (see Section 3 in Davis 1992) and candidate ranking criteria (see Section 4 in Davis 1992).

5.1 CANDIDATE SCREENING CRITERIA

Four screening criteria were applied based on DOE-RL Order 4320.2A (DOE-RL 1990a), *Site Selection*, and DOE-RL Order 6430.1A, §200-1(DOE-RL 1989), *General Design Criteria* (Davis 1992):

- No conflict with other uses

- No negative effects on RCRA, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or other treated effluent disposal sites
- No negative effects on cultural resources
- No negative effects on threatened or endangered species.

These criteria were applied to determine whether the available areas that had been delineated by functional design considerations were suitable candidates for additional evaluation.

Areas without conflicts with (1) other current or planned uses, (2) without identified subsurface contamination that could be remobilized by operation of the proposed facility, (3) without sites of cultural, historic or archaeological interest, and (4) with no threatened or endangered plants or animals were subsequently ranked for relative merit. Those areas that failed to comply with any of the four screening criteria were dropped from further consideration. Four candidate areas, each of which contained one reference candidate site, were identified for further evaluation (see Figure 10 of Davis 1992).

5.2 CANDIDATE RANKING CRITERIA

Five criteria were applied to numerically rank the relative merits of the four reference candidate sites that complied with the screening criteria. These five criteria were perceived to be of varying importance; human health and environmental protection were the overriding concerns (Davis 1992). The following ranking criteria and relative weights were used to tentatively choose a preferred site from four candidates:

- Safety and Environmental Protection Criteria (60%)
 - Potential effect on occupational health and safety (30%)
 - Potential effect on groundwater and on existing contamination (70%)
- Design and Constructibility Criteria (40%)
 - Obstructions between the proposed site and effluent collection point (25%)
 - Interference with the operation of other facilities (25%)
 - Availability of adjacent land for expansion (50%).

Based on the application of these criteria to the four reference candidate sites (see Figures 10 and 12 of Davis 1992), a preferred site (see Figure 1) was proposed (Davis 1992) for detailed investigation.

5.3 REEVALUATION OF PROPOSED SITE

Of the five criteria used to select a preferred site from the four candidate sites, only one criterion required further evaluation because of inadequate data. This was the criterion relating to the potential effect of operating the TEDB at the proposed site on groundwater and existing contamination. Analyses of sediments and groundwater at the proposed site (see Sections 3.5 and 4.3) indicate that it is free of contamination. Areas with known contamination in the area of interest are beneath part of the B Pond complex and facilities in the 200 East Area. These areas of known contamination above the current water table are associated with the western part of the B Pond complex and the area immediately east of the PUREX Plant in the southeast corner of the 200 East Area (e.g., see Appendix A, Figures A.2.1 and A.2.2 of Davis 1992).

The site-specific data needed to evaluate the suitability of the proposed site were obtained from the three boreholes drilled to characterize the TEDB site and newly drilled groundwater monitoring wells associated with the B Pond complex. The new data were used to refine and update the conceptual and numerical models previously used to help select the preferred site from the four candidates. The results of the revised conceptual and numerical models were reported in Section 4.6.4.

The results reported in Section 4.6 indicate that, because of the high hydraulic conductivity of the Hanford formation, any mounding of the water table resulting from operation of the TEDB at the preferred site, for the expected volumes of treated effluent, is likely to be of very limited extent. Because of the limited extent of mounding of the water table due to treated effluent discharge, contamination associated with parts of the B Pond or other upgradient facilities in the 200 East Area is not expected to be remobilized by the rise in the water table associated with operation of the TEDB. Conversely, the elevated head in the area beneath and in the immediate vicinity of the TEDB can be expected to impede the downgradient migration of contaminants in the uppermost aquifer that are associated with past operations in the 200 East Area (e.g., see the contaminant plumes shown in Appendix A, Figures A.2.3 through A.2.10 of Davis 1992).

6.0 REFERENCES

- Agarwal, R. G., 1980, A New Method to Account for Producing-Time Effects When Drawdown Type Curves Are Used to Analyze Pressure Buildup and Other Test Data, Society of Petroleum Engineers, SPE Paper 9289, presented at the 1980 SPE Annual Technical Conference and Exhibition, Dallas, TX.
- American Society of Agronomy, 1982, Methods of Soil Analysis: Chemical and Microbiological Properties, in Agronomy, 2nd Edition, No. 9, Part 2, Chapter 8, Section 8-3, "Cation Exchange of Arid Soils", Madison, Wisconsin.
- Bianchi, W. C., 1984, A Method for Prediction of the Waste Water Percolation Capacity for the Extension of the Pond B Facility -- DOE Hanford Reservation, (unnumbered), Rockwell Hanford Operations Historical Document No. 0002, Westinghouse Hanford Company, Richland, Washington.
- Bouwer, H. and R. C. Rice, 1976, A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells: Water Resources Research, Vol. 12, No. 3, p. 423-428.
- Clark, W. E., 1967, Computing the Barometric Efficiency of a Well: Proceedings of the American Society of Civil Engineers, Journal of the Hydraulics Division, Vol. 43, No. HY4, p. 93-98.
- Connelly, M. J., J. V. Borghese, C. D. Delaney, B. H. Ford, J. W. Lindberg and S. J. Trent, 1992, Hydrogeologic Model for the 200 East Ground Water Aggregate Area, WHC-SD-EN-TI-019, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Cooper, H. H., Jr. and C. E. Jacob, 1946, A Generalized Graphical Method for Evaluating Formation Constants and Summarizing Well-Field History: Am. Geophys. Union Trans., Vol. 27, No. 4, p. 526-534.
- Cooper, H. H., J. D. Bredehoeft and I. S. Papadopoulos, 1967, Response of a Finite-Diameter Well to an Instantaneous Charge of Water: Water Resources Research., Vol. 3, p. 263-269.
- Crane, A. F., 1992, Functional Design Criteria for the 200 Area Treated Effluent Disposal Facility. Project W-049H, WHC-SD-W049H-FDC-001 Rev. 1, Westinghouse Hanford Company, Richland, Washington.
- Davis, J. D., 1992, Site Evaluation Report -- Site Screening, Evaluation, and Selection: Project W-049H. 200 Areas Treated Effluent Disposal Basin, WHC-SD-W049H-SE-004, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

- Davis, J. D. and Delaney, C. D., 1992, Site Characterization Work Plan -- 200 Areas Treated Effluent Disposal Basin, Project W-049H, WHC-SD-W049H-WP-001, Rev. 1, Westinghouse Hanford Company, Richland, Washington.
- Delaney, C. D., K. A. Lindsey and S. P. Reidel, 1991, Geology and Hydrology of the Hanford Site: A Standardized Text for Use in Westinghouse Hanford Company Documents and Reports, WHC-SD-ER-TI-003, Westinghouse Hanford Company, Richland, Washington.
- Delaney, C. D., 1993, Hydrologic Test Plan -- W-049H 200 Areas Treated Effluent Disposal Facility, WHC-SD-EN-TP-025, Westinghouse Hanford Company, Richland, Washington.
- DOE, 1992, Environmental Assessment, Hanford Environmental Compliance Project -- Hanford Site, Richland, Washington, DOE/EA-0383, U. S. Department of Energy, Washington, D.C.
- DOE-RL, 1987, Plan and Schedule to Discontinue Disposal of Contaminated Liquids into the Soil Column at the Hanford Site, WHC-EP-0196, U. S. Department of Energy, Richland Operations Office, Richland, Washington.
- DOE-RL, 1989, General Design Criteria, DOE Order 6430.1A, U. S. Department of Energy, Richland Operations Office, Richland, Washington.
- DOE-RL, 1990a, Site Selection, DOE Order 4320.2A, U. S. Department of Energy, Richland Operations Office, Richland, Washington.
- DOE-RL, 1990b, 216-B-3 Pond Closure/Post-Closure Plan, DOE-RL-89-29, Rev. 0, U. S. Department of Energy, Richland Operations Office, Richland, Washington.
- DOE-RL, 1993, Hanford Site Background: Part 1. Soil Background for Nonradioactive Analytes, DOE-RL-92-24 , Rev. 1, Richland Operations Office, Richland, Washington.
- Ecology, 1988, State Waste Discharge Permit Program, Washington Administrative Code 173-216, Washington State Department of Ecology, Olympia, Washington.
- Ecology, U. S. Environmental Protection Agency and U. S. Department of Energy, 1989 et seq., Hanford Federal Facility Agreement and Consent Order, Washington State Department of Ecology, Olympia, Washington.
- Ecology, 1989, Minimum Standards for Construction and Maintenance of Wells, Washington Administrative Code 173-160, Washington State Department of Ecology, Olympia, Washington.
- Ecology, 1992, The Model Toxics Control Act -- Cleanup: WAC 173-340, Washington State Department of Ecology, Olympia, Washington.

- EPA, 1989, USEPA Contract Laboratory Program. Statement of Work for Inorganics Analysis: Multi-Media Concentration, U. S. Environmental Protection Agency, Washington, D.C.
- ERDA, 1975, Final Environmental Impact Statement. Waste Management Operations, ERDA-1538, Energy Research and Development Administration, Richland, Washington.
- Freeze, R. A., and Cherry, J. A., 1979, Groundwater, Prentice Hall, Englewood Cliffs, New Jersey.
- 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., M. D. Hall, S. R. Strait and W. R. Brown, 1981, Hydrology of the Separations Areas, RHO-ST-42, 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.
- Jackson, R. L., 1990, Quality Assurance Project Plan for RCRA Ground Water Monitoring Activities, WHC-SD-EN-QAPP-001, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Johnson, V. G., 1993, Westinghouse Hanford Company Operational Groundwater Status Report. 1990-1992, WHC-EP-0595, Westinghouse Hanford Company, Richland, Washington.
- Kasza, G. L. and A. L. Schatz, 1989, Groundwater Maps of the Hanford Site Separations Area, WHC-EP-0142-2, Westinghouse Hanford Company, Richland, Washington.
- Lindsey, K. A., 1991, Revised Stratigraphy for the Ringold Formation. Hanford Site. South-Central Washington, WHC-SD-EN-EE-004, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Lindsey, K. A., B. N. Bjornstad, J. W. Lindberg and K. M. Hoffman, 1992, Geologic Setting of the 200 East Area: An Update, WHC-SD-EN-TI-012, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Lohman, S. W., 1972, Groundwater Hydraulics, U. S. Geological Survey Professional Paper 708, Reston, Virginia.

- Myers, C. W., S. M. Price, J. A. Caggiano, M. P. Cochran, W. J. Czimer, N. J. Davidson, R. C. Edwards, K. R. Fecht, G. E. Holmes, M. G. Jones, K. R. Kunk, R. D. Landon, R. K. Ledgerwood, J. T. Lillie, P. E. Long, T. H. Mitchell, E. H. Price, S. P. Reidel and A. M. Tallman, 1979, Geologic Studies of the Columbia Plateau: A Status Report, RHO-BWI-ST-4, Rockwell Hanford Operations, Richland, Washington.
- PNL, 1991, A Study Plan for Determining Recharge Rates at the Hanford Site Using Environmental Tracers, PNL-7626, Pacific Northwest Laboratory, Richland, Washington.
- PSPL, 1982, Skagit/Hanford Nuclear Project. Preliminary Safety Analysis Report, Vol. 4, Appendix 20, Amendment 23, Puget Sound Power and Light Company, Bellevue, Washington.
- Reidel, S. P. and K. R. Fecht, 1981, Wanapum and Saddle Mountains Basalt in the Cold Creek Syncline Area, in *Subsurface Geology of the Cold Creek Syncline*, RHO-BWI-ST-14, Rockwell Hanford Operations, Richland, Washington.
- Reidel, S. P., K. R. Fecht, M. C. Hagood, and T. L. Tolan, 1989, The Geologic Evolution of the Central Columbia Plateau, in *Volcanism and Tectonism in the Columbia River Flood-Basalt Province*, p. 247-264, Special Paper 239, Edited by S. P. Reidel and P. R. Hooper, Geological Society of America, Boulder, Colorado.
- Tallman, A. M., K. R. Fecht, M. C. Marratt and G. V. Last, 1979, Geology of the Separations Areas, Hanford Site, South-Central Washington, RHO-ST-23, Rockwell Hanford Operations, Richland, Washington.
- Thorne, P. D. and D. R. Newcomer, 1992, Summary and Evaluation of Available Hydraulic Property Data for the Hanford Site Unconfined Aquifer System, PNL-8337, Pacific Northwest Laboratory, Richland, WA.
- Tyler, D. K., 1991, A Methodology for Assessing Impacts to Groundwater from Disposal of Liquid Effluents to the Soil at the Hanford Site, WHC-SD-EN-EV-008, Westinghouse Hanford Company, Richland, Washington.
- U. S. Geological Survey (USGS), 1987, Subsurface Transport of Radionuclides in Shallow Deposits of the Hanford Nuclear Reservation, Washington -- Review of Selected Previous Work and Suggestions for Further Study, Open File Report 87-222.
- WHC, 1988, Environmental Compliance Manual, WHC-CM-7-5, Westinghouse Hanford Company, Richland, Washington.
- WHC, 1989, Environmental Investigations and Site Characterization Manual, WHC-CM-7-7, Westinghouse Hanford Company, Richland, Washington.

WHC, 1991, Generic Specifications -- Groundwater Monitoring Wells, WHC-S-014, Rev. 6, Westinghouse Hanford Company, Richland, Washington.

WHC, 1992, Treated Effluent Disposal Alternatives Engineering Study, WHC-SD-W049H-ES-003, Rev. 0, prepared by Bovay Northwest, Inc. for Westinghouse Hanford Company, Richland, Washington.

WHC, 1993a, Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1992, DOE-RL-93-56-1, Westinghouse Hanford Company, Richland, Washington.

WHC, 1993b, Borehole Data Package for 200 Areas Treated Effluent Disposal Basin, Project W-049H, WHC-SD-EN-DP-065, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

WHC, 1993c, Soil Chemistry Data Package for the Proposed W-049H Site, WHC-SD-EN-DP-065, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

WHC, 1993d, Quarterly Report of RCRA Groundwater Monitoring Data for the Period of January 1, 1993 Through March 31, 1993, DOE-RL-93-56-1, Westinghouse Hanford Company, Richland, Washington..

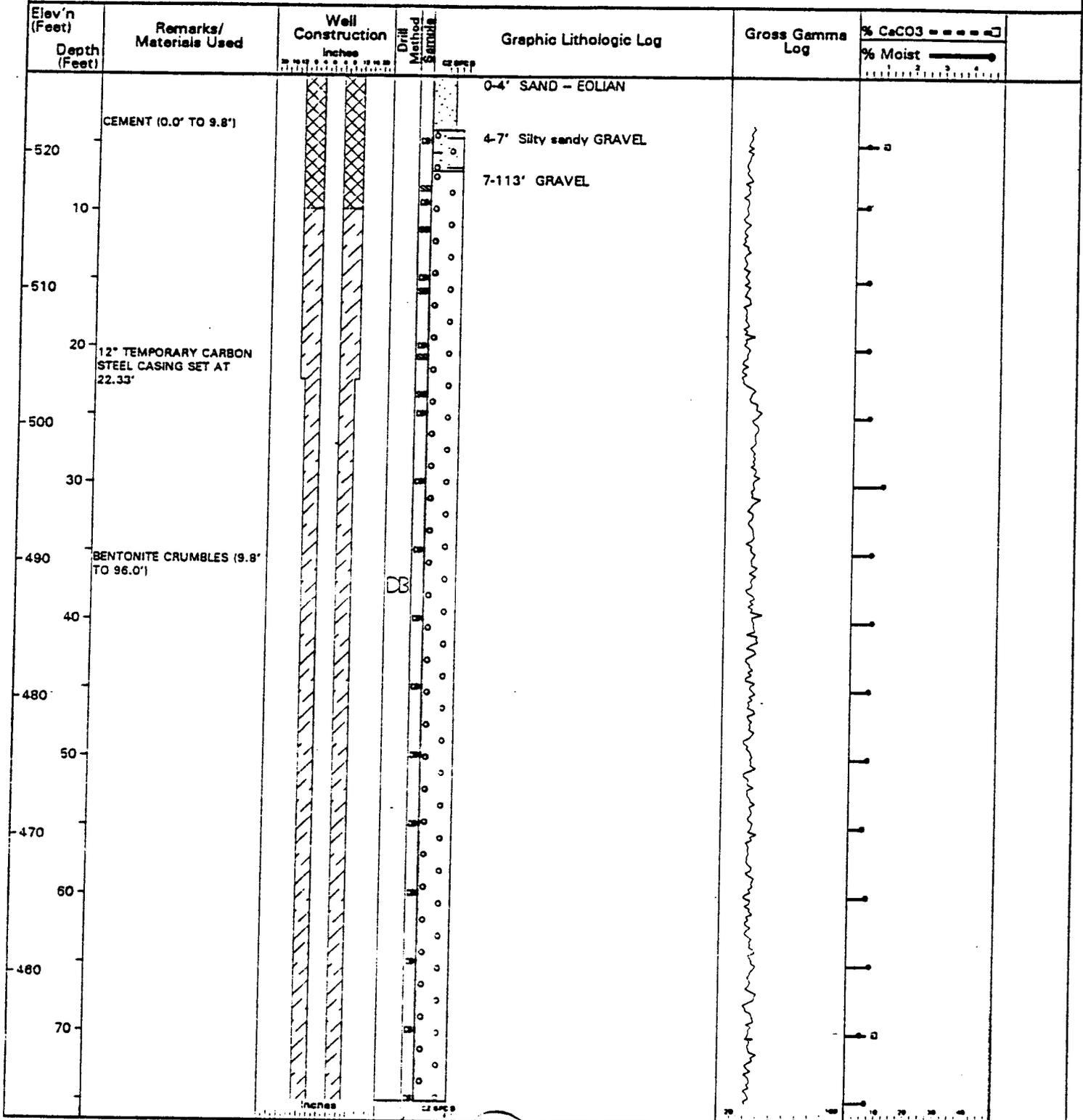
WHC, 1993e, Characterization Report, C-018H Disposal Siting Evaluation, WHC-SD-C-018H-RPT-001, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

APPENDIX A

**GEOLOGIC LOGS FOR PROJECT W-049H SITE CHARACTERIZATION
AND RCRA GROUNDWATER MONITORING WELLS**

This appendix provides, in graphical form, details of construction, lithologies, gross gamma-ray activities, CaCO₃ abundance, moisture content, and X-ray fluorescence analyses of basalt for wells 699-40-36, 699-41-35, and 699-42-37.

Project: W-017H/W049H RCRA GROUNDWATER MONITORING WELL INSTALLATION		Well No: 699-40-36		Page 1 of 4
Date Started: 8-18-92		Date Completed: 12-2-92		Total Depth: 280.00
Location: 200 AREAS TEDB CANDIDATE SITE		Surface Elevation: 525.79		Static Water Level: 115.20
Prepared By: KS SWETT/S CAUSEY		Northing: 135633.84		Casing Elevation: 528.92
Drilling Co: KEH		Driller: L WATKINS/M WRASPIR		Hanford N: 39830.00
Screen: 10.27' OF 4" DIAM 10-SLOT T-304 STAINLESS STEEL CONTINUOUS WIREWRAP W/ENDCAP SET FROM 209.24' TO 219.51'		Hanford W: 36432.00		Drill Meth: CABLE TOOL
Filter Pack: 20-40 MESH SILICA SAND FROM 203.6' TO 223.2'		Drill Equip: BE 22W		
Permanent Casing: 4" DIAMETER TYPE 304 SCHEDULE 5 STAINLESS STEEL WITH CENTRALIZERS SET TO 209.24'				
Comments: CaCO3 VALUES NOT POSTED ARE LESS THAN 1%.				

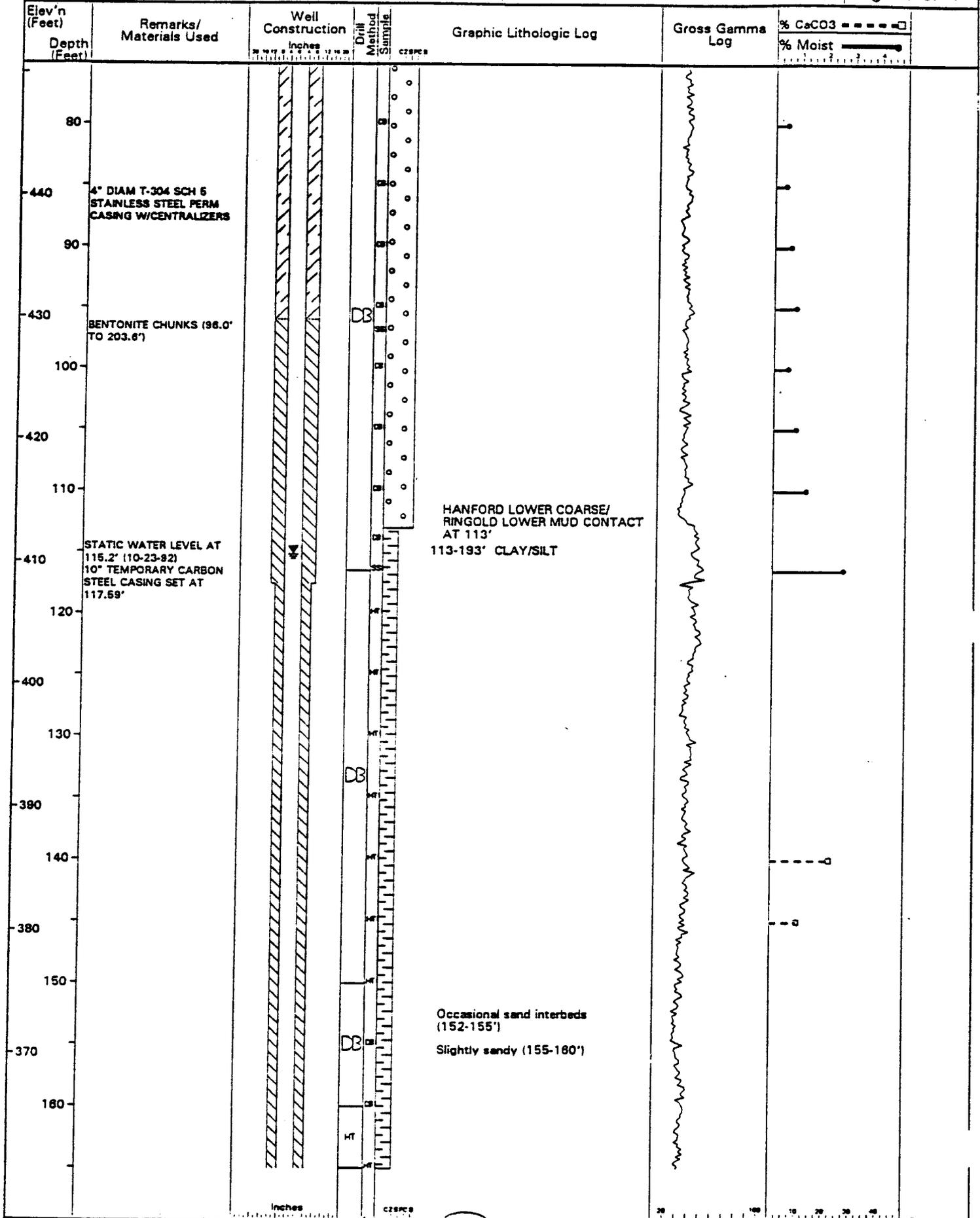


Reviewed By:

Kent D. Reynolds

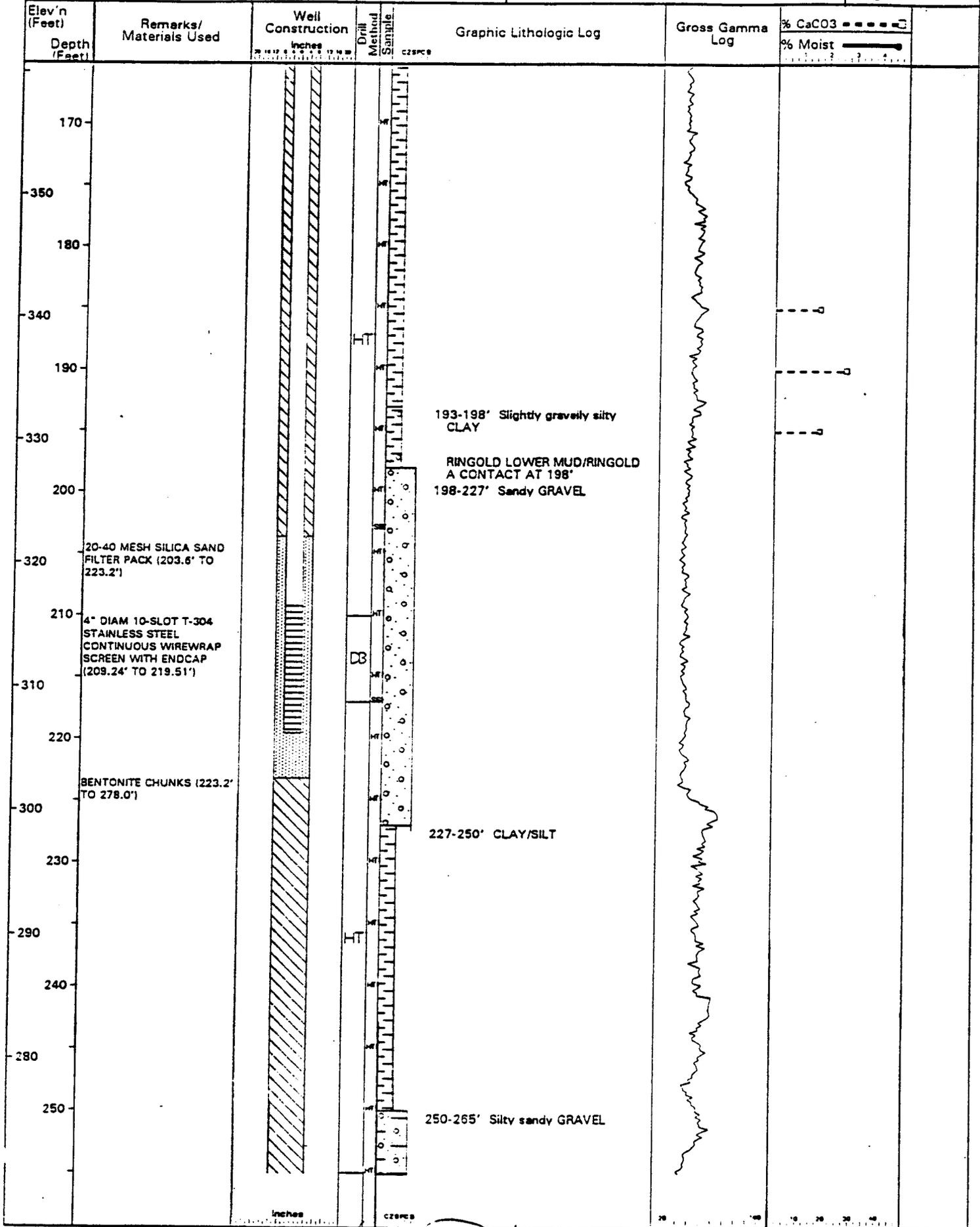
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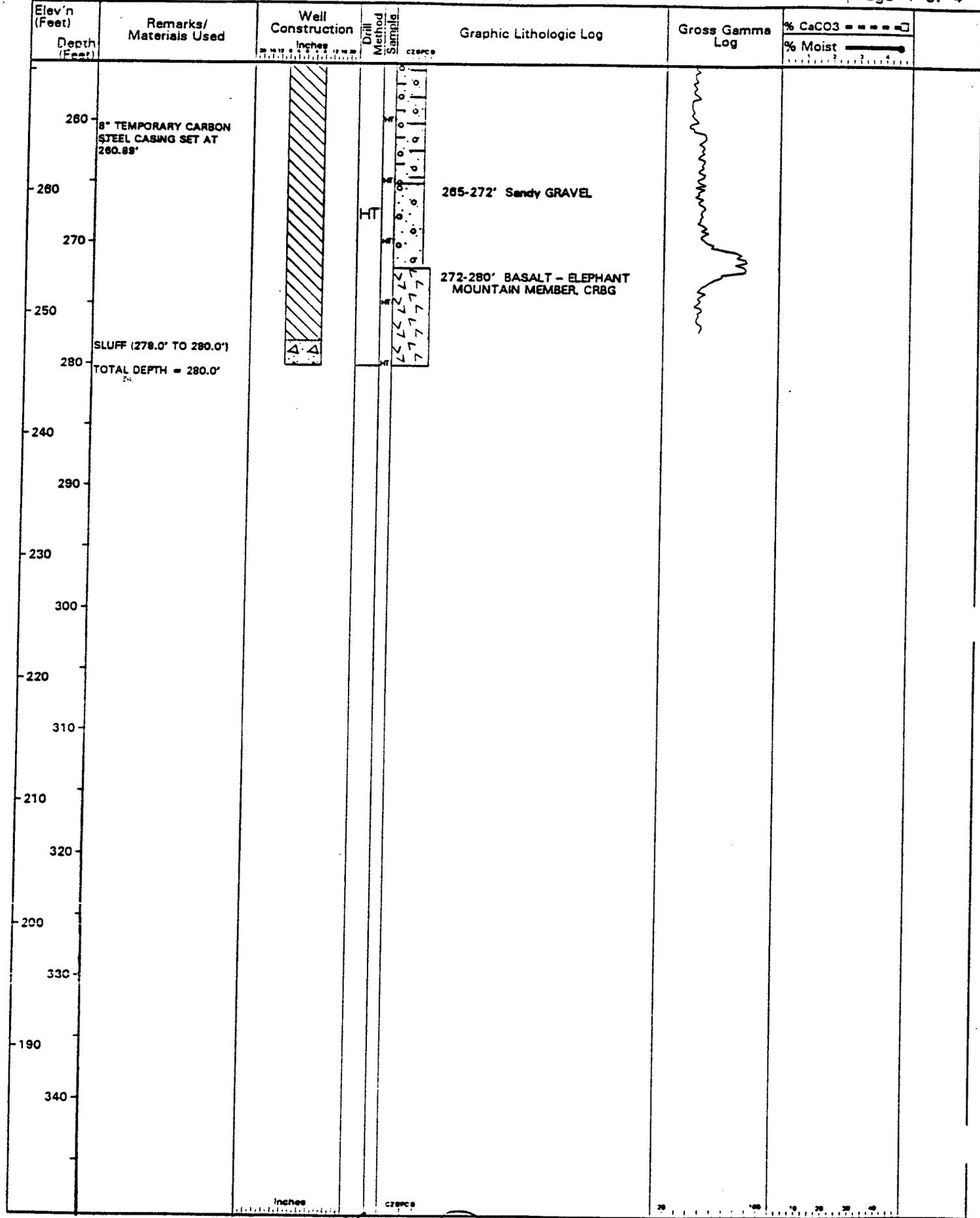
Reviewed By: Kent D. Reynolds *[Signature]*

Date: FEB. 13 1993



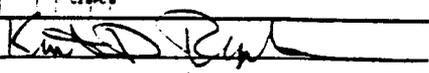
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Date: FEB 19 1993



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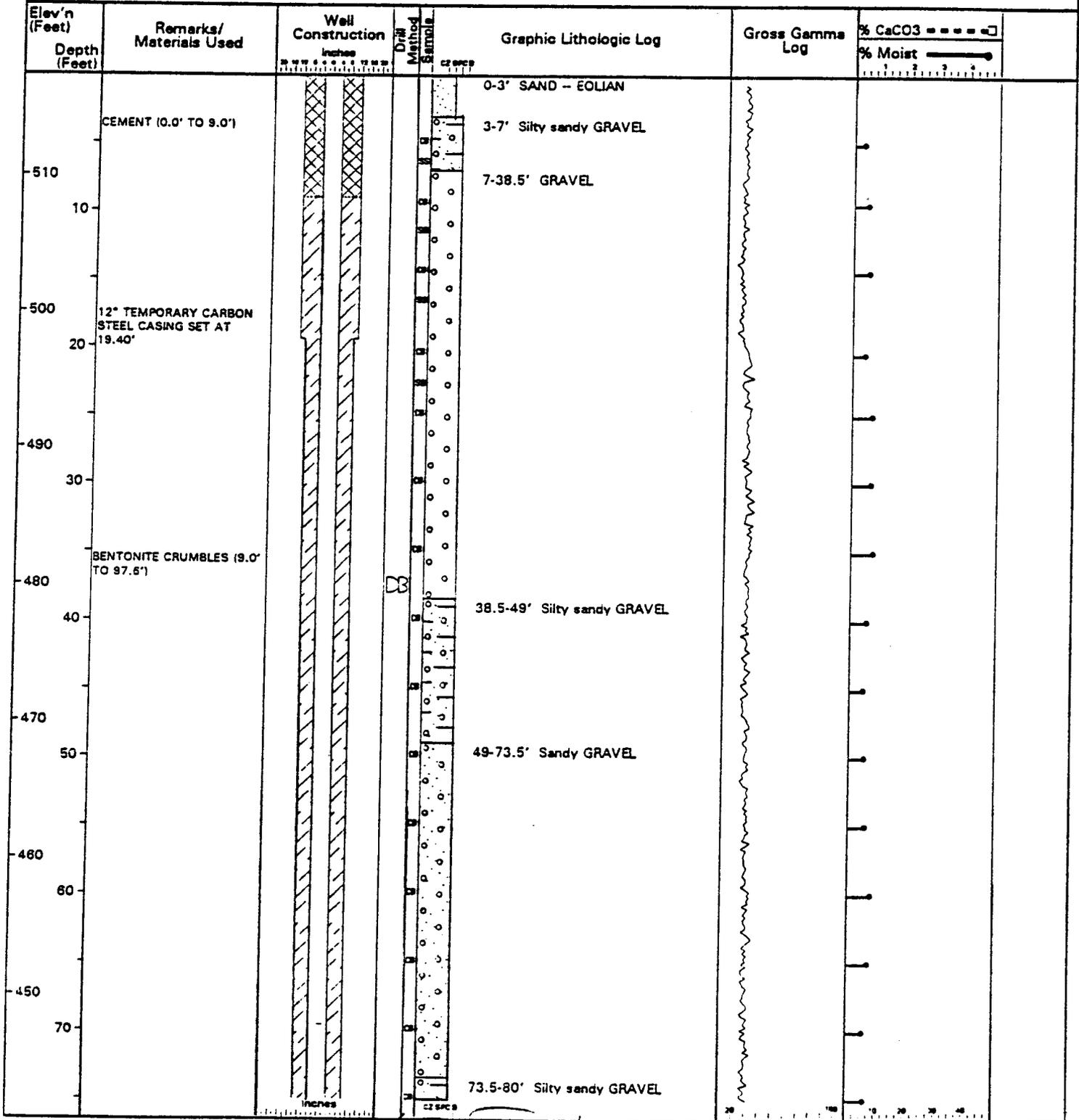
Kent D. Reynolds



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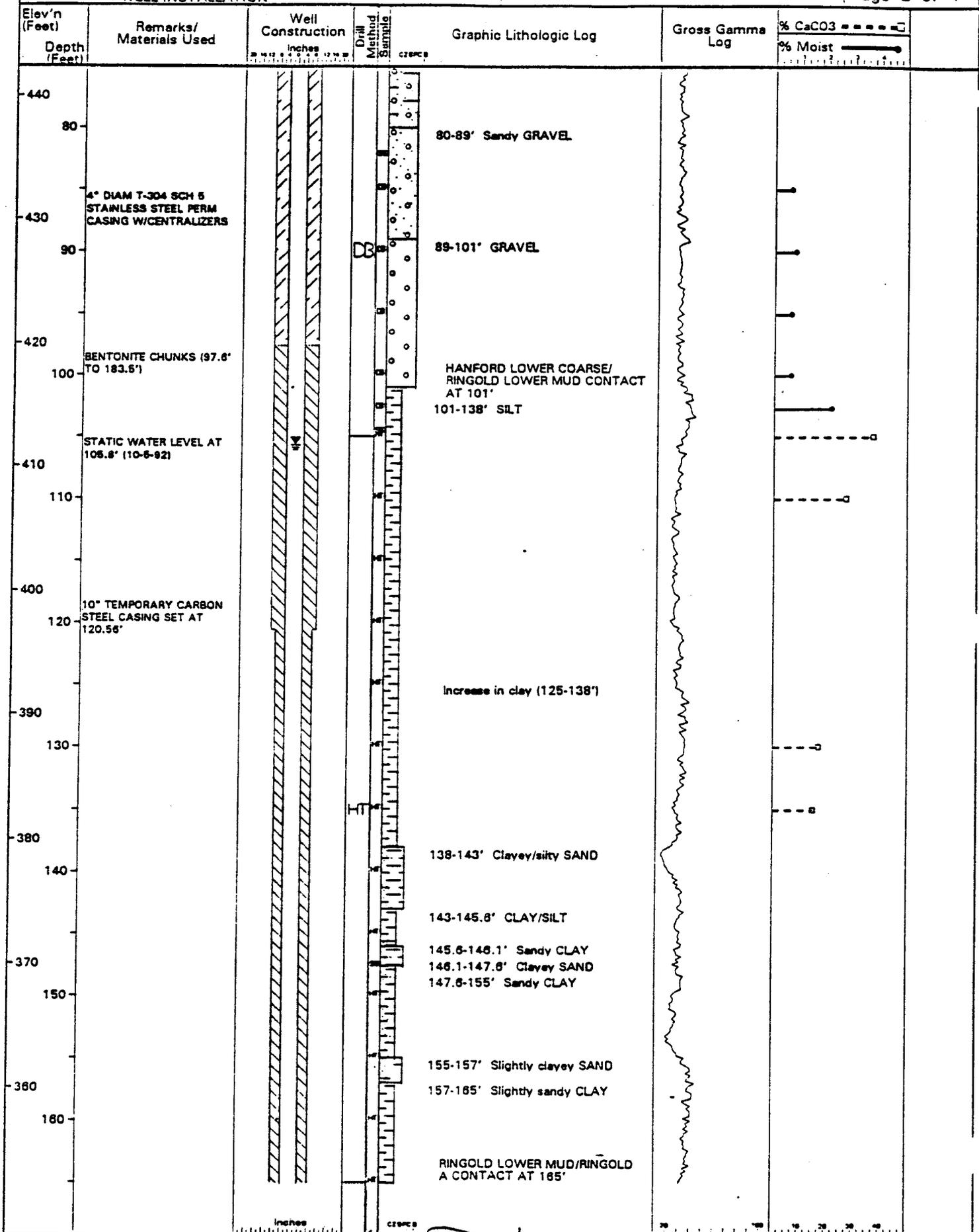
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Project: W-017H/W049H RCRA GROUNDWATER MONITORING WELL INSTALLATION		Well No: 699-41-35		Page 1 of 4	
Date Started: 8-24-92		Date Completed: 11-4-92		Total Depth: 260.00	
Location: 200 AREAS TEDB CANDIDATE SITE		Surface Elevation: 517.42		Static Water Level: 105.75	
Prepared By: KS SWETT		Northing: 135947.44		Casing Elevation: 520.38	
Drilling Co: KEH		Hanford N: 40856.00		Hanford W: 35476.00	
Driller: L WATKINS		Drill Meth: CABLE TOOL		Drill Equip: BE 22W	
Screen: 10.3' OF 4" DIAM 10-SLOT T-304 STAINLESS STEEL CONTINUOUS WIREWRAP W/ENDCAP SET FROM 189.81' TO 200.11'					
Filter Pack: 20-40 MESH SILICA SAND FROM 183.5' TO 201.9'					
Permanent Casing: 4" DIAMETER TYPE 304 SCHEDULE 5 STAINLESS STEEL WITH CENTRALIZERS SET TO 189.81'					
Comments: SPECTRA GAMMA LOG RUN 10-8-92. CaCO3 VALUES NOT POSTED ARE LESS THAN 1%.					

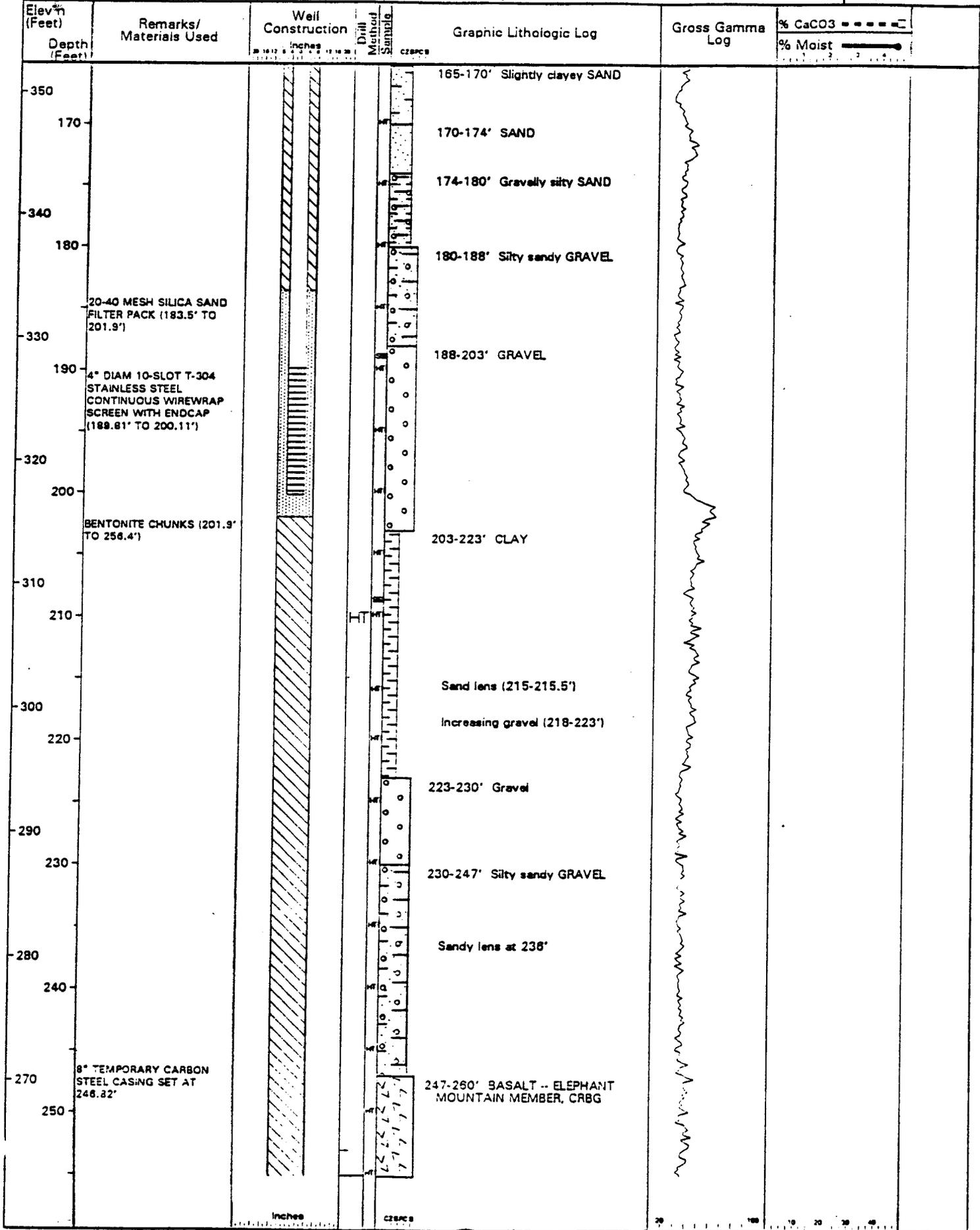


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Date: FEB. 19 1993



Reviewed By: Kent D. Reynolds Date: FEB. 19 1999



Reviewed By: Kent D. Reynolds 

Date: FEB. 19 1993

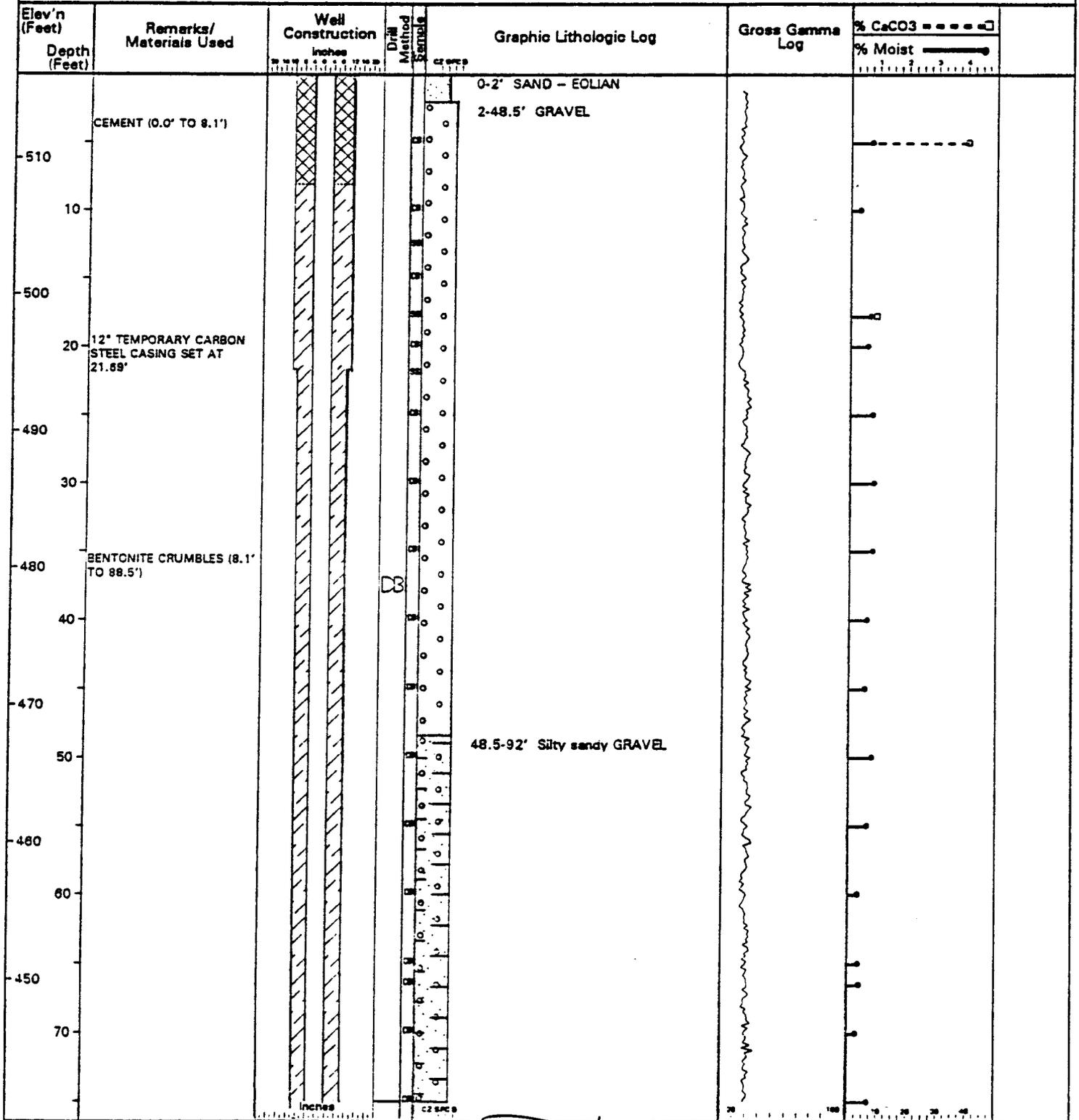
Project: W-017H/WC-49H RCRA GROUNDWATER MONITORING WELL INSTALLATION Well No: 699-41-35 Page 4 of 4

Elev'n (Feet)	Remarks/ Materials Used	Well Construction Inches	Drill Method Casing	Graphic Lithologic Log	Gross Gamma Log	% CaCO ₃ -----	
						% Moist -----	
-280	SLUFF (256.4' TO 260.0')						
260	TOTAL DEPTH = 260.0'						
-250							
270							
-240							
280							
-230							
290							
-220							
300							
-210							
310							
-200							
320							
-190							
330							
-180							
340							

Reviewed By: Kent D. Reynolds

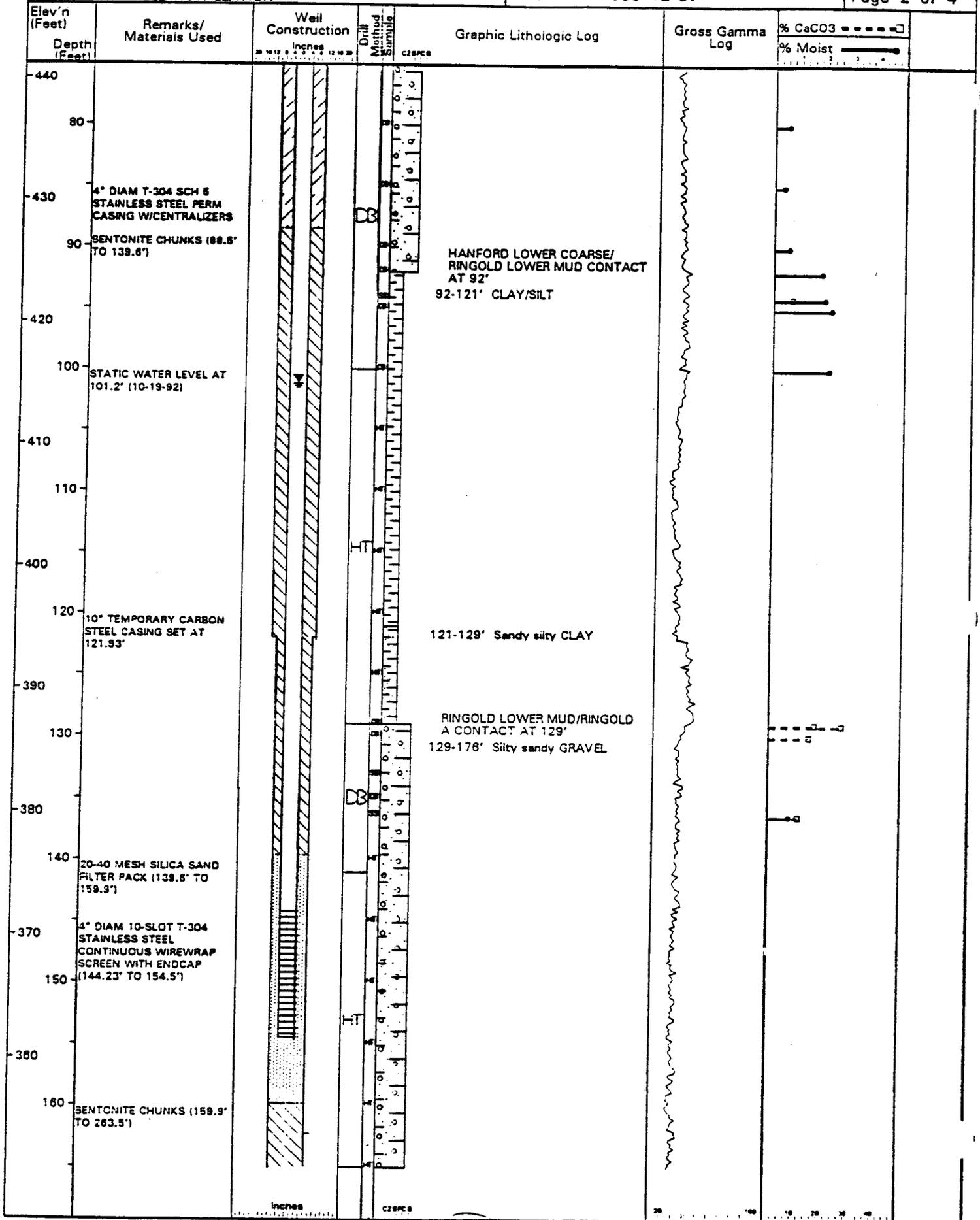
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Project: W-017H/W049H RCRA GROUNDWATER MONITORING WELL INSTALLATION		Well No: 699-42-37		Page 1 of 4
Date Started: 8-12-92		Date Completed: 11-2-92		Total Depth: 268.00
Location: 200 AREAS TEDB CANDIDATE SITE		Surface Elevation: 516.18		Static Water Level: 101.20
Prepared By: KS SWETT, et al.		Northing: 136247.24		Casing Elevation: 519.40
Drilling Co: KEH		Driller: M WRASPIR		Hanford N: 41846.00
Screen: 10.27' OF 4" DIAM 10-SLOT T-304 STAINLESS STEEL CONTINUOUS WIREWRAP W/ENDCAP SET FROM 144.23' TO 154.5'		Hanford W: 37451.00		Drill Meth: CABLE TOOL
Filter Pack: 20-40 MESH SILICA SAND FROM 139.8' TO 159.9'		Drill Equip: 8E 22W		
Permanent Casing: 4" DIAMETER TYPE 304 SCHEDULE 5 STAINLESS STEEL WITH CENTRALIZERS SET TO 144.23'				
Comments: CaCO3 VALUES NOT POSTED ARE LESS THAN 1%.				



Reviewed By: Kent D. Reynolds *[Signature]* Date: FEB. 1 1993

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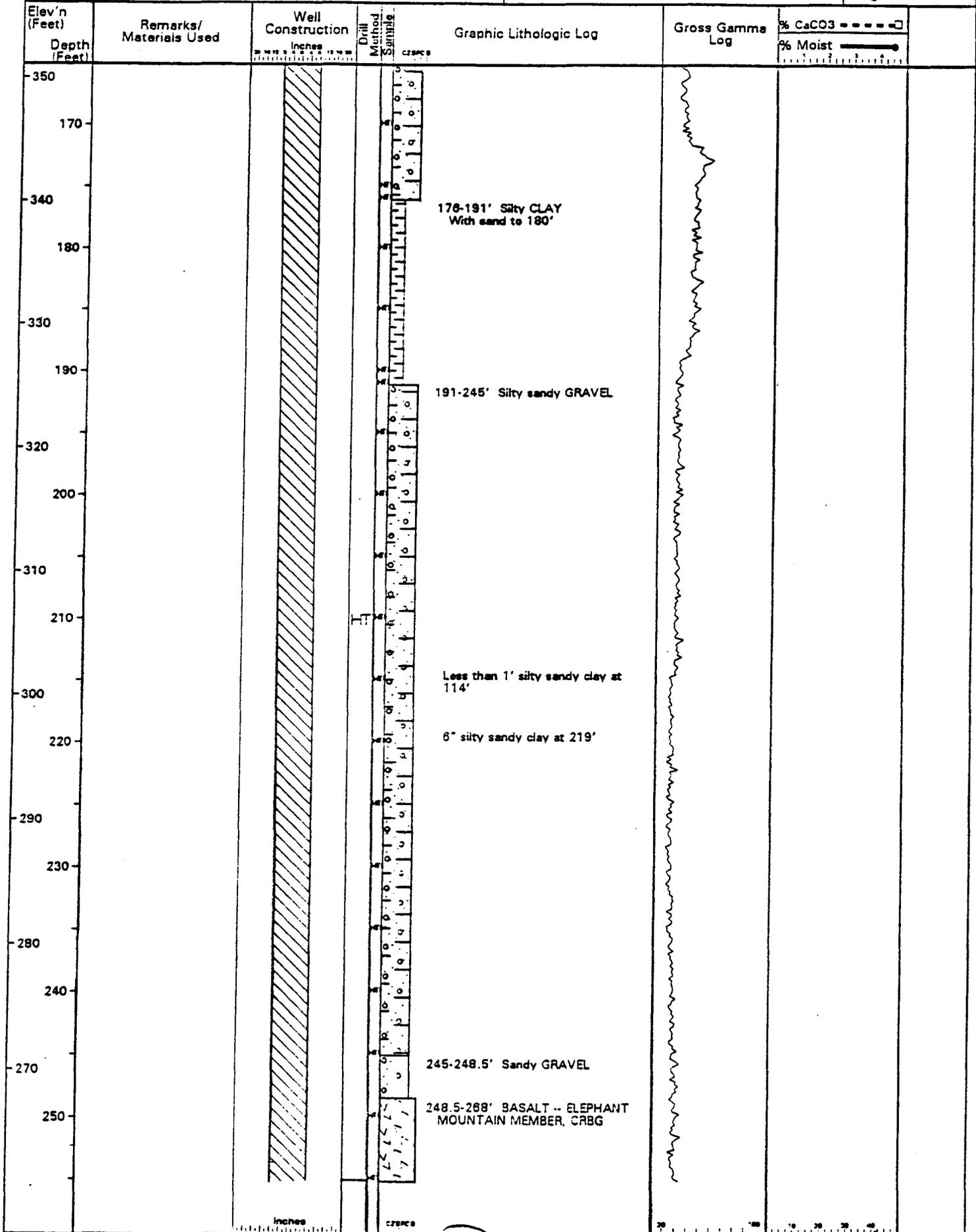


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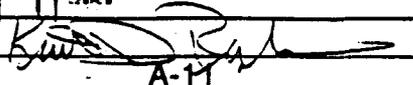
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Kent D. Reynolds



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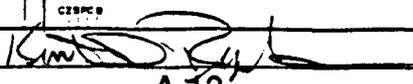
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Elev'n (Feet)	Remarks/ Materials Used	Well Construction	Drill Method	Graphic Lithologic Log	Gross Gamma Log	% CaCO3 % Moist
-260	8" TEMPORARY CARBON STEEL CASING SET AT 258.09'					
260	SLUFF (263.5' TO 268.0')					
-250	TOTAL DEPTH = 268.0'					
270						
-240						
280						
-230						
290						
-220						
300						
-210						
310						
-200						
320						
-190						
330						
-180						
340						

Reviewed By:

Kent D. Reynolds



Date:

FEB. 1 1999

**X-RAY FLUORESCENCE ANALYSES OF BASALT SAMPLES FROM
WELLS 699-40-36, 699-41-35, 699-42-37, AND 699-440-39B**

Washington State University GeoAnalytical Laboratory

Date: 30 December 1992

Analytical Method: X-ray fluorescence

Unnormalized Results -- Major Elements (Wt. %)

Oxide	Project W-049H wells				B Pond well
	699-40-36	699-41-35	699-42-37	699-42-37 ^b	699-44-39B
SiO ₂	50.03	48.85	50.82	51.11	50.89
Al ₂ O ₃	13.44	13.82	12.53	12.55	12.66
TiO ₂	3.751	3.994	3.639	3.659	3.710
FeO ^c	14.67	15.51	15.68	15.03	15.65
MnO	0.188	0.191	0.232	0.228	0.205
CaO	8.90	7.87	8.21	8.26	8.25
MgO	3.32	3.65	4.04	4.08	3.95
K ₂ O	0.83	0.70	1.14	1.15	0.71
Na ₂ O	2.39	2.40	2.28	2.30	1.97
P ₂ O ₅	0.602	0.571	0.571	0.570	0.606
Total	98.12	97.56	99.14	98.94	98.60

Normalized Results^a -- Major Elements (Wt. %)

Oxide	Project W-049H wells				B Pond well
	699-40-36	699-41-35	699-42-37	699-42-37 ^b	699-44-39B
SiO ₂	50.99	50.07	51.26	51.66	51.61
Al ₂ O ₃	13.70	14.17	12.64	12.68	12.84
TiO ₂	3.82 ^d	4.09 ^d	3.67 ^d	3.70 ^d	3.76 ^d
FeO ^c	14.95 ^d	15.90 ^d	15.82 ^d	15.19 ^d	15.87 ^d
MnO	0.192	0.196	0.234	0.230	0.208
CaO	9.07	8.07	8.28	8.35	8.37
MgO	3.38	3.74	4.07	4.12	4.01
K ₂ O	0.85	0.72	1.15	1.16	0.72
Na ₂ O	2.44	2.46	2.30	2.32	2.00
P ₂ O ₅	0.61 ^d	0.585	0.576	0.576	0.61 ^d

Trace Elements (ppm)

Element	Project W-049H wells				B Pond well
	699-40-36	699-41-35	699-42-37	699-42-37 ^b	699-44-39B
Ni	1	1	5	3	1
Cr	24	25	32	29	28
Sc	34	36	32	35	38
Y	435	441	408	428	421
Ba	448	476	532	542	528

Trace Elements (ppm) (continued)					
Element	Project W-049H wells				B Pond well
	699-40-36	699-41-35	699-42-37	699-42-37 ^b	699-44-39B
Rb	26	23	31	31	20
Sr	267	289	241	244	243
Zr	253	262	252	251	252
Y	55	60	54	54	54
Nb	28.6	27.6	28.2	28.8	29.3
Ga	23	27	26	24	24
Cu	10	27	17	13	4
Zn	157	176	152	157	152
Pb	7	8	8	7	8
La	35	31	33	31	28
Ce	76	78	79	82	72
Th	6	6	4	5	5

^a Major elements are normalized on a volatile-free basis

^b Analysis of a duplicate bead made from the same rock powder

^c Total Fe is expressed as FeO

^d Denotes values >120% of the highest standard.

APPENDIX B

SPECTRAL GAMMA-RAY SURVEY REPORT FOR BOREHOLE 699-41-35

This appendix contains the results of a spectral gamma-ray survey of borehole 699-41-35, immediately east of the proposed 200 Areas TEDB. The survey was made using a high-resolution radionuclide logging system that employs a high-purity germanium detector. The objectives of the survey were to establish a baseline response and determine the presence or absence of man-made gamma-ray emitting radionuclides.

Report Date: December 3, 1992
Project: Treated Effluent Disposal Basin Candidate Site
Borehole: 699-41-35
Survey Date: October 21, 1992
Calibration Date: November 1991
Logging Engineers: L. V. Cram, S. E. Kos
Analysts: R. K. Price, J. P. Kiesler

Summary

Well 699-41-35 was logged using a high-resolution, high-purity germanium, passive spectral gamma-ray system. The well was surveyed after the well sealing materials and permanent stainless steel casing had been installed and the temporary construction casings had been removed.

The survey was acquired continuously from the surface to 198 ft in 0.5-ft increments. The count time for each increment was 180 seconds. No man-made radionuclides were identified in the subsurface. The well may subsequently be surveyed to detect changes, if any, in the baseline subsurface conditions.

Objectives

The objectives of the survey were to establish a baseline response of the subsurface conditions and to verify results of the radiochemical analyses of samples from the same borehole.

Scope

The contents of this appendix are limited to description of the spectral gamma-ray survey, discussion of the data analysis, and presentation of the survey results. The results are shown as graphs of decay activities vs depth in the well; decay activities are reported as picocuries per gram (pCi/g) of sampled media.

Details of the equipment configuration, calibration, logging procedures, casing and water correction factors, spectra analysis software, and data management for RCRA wells are in Koizumi et al. (1991, 1992a,b) and Brodeur et al. (1991).

Discussion of the Survey Environment and Analytical Limitations

The 180-second counting time at each 0.5-ft-depth interval in the borehole permitted ~40 ft of borehole to be surveyed each day. The logging process was such that there was an overlap of ~2 ft for the intervals surveyed on consecutive days. These overlaps were at depths of 45, 81, 123, and 166 ft. Calculation of calibration factors used in data reduction depended on the calibration data and nuclear decay data for a specific radionuclide; i.e., half-lives, daughter-product branching ratios, and number of gamma-ray emissions per decay. All nuclear data were taken from Erdtmann and Soyka (1979).

The decay of radionuclides occurs randomly; the 180-second counting times used for the survey presume a steady-state decay activity for the volume sampled during the specified time interval. Differences between the areas observed under the gamma-ray spectral peaks and the activities computed for these spectra were determined to be within the uncertainties expected for the activity levels present and the measurement precision.

Variations in the relative abundance of the naturally occurring radionuclides of potassium, uranium, and thorium have commonly been used to map lithologic changes in uncased, unsealed portions of boreholes. However, because borehole 699-41-35 had been cased and its annulus sealed prior to the spectral gamma-ray survey, no attempt was made to create a detailed geophysical map of the borehole lithology.

The sediments of the Hanford formation typically contain naturally occurring uranium and thorium with activities of ~0.3-1 pCi/g and potassium with an activity of ~8-18 pCi/g. The uranium and thorium activities of the Hanford formation plus the bentonite seal that were recorded through the stainless steel casing in borehole 699-41-35 were ~2-5 pCi/g; the potassium activity of the Hanford formation plus the bentonite seal was less than 12 pCi/g. Hence, the variations in the activities measured in the borehole may be an indicator of the thickness of the sealed annulus. A trace of cesium-137 (less than 0.2 pCi/g) was detected from the surface to a depth of ~1 ft at the borehole location. Scattered traces of airborne cesium-137 at the surface of the ground in and near the 200 Areas are common.

The waterproof logging cable supporting the liquid-nitrogen-cooled down-hole detector supplied electrical power to and received voltage signals from the detector. The gamma-ray detector was fabricated specifically for the spectral gamma-ray logging system used at the Hanford Site. The detector depths recorded in the borehole are estimated to be accurate to within 98.5%, with a precision of 99%. Comparisons with drilling measurements, other logging equipment, and secondary measuring systems have verified this accuracy.

The standard logging configuration used for the survey optimized the detection of low decay activities. Using this configuration, the system was able to detect activities as low as 0.3 pCi/g for radionuclides with energies >500 keV and gamma rays emitted

during >50% of the decay events. The maximum decay activity detected by the system in this standard configuration was ~10,000 pCi/g.

Correction factors have been determined for boreholes cased with steel and for boreholes containing water. The former corrections are available for steel casing up to 0.4 in. thick. Corrections for casings of different materials and/or cumulative thicknesses that exceed 0.4 in. are not available. Other borehole conditions for which correction factors currently are not available include grout seals between multiple casings, bentonite, sand or grout behind steel casing, and drilling mud within the borehole. For these conditions, the decay activities of man-made radionuclides are known to be underestimated.

The calibration data were recorded with the detector centered in calibration zones that were known to be of uniform density and to have a homogeneous water content and gamma-ray source. The dimensions of each calibration zone were sufficiently large that the detector responded as if it were surrounded by a medium of infinite extent. Consequently, use of the calibration results to calculate the logged radionuclide activity incorporates the same response configuration. However, most sources are actually inhomogeneous. These inhomogeneities are reflected by fluctuations in the amplitudes of the spectra on the log.

Results

The findings of the survey are summarized by the pages that follow. Logging information pertinent to results of the down-hole spectral gamma-ray survey is provided by the Log Header sheet. The spectral gamma-ray log is the last two pages of the appendix.

References

- Brodeur, J. R., C. J. Koizumi, W. H. Ulbricht, and R. K. Price, 1991, Calibration of a High-Resolution Passive Gamma-Ray Logging System for Nuclear Waste Assessment, WHC-SA-1175-FP, Westinghouse Hanford Company, Richland, Washington.
- Erdtmann, G. and W. Soyka, 1979, Die Gamma-Linien der Radionuklide (The Gamma Rays of the Radionuclides), Verlag Chemie GMBh, Weinheim, Deutschland.
- Koizumi, C. J., J. R. Brodeur, W. H. Ulbricht, and R. K. Price, 1991, Calibration of the RLS HPGe Spectral Gamma Ray Logging System. WHC-EP-0464, Westinghouse Hanford Company, Richland, Washington.
- Koizumi, C. J., R. K. Price, and R. D. Wilson, 1992a, Calibration of the RLS System for 200 Aggregate Area Management Study Screening Measurements, WHC-SD-EN-TRP-001, Westinghouse Hanford Company, Richland, Washington.

Koizumi, C. J., R. K. Price, and R. D. Wilson, 1992b, Gamma-Ray Logging Results for the 200 Aggregate Area Management Study, WHC-SD-EN-TI-021, Westinghouse Hanford Company, Richland, Washington.

WELL 699-41-35 -- TREATED EFFLUENT DISPOSAL BASIN SITE**Casing**

Depth: 260 ft
Size: 4 in.
Thickness: 0.188 in.

Water Table

Depth: 107.9 ft

Survey Intervals (ft)

<u>Depth:</u>	<u>Date Surveyed:</u>
0-46	10/08/92
44-82	10/09/92
80-124	10/19/92
123-166	10/20/92
165-198	10/21/92

General Notes

No man-made radionuclides were identified below 1 ft. The plots for potassium, uranium, and thorium show that the calculated potassium decay activities vary between about 2 and 10 pCi/g over the logged interval; the uranium and thorium decay activities are less than 5 pCi/g. The computed potassium decay activity varies inversely with the uranium and thorium activities. This is not uncommon for the geology of the Hanford Site. The elevated uranium and thorium decay activity is believed to originate from the bentonite well-sealing material.

Man-Made Radionuclides

Cesium-137 was detected only at the surface, from 0 to 1 ft. The maximum activity indicated was 0.2 pCi/g. The cesium-137 activity was not plotted.

Westinghouse Hanford Company
 RLS Spectral Gamma-Ray Borehole Survey Log Header

Project: 200 Area Treated Effluent Disposal Basin Candidate Site

Borehole	<u>699-41-35</u>		
Coordinates	<u>40.857</u> N	<u>35.476</u> W	Feet (Plant 200 W)
Elevation	<u>517.</u> feet	Ground level	(Plant 200 W)

Borehole Environment Information

Borehole Fluid Depth <u>107.9</u> (Feet) from Zero (0.0) Depth Reference of Log			
Casing Size I.D. (inch)	Casing Thickness (inch)	Top Depth (feet)	Base Depth (feet)
4	0.188	0.0	260.

RLS Passive Spectral Gamma Survey Information

Logging Engineers <u>R. V. Cram</u> <u>S. E. Kos</u>					
Log Depth Reference at Zero (0.0) depth is <u>Ground Level</u>					
Log Date	Archive File Names	Log Mode, Speed	Depth Interval (feet)		
			Top	Base	Incr
Oct 08, 92	H64135\A258	MSA 180sec RT	0.	46.	0.5
Oct 09, 92	H64135\A259	MSA 180sec RT	44.	82.	0.5
Oct 19, 92	H64135\A265	MSA 180sec RT	80.	124.	0.5
Oct 20, 92	H64135\A266	MSA 180sec RT	123.	166.	0.5
Oct 21, 92	H64135\A267	MSA 180sec RT	165.	198.	0.5

MSA: Move-Stop-Acquire RT: Real Time

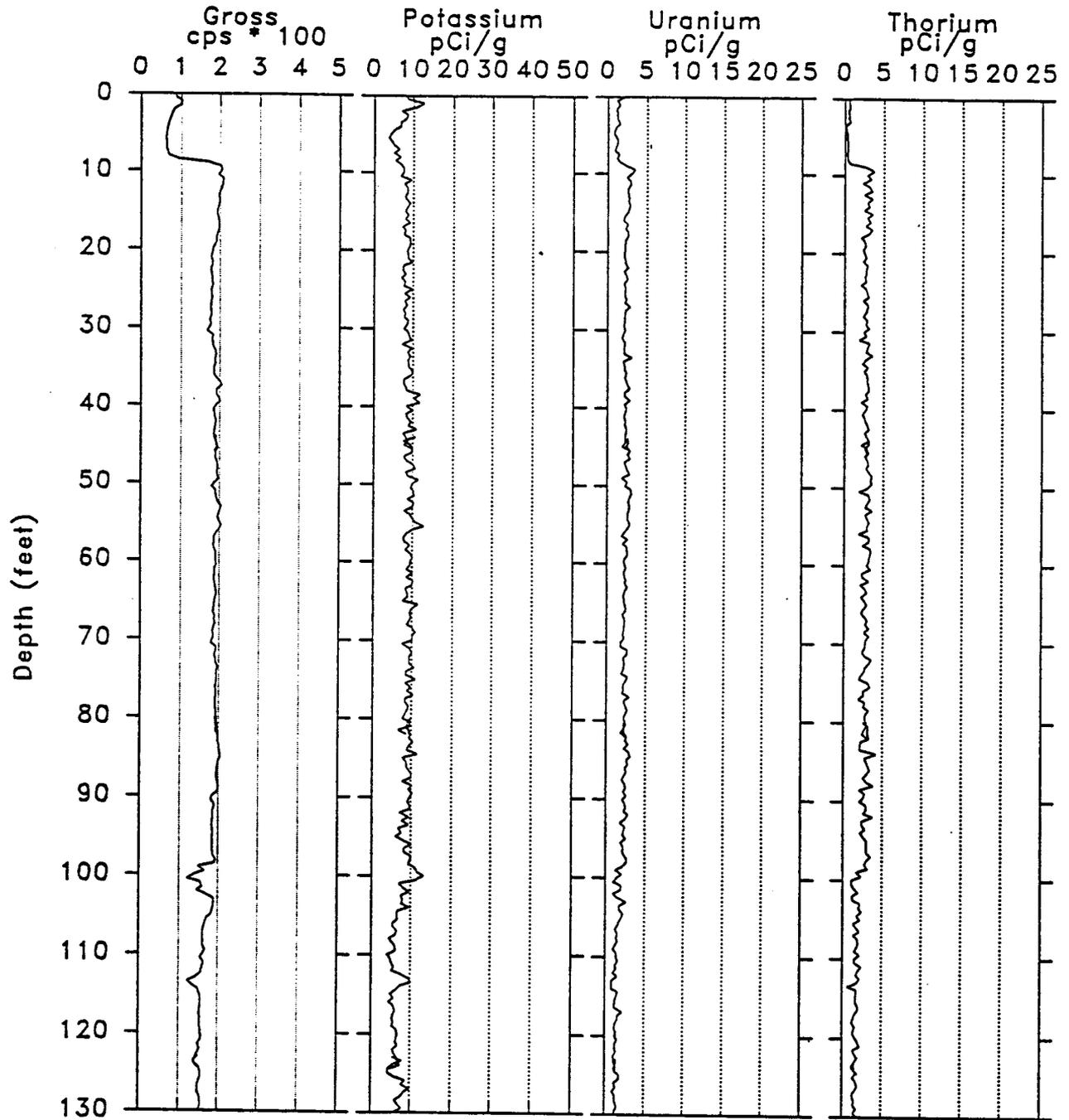
Calibration and Analysis Information

RLS Calibration Date: Nov 21, 1991
Calibration Report: WHC-SD-EN-TRP-001
Analyst Names: <u>J. P. Kiesler</u>
Analysis Date: <u>Nov 23, 1992</u>
Analysis Notes: <u>Baseline survey identified only natural rad. below 2ft</u>
Radionuclides identified: <u>Cs-137 encountered only at the surface</u>

RLS Spectral Gamma-Ray Borehole Survey

Project: TEDB Candidate Site
Borehole : 699-41-35

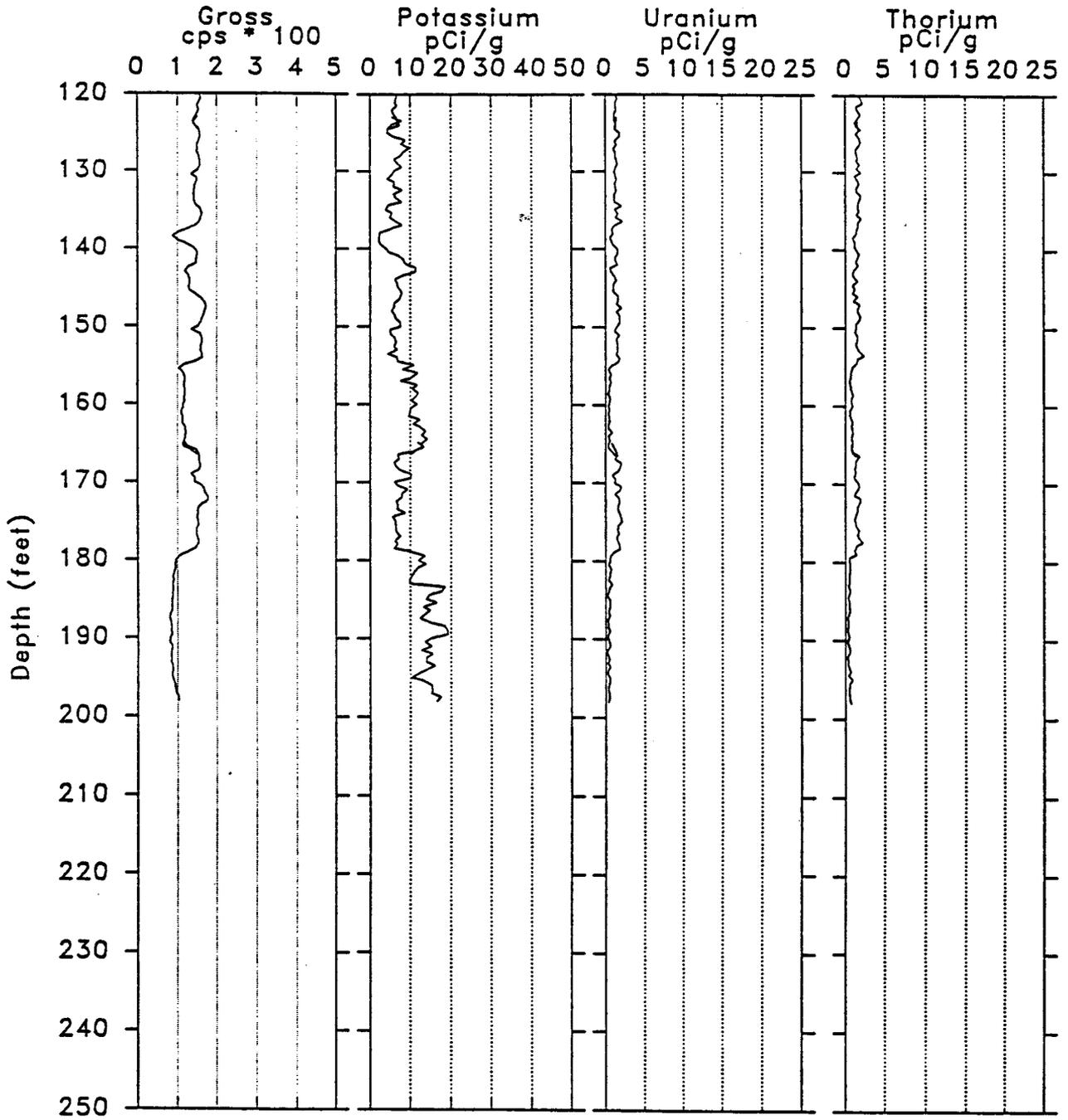
Log Date : Oct 21, 1992
Anal Date: Nov 23, 1992



RLS Spectral Gamma-Ray Borehole Survey

Project: TEDB Candidate Site
Borehole: 699-41-35

Log Date: Oct 21, 1992
Anal Date: Nov 23, 1992



APPENDIX C

RESULTS OF CHEMICAL ANALYSES OF GROUNDWATER SAMPLES

This appendix contains a complete set of the data sheets for the chemical analyses of groundwater from the uppermost aquifer in wells 699-40-36, 699-41-35, and 699-42-37. Two samples of perched water from well 699-40-36 are included. The constituents and the methods of analysis were listed in Table 4 (see Section 1.3.6).

Explanation of data qualifiers and notations:

- U = Concentration is below the indicated result**
- B = Blank associated with the analyte is contaminated**
- Y = Filtered sample**
- A = Result is associated with a laboratory audit finding*.**

* Refer to WHC (1993a,b)

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Well	Constituent Name	Sample Date	Sample Number	Result	Qualifiers	Units	
699-40-36	1,1,1-Trichloroethane	2/22/93	B08717	.50	U	ppb	
	1,1,2-Trichloroethane	2/22/93	B08717	.50	U	ppb	
	1,1-Dichloroethane	2/22/93	B08717	1.00	U	ppb	
	1,2-Dichloroethane	2/22/93	B08717	.50	U	ppb	
	1,4-Dichlorobenzene	2/22/93	B08717	2.00	U	ppb	
	2-Methylphenol		12/21/92	B07TB1	10.00	U	ppb
			2/22/93	B08717	10.00	U	ppb
	4,4'-DDD		12/21/92	B07TB1	.10	U	ppb
			2/22/93	B08717	.10	U	ppb
	4,4'-DDE		12/21/92	B07TB1	.05	U	ppb
			2/22/93	B08717	.05	U	ppb
	4,4'-DDT		12/21/92	B07TB1	.10	U	ppb
			2/22/93	B08717	.10	U	ppb
	4-Methylphenol		12/21/92	B07TB1	10.00	U	ppb
			2/22/93	B08717	10.00	U	ppb
	Aldrin		12/21/92	B07TB1	.05	U	ppb
2/22/93			B08717	.05	U	ppb	
Alpha-BHC		12/21/92	B07TB1	.05	U	ppb	
		2/22/93	B08717	.05	U	ppb	
Ammonium ion		12/21/92	B07TB1	100.00	U	ppb	
		2/22/93	B08717	100.00	U	ppb	

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Well	Constituent Name	Sample Date	Sample Number		Result	Qualifiers	Units	
699-40-36	Antimony	12/21/92	B07T81		200.00	U	ppb	
		2/22/93	B08717		200.00	U	ppb	
	Antimony, Filtered	12/21/92	B07T88	Y	200.00	U	ppb	
		2/22/93	B08721	Y	200.00	U	ppb	
	Arsenic	12/21/92	B07T81		5.00	U	ppb	
		2/22/93	B08717		5.00	U	ppb	
	Arsenic, Filtered	12/21/92	B07T88	Y	5.00	U	ppb	
		2/22/93	B08721	Y	5.00	U	ppb	
	Barium	12/21/92	B07T81		80.00		ppb	
		2/22/93	B08717		80.00		ppb	
	Barium, Filtered	12/21/92	B07T88	Y	80.00		ppb	
		2/22/93	B08721	Y	80.00		ppb	
	Benzene		2/22/93	B08717		2.00	U	ppb
	Beryllium	12/21/92	B07T81		3.00	U	ppb	
		2/22/93	B08717		3.00	U	ppb	
	Beryllium, Filtered	12/21/92	B07T88	Y	3.00	U	ppb	
		2/22/93	B08721	Y	3.00	U	ppb	
	Beta-BHC	12/21/92	B07T81		.05	U	ppb	
2/22/93		B08717		.05	U	ppb		
Bromide	12/21/92	B07T81		500.00	U	ppb		
	2/22/93	B08717		500.00	U	ppb		

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Well	Constituent Name	Sample Date	Sample Number		Result	Qualifiers	Units
699-40-36	Cadmium	12/21/92	B07TB1		10.00	U	ppb
		2/22/93	B08717		10.00	U	ppb
	Cadmium, Filtered	12/21/92	B07TB8	Y	10.00	U	ppb
		2/22/93	B08721	Y	10.00	U	ppb
	Calcium	12/21/92	B07TB1		15000.00		ppb
		2/22/93	B08717		15000.00		ppb
	Calcium, Filtered	12/21/92	B07TB8	Y	15000.00		ppb
		2/22/93	B08721	Y	17000.00		ppb
	Carbon tetrachloride	2/22/93	B08717		1.00	U	ppb
	Chlordane	12/21/92	B07TB1		.10	U	ppb
		2/22/93	B08717		.10	U	ppb
	Chloride	12/21/92	B07TB1		3100.00		ppb
		2/22/93	B08717		3400.00		ppb
	Chloroform	2/22/93	B08717		.50	U	ppb
	Chromium	12/21/92	B07TB1		30.00		ppb
		2/22/93	B08717		30.00		ppb
	Chromium, Filtered	12/21/92	B07TB8	Y	20.00	U	ppb
		2/22/93	B08721	Y	20.00	U	ppb
	Cobalt	12/21/92	B07TB1		20.00	U	ppb
		2/22/93	B08717		20.00	U	ppb
	Cobalt, filtered	12/21/92	B07TB8	Y	20.00	U	ppb
		2/22/93	B08721	Y	20.00	U	ppb

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Well	Constituent Name	Sample Date	Sample Number		Result	Qualifiers	Units
699-40-36	Coliforms	2/22/93	B08717		1.00	U	COL
	Copper	12/21/92	B07TB1		20.00	U	ppb
		2/22/93	B08717		20.00	U	ppb
	Copper, Filtered	12/21/92	B07TB8	Y	20.00	U	ppb
		2/22/93	B08721	Y	20.00	U	ppb
	Cyanide	12/21/92	B07TB1		20.00	U	ppb
		2/22/93	B08717		20.00	U	ppb
		12/21/92	B07TB1		20.00	U	ppb
	Decane	12/21/92	B07TB1		10.00	U	ppb
		2/22/93	B08717		10.00	U	ppb
	Delta-BHC	12/21/92	B07TB1		.10	U	ppb
		2/22/93	B08717		.10	U	ppb
	Dieldrin	12/21/92	B07TB1		.05	U	ppb
		2/22/93	B08717		.05	U	ppb
	Dodecane	12/21/92	B07TB1		10.00	U	ppb
		2/22/93	B08717		10.00	U	ppb
	Endosulfan I	12/21/92	B07TB1		.10	U	ppb
		2/22/93	B08717		.10	U	ppb
	Endosulfan II	12/21/92	B07TB1		.05	U	ppb
		2/22/93	B08717		.05	U	ppb
	Endosulfan sulfate	12/21/92	B07TB1		.50	U	ppb
		2/22/93	B08717		.50	U	ppb

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Well	Constituent Name	Sample Date	Sample Number	Result	Qualifiers	Units
699-40-36	Endrin	12/21/92	B07TB1	.10	U	ppb
		2/22/93	B08717	.10	U	ppb
	Endrin Aldehyde	12/21/92	B07TB1	.20	U	ppb
		2/22/93	B08717	.20	U	ppb
	Ethylbenzene	2/22/93	B08717	2.00	U	ppb
	Fluoride	12/21/92	B07TB1	900.00		ppb
		2/22/93	B08717	900.00		ppb
	Gross alpha	12/21/92	B07TB1	4.44		pCi/L
		2/22/93	B08717	1.47		pCi/L
	Gross beta	12/21/92	B07TB1	8.24		pCi/L
		2/22/93	B08717	8.77		pCi/L
	Heptachlor	12/21/92	B07TB1	.05	U	ppb
		2/22/93	B08717	.05	U	ppb
	Heptachlor epoxide	12/21/92	B07TB1	1.00	U	ppb
		2/22/93	B08717	1.00	U	ppb
	Hydrazine	12/21/92	B07TB1	30.00	U	ppb
		2/22/93	B08717	30.00	U	ppb
	Iodine-129, low detec	12/21/92	B07TB1	.01	U	pCi/L
Iron	12/21/92	B07TB1	550.00		ppb	
	2/22/93	B08717	580.00		ppb	
Iron, Filtered	12/21/92	B07TB8	80.00	Y	ppb	
	2/22/93	B08721	40.00	Y	ppb	

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Well	Constituent Name	Sample Date	Sample Number		Result	Qualifiers	Units
699-40-36	Lead	12/21/92	B07TB1		5.00	U	ppb
		2/22/93	B08717		5.00	U	ppb
	Lead, filtered	12/21/92	B07TB8	Y	5.00	U	ppb
		2/22/93	B08721	Y	5.00	U	ppb
	Magnesium	12/21/92	B07TB1		5300.00		ppb
		2/22/93	B08717		5200.00		ppb
	Magnesium, Filtered	12/21/92	B07TB8	Y	5300.00		ppb
		2/22/93	B08721	Y	5800.00		ppb
	Manganese	12/21/92	B07TB1		120.00		ppb
		2/22/93	B08717		170.00		ppb
	Manganese, Filtered	12/21/92	B07TB8	Y	110.00		ppb
		2/22/93	B08721	Y	150.00		ppb
	Mercury	12/21/92	B07TB1		.20	U	ppb
		2/22/93	B08717		.20	U	ppb
	Mercury, filtered	12/21/92	B07TB8	Y	.20	U	ppb
		2/22/93	B08721	Y	.20	U	ppb
	Methoxychlor	12/21/92	B07TB1		2.00	U	ppb
		2/22/93	B08717		2.00	U	ppb
Methylene chloride	2/22/93	B08717		5.00	U	ppb	
Naphthalene	12/21/92	B07TB1		10.00	U	ppb	
	2/22/93	B08717		10.00	U	ppb	

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Well	Constituent Name	Sample Date	Sample Number		Result	Qualifiers	Units
699-40-36	Nickel	12/21/92	B07TB1		30.00	U	ppb
		2/22/93	B08717		30.00	U	ppb
	Nickel, Filtered	12/21/92	B07TB8	Y	30.00	U	ppb
		2/22/93	B08721	Y	30.00	U	ppb
	Nitrate	12/21/92	B07TB1		200.00	U	ppb
		2/22/93	B08717		200.00	U	ppb
	Nitrite	12/21/92	B07TB1		200.00	U	ppb
		2/22/93	B08717		200.00	U	ppb
	Pentachlorophenol	12/21/92	B07TB1		50.00	U	ppb
		2/22/93	B08717		50.00	U	ppb
	Phenol	12/21/92	B07TB1		10.00	U	ppb
		2/22/93	B08717		10.00	U	ppb
	Phosphate	12/21/92	B07TB1		400.00	U	ppb
		2/22/93	B08717		400.00	U	ppb
	Potassium	12/21/92	B07TB1		7100.00		ppb
		2/22/93	B08717		7700.00		ppb
	Potassium, Filtered	12/21/92	B07TB8	Y	7400.00		ppb
		2/22/93	B08721	Y	8800.00		ppb
	Selenium	12/21/92	B07TB1		10.00	U	ppb
		2/22/93	B08717		10.00	U	ppb
	Selenium, Filtered	12/21/92	B07TB8	Y	10.00	U	ppb
		2/22/93	B08721	Y	10.00	U	ppb
	Silver	12/21/92	B07TB1		20.00	U	ppb

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Well	Constituent Name	Sample Date	Sample Number	Result	Qualifiers	Units
699-40-36	Silver	2/22/93	B08717	20.00	U	ppb
	Silver, Filtered	12/21/92	B07TB8	20.00	U	ppb
		2/22/93	B08721	20.00	U	ppb
	Sodium	12/21/92	B07TB1	45000.00		ppb
		2/22/93	B08717	47000.00		ppb
	Sodium, Filtered	12/21/92	B07TB8	48000.00		ppb
		2/22/93	B08721	54000.00		ppb
	Specific conductance	12/21/92	B07TB1	310.00		umhos
			B07TB3	310.00		umhos
			B07TB5	309.00		umhos
			B07TB7	308.00		umhos
		2/22/93	B08717	310.00		umhos
			B08718	312.00		umhos
			B08719	310.00		umhos
			B08720	313.00		umhos
	Sulfate	12/21/92	B07TB1	7300.00		ppb
		2/22/93	B08717	17000.00		ppb
	Temperature, field	12/21/92	B07TB1	17.80		DegC
		2/22/93	B08717	17.20		DegC
			B08718	17.20		DegC
			B08719	17.20		DegC
			B08720	17.20		DegC
	Tetrachloroethene	2/22/93	B08717	.50	U	ppb
	Tetradecane	12/21/92	B07TB1	10.00	U	ppb
		2/22/93	B08717	10.00	U	ppb
	Tin	12/21/92	B07TB1	100.00	U	ppb
		2/22/93	B08717	100.00	U	ppb

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Well	Constituent Name	Sample Date	Sample Number		Result	Qualifiers	Units
699-40-36	Tin, Filtered	12/21/92	B07T88	Y	100.00	U	ppb
		2/22/93	B08721	Y	100.00	U	ppb
	Toluene	2/22/93	B08717		2.00	U	ppb
	Total Organic Carbon	12/21/92	B07T81		1000.00	U	ppb
B07T83				1000.00	U	ppb	
B07T85				1000.00	U	ppb	
B07T87				1000.00	U	ppb	
		2/22/93	B08717		1000.00	U	ppb
B08718				1000.00	U	ppb	
B08719				1000.00	U	ppb	
B08720				1000.00	U	ppb	
	Total Organic Halogen	12/21/92	B07T81		180.00	A	ppb
B07T83				180.00	A	ppb	
B07T85				100.00	A	ppb	
B07T87				130.00	A	ppb	
		2/22/93	B08717		220.00	A	ppb
B08718				230.00	A	ppb	
B08719				230.00	A	ppb	
B08720				230.00	A	ppb	
	Toxaphene	12/21/92	B07T81		2.00	U	ppb
		2/22/93	B08717		2.00	U	ppb
	Tributyl Phosphate	12/21/92	B07T81		10.00	U	ppb
		2/22/93	B08717		10.00	U	ppb
	Trichloroethene	2/22/93	B08717		1.00	U	ppb
	Tritium	12/21/92	B07T81		26.80	U	pCi/L
		2/22/93	B08717		-86.50	U	pCi/L
	Vanadium	12/21/92	B07T81		30.00	U	ppb

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Well	Constituent Name	Sample Date	Sample Number		Result	Qualifiers	Units
699-40-36	Vanadium	2/22/93	B08717		30.00	U	ppb
	Vanadium, Filtered	12/21/92	B07T88	Y	30.00	U	ppb
		2/22/93	B08721	Y	30.00	U	ppb
	Vinyl chloride	2/22/93	B08717		2.00	U	ppb
	Xylenes (total)	2/22/93	B08717		5.00	U	ppb
	Zinc	12/21/92	B07T81		100.00		ppb
		2/22/93	B08717		690.00		ppb
	Zinc, Filtered	12/21/92	B07T88	Y	10.00		ppb
		2/22/93	B08721	Y	10.00	U	ppb
	cis-1,2-Dichloroethyl	2/22/93	B08717		1.00	U	ppb
	gamma-BHC (Lindane)	12/21/92	B07T81		.05	U	ppb
		2/22/93	B08717		.05	U	ppb
	m-Cresol	12/21/92	B07T81		10.00	U	ppb
		2/22/93	B08717		10.00	U	ppb
	pH	12/21/92	B07T81		7.92		
			B07T83		7.92		
			B07T85		7.92		
			B07T87		7.92		
		2/22/93	B08717		7.85		
			B08718		7.85		
			B08719		7.84		
			B08720		7.84		
	trans-1,2-Dichloroeth	2/22/93	B08717		1.00	U	ppb

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Well	Constituent Name	Sample Date	Sample Number	Result	Qualifiers	Units
699-41-35	1,1,1-Trichloroethane	2/22/93	B08707	.50	U	ppb
	1,1,2-Trichloroethane	2/22/93	B08707	.50	U	ppb
	1,1-Dichloroethane	2/22/93	B08707	1.00	U	ppb
	1,2-Dichloroethane	2/22/93	B08707	.50	U	ppb
	1,4-Dichlorobenzene	2/22/93	B08707	2.00	U	ppb
	2-Methylphenol	12/21/92	B07TB9	10.00	U	ppb
		2/22/93	B08707	10.00	U	ppb
	4,4'-DDD	12/21/92	B07TB9	.10	U	ppb
		2/22/93	B08707	.10	U	ppb
	4,4'-DDE	12/21/92	B07TB9	.05	U	ppb
		2/22/93	B08707	.05	U	ppb
	4,4'-DDT	12/21/92	B07TB9	.10	U	ppb
		2/22/93	B08707	.10	U	ppb
	4-Methylphenol	12/21/92	B07TB9	10.00	U	ppb
		2/22/93	B08707	10.00	U	ppb
	Aldrin	12/21/92	B07TB9	.05	U	ppb
		2/22/93	B08707	.05	U	ppb
	Alpha-BHC	12/21/92	B07TB9	.05	U	ppb
		2/22/93	B08707	.05	U	ppb
	Ammonium ion	12/21/92	B07TB9	100.00	U	ppb

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Well	Constituent Name	Sample Date	Sample Number		Result	Qualifiers	Units
699-41-35	Ammonium ion	2/22/93	B08707		100.00	U	ppb
	Antimony	12/21/92	B07TB9		200.00	U	ppb
		2/22/93	B08707		200.00	U	ppb
	Antimony, Filtered	12/21/92	B07TC3	Y	200.00	U	ppb
		2/22/93	B08711	Y	200.00	U	ppb
	Arsenic	12/21/92	B07TB9		5.00	U	ppb
		2/22/93	B08707		5.00	U	ppb
	Arsenic, Filtered	12/21/92	B07TC3	Y	5.00	U	ppb
		2/22/93	B08711	Y	5.00	U	ppb
	Barium	12/21/92	B07TB9		130.00		ppb
		2/22/93	B08707		140.00		ppb
	Barium, Filtered	12/21/92	B07TC3	Y	120.00		ppb
		2/22/93	B08711	Y	170.00		ppb
	Benzene	2/22/93	B08707		2.00	U	ppb
	Beryllium	12/21/92	B07TB9		3.00	U	ppb
		2/22/93	B08707		3.00	U	ppb
	Beryllium, Filtered	12/21/92	B07TC3	Y	3.00	U	ppb
		2/22/93	B08711	Y	3.00	U	ppb
	Beta-BHC	12/21/92	B07TB9		.05	U	ppb
		2/22/93	B08707		.05	U	ppb
	Bromide	12/21/92	B07TB9		500.00	U	ppb
		2/22/93	B08707		500.00	U	ppb

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Well	Constituent Name	Sample Date	Sample Number		Result	Qualifiers	Units
699-41-35	Cadmium	12/21/92	B07TB9		10.00	U	ppb
		2/22/93	B08707		10.00	U	ppb
	Cadmium, Filtered	12/21/92	B07TC3	Y	10.00	U	ppb
		2/22/93	B08711	Y	10.00	U	ppb
	Calcium	12/21/92	B07TB9		18000.00		ppb
		2/22/93	B08707		18000.00		ppb
	Calcium, Filtered	12/21/92	B07TC3	Y	18000.00		ppb
		2/22/93	B08711	Y	23000.00		ppb
	Carbon tetrachloride	2/22/93	B08707		1.00	U	ppb
	Chlordane	12/21/92	B07TB9		.10	U	ppb
		2/22/93	B08707		.10	U	ppb
	Chloride	12/21/92	B07TB9		3400.00		ppb
		2/22/93	B08707		3600.00		ppb
	Chloroform	2/22/93	B08707		.50	U	ppb
	Chromium	12/21/92	B07TB9		20.00	U	ppb
		2/22/93	B08707		20.00	U	ppb
	Chromium, Filtered	12/21/92	B07TC3	Y	20.00	U	ppb
		2/22/93	B08711	Y	20.00	U	ppb
Cobalt	12/21/92	B07TB9		20.00	U	ppb	
	2/22/93	B08707		20.00	U	ppb	
Cobalt, filtered	12/21/92	B07TC3	Y	20.00	U	ppb	
	2/22/93	B08711	Y	20.00	U	ppb	

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Well	Constituent Name	Sample Date	Sample Number		Result	Qualifiers	Units
699-41-35	Coliforms	2/22/93	B08707		1.00	U	COL
	Copper	12/21/92	B07T89		20.00	U	ppb
		2/22/93	B08707		20.00	U	ppb
	Copper, Filtered	12/21/92	B07TC3	Y	20.00	U	ppb
		2/22/93	B08711	Y	20.00	U	ppb
	Cyanide	12/21/92	B07T89		20.00	U	ppb
		2/22/93	B08707		20.00	U	ppb
		12/21/92	B07T89		20.00	U	ppb
	Decane	12/21/92	B07T89		10.00	U	ppb
		2/22/93	B08707		10.00	U	ppb
	Delta-BHC	12/21/92	B07T89		.10	U	ppb
		2/22/93	B08707		.10	U	ppb
	Dieldrin	12/21/92	B07T89		.05	U	ppb
		2/22/93	B08707		.05	U	ppb
	Dodecane	12/21/92	B07T89		10.00	U	ppb
		2/22/93	B08707		10.00	U	ppb
	Endosulfan I	12/21/92	B07T89		.10	U	ppb
		2/22/93	B08707		.10	U	ppb
	Endosulfan II	12/21/92	B07T89		.05	U	ppb
		2/22/93	B08707		.05	U	ppb
	Endosulfan sulfate	12/21/92	B07T89		.50	U	ppb
		2/22/93	B08707		.50	U	ppb

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699-41-35	Endrin	12/21/92	B07T89	.10	U	ppb
		2/22/93	B08707	.10	U	ppb
	Endrin Aldehyde	12/21/92	B07T89	.20	U	ppb
		2/22/93	B08707	.20	U	ppb
	Ethylbenzene	2/22/93	B08707	2.00	U	ppb
	Fluoride	12/21/92	B07T89	800.00		ppb
		2/22/93	B08707	1000.00		ppb
	Gross alpha	12/21/92	B07T89	7.40		pCi/L
		2/22/93	B08707	1.88		pCi/L
	Gross beta	12/21/92	B07T89	8.37		pCi/L
		2/22/93	B08707	4.47		pCi/L
	Heptachlor	12/21/92	B07T89	.05	U	ppb
		2/22/93	B08707	.05	U	ppb
	Heptachlor epoxide	12/21/92	B07T89	1.00	U	ppb
		2/22/93	B08707	1.00	U	ppb
	Hydrazine	12/21/92	B07T89	30.00	U	ppb
		2/22/93	B08707	30.00	U	ppb
	Iodine-129, low detec	12/21/92	B07T89	-.03	U	pCi/L
	Iron	12/21/92	B07T89	300.00		ppb
		2/22/93	B08707	270.00		ppb
	Iron, Filtered	12/21/92	B07TC3	20.00	U	ppb

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699-41-35	Iron, Filtered	2/22/93	B08711	Y	30.00		ppb
	Lead	12/21/92	B07T89		5.00	U	ppb
		2/22/93	B08707		5.00	U	ppb
	Lead, filtered	12/21/92	B07TC3	Y	5.00	U	ppb
		2/22/93	B08711	Y	5.00	U	ppb
	Magnesium	12/21/92	B07T89		6900.00		ppb
		2/22/93	B08707		6600.00		ppb
	Magnesium, Filtered	12/21/92	B07TC3	Y	6400.00		ppb
		2/22/93	B08711	Y	8300.00		ppb
	Manganese	12/21/92	B07T89		180.00		ppb
		2/22/93	B08707		150.00		ppb
	Manganese, Filtered	12/21/92	B07TC3	Y	170.00		ppb
		2/22/93	B08711	Y	170.00		ppb
	Mercury	12/21/92	B07T89		.20	U	ppb
		2/22/93	B08707		.20	U	ppb
	Mercury, filtered	12/21/92	B07TC3	Y	.20	U	ppb
		2/22/93	B08711	Y	.20	U	ppb
	Methoxychlor	12/21/92	B07T89		2.00	U	ppb
		2/22/93	B08707		2.00	U	ppb
	Methylene chloride	2/22/93	B08707		5.00	U	ppb
	Naphthalene	12/21/92	B07T89		10.00	U	ppb
		2/22/93	B08707		10.00	U	ppb

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Well	Constituent Name	Sample Date	Sample Number		Result	Qualifiers	Units
699-41-35	Nickel	12/21/92	B07T89		30.00	U	ppb
		2/22/93	B08707		30.00	U	ppb
	Nickel, Filtered	12/21/92	B07TC3	Y	30.00	U	ppb
		2/22/93	B08711	Y	30.00	U	ppb
	Nitrate	12/21/92	B07T89		500.00		ppb
		2/22/93	B08707		200.00	U	ppb
	Nitrite	12/21/92	B07T89		200.00	U	ppb
		2/22/93	B08707		200.00	U	ppb
	Pentachlorophenol	12/21/92	B07T89		50.00	U	ppb
		2/22/93	B08707		50.00	U	ppb
	Phenol	12/21/92	B07T89		10.00	U	ppb
		2/22/93	B08707		10.00	U	ppb
	Phosphate	12/21/92	B07T89		400.00	U	ppb
		2/22/93	B08707		400.00	U	ppb
	Potassium	12/21/92	B07T89		6500.00		ppb
		2/22/93	B08707		6500.00		ppb
	Potassium, Filtered	12/21/92	B07TC3	Y	5100.00		ppb
		2/22/93	B08711	Y	8000.00		ppb
	Selenium	12/21/92	B07T89		10.00	U	ppb
		2/22/93	B08707		10.00	U	ppb
	Selenium, Filtered	12/21/92	B07TC3	Y	10.00	U	ppb
		2/22/93	B08711	Y	10.00	U	ppb

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Well	Constituent Name	Sample Date	Sample Number	Result	Qualifiers	Units
699-41-35	Silver	12/21/92	B07TB9	20.00	U	ppb
		2/22/93	B08707	20.00	U	ppb
	Silver, Filtered	12/21/92	B07TC3	20.00	U	ppb
		2/22/93	B08711	20.00	U	ppb
	Sodium	12/21/92	B07TB9	47000.00		ppb
		2/22/93	B08707	45000.00		ppb
	Sodium, Filtered	12/21/92	B07TC3	39000.00		ppb
		2/22/93	B08711	53000.00		ppb
	Specific conductance	12/21/92	B07TB9	325.00		umhos
			B07TC0	323.00		umhos
			B07TC1	323.00		umhos
			B07TC2	322.00		umhos
		2/22/93	B08707	324.00		umhos
			B08708	323.00		umhos
			B08709	322.00		umhos
			B08710	321.00		umhos
	Sulfate	12/21/92	B07TB9	8500.00		ppb
		2/22/93	B08707	7500.00		ppb
	Temperature, field	12/21/92	B07TB9	17.10		DegC
		2/22/93	B08707	15.30		DegC
	Tetrachloroethene	2/22/93	B08707	.50	U	ppb
	Tetradecane	12/21/92	B07TB9	10.00	U	ppb
		2/22/93	B08707	10.00	U	ppb
	Tin	12/21/92	B07TB9	100.00	U	ppb
		2/22/93	B08707	100.00	U	ppb

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699-41-35	Tin, Filtered	12/21/92	B07TC3	Y	100.00	U	ppb
		2/22/93	B08711	Y	100.00	U	ppb
	Toluene	2/22/93	B08707		2.00	U	ppb
	Total Organic Carbon	12/21/92	B07TB9		1000.00	U	ppb
B07TC0				1000.00	U	ppb	
B07TC1				1000.00	U	ppb	
B07TC2				1000.00	U	ppb	
2/22/93		B08707		1000.00	U	ppb	
		B08708		1000.00	U	ppb	
		B08709		1000.00	U	ppb	
		B08710		1000.00	U	ppb	
	Total Organic Halogen	12/21/92	B07TB9		150.00	A	ppb
B07TC0				110.00	A	ppb	
B07TC1				110.00	A	ppb	
B07TC2				100.00	A	ppb	
2/22/93		B08707		600.00	A	ppb	
		B08708		480.00	A	ppb	
		B08709		350.00	A	ppb	
		B08710		400.00	A	ppb	
	Toxaphene	12/21/92	B07TB9		2.00	U	ppb
2/22/93		B08707		2.00	U	ppb	
	Tributyl Phosphate	12/21/92	B07TB9		10.00	U	ppb
2/22/93		B08707		10.00	U	ppb	
	Trichloroethene	2/22/93	B08707		1.00	U	ppb
	Tritium	12/21/92	B07TB9		-15.70	U	pci/L
2/22/93		B08707		-63.40	U	pci/L	
	Vanadium	12/21/92	B07TB9		30.00	U	ppb
2/22/93		B08707		30.00	U	ppb	

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699-41-35	Vanadium, Filtered	12/21/92	B07TC3	Y	30.00	U	ppb
		2/22/93	B08711	Y	30.00	U	ppb
	Vinyl chloride	2/22/93	B08707		2.00	U	ppb
	Xylenes (total)	2/22/93	B08707		5.00	U	ppb
	Zinc	12/21/92	B07TB9		20.00		ppb
		2/22/93	B08707		40.00		ppb
	Zinc, Filtered	12/21/92	B07TC3	Y	10.00	U	ppb
		2/22/93	B08711	Y	10.00	U	ppb
	cis-1,2-Dichloroethyl	2/22/93	B08707		1.00	U	ppb
	gamma-BHC (Lindane)	12/21/92	B07TB9		.05	U	ppb
		2/22/93	B08707		.05	U	ppb
	m-Cresol	12/21/92	B07TB9		10.00	U	ppb
		2/22/93	B08707		10.00	U	ppb
	pH	12/21/92	B07TB9		7.95		
			B07TC0		7.94		
			B07TC1		7.94		
			B07TC2		7.94		
		2/22/93	B08707		7.44		
B08708				7.44			
B08709				7.45			
B08710		7.46					
trans-1,2-Dichloroeth	2/22/93	B08707		1.00	U	ppb	
699-42-37	1,1,1-Trichloroethane	12/22/92	B07TC4		5.00	U	ppb

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Well	Constituent Name	Sample Date	Sample Number	Result	Qualifiers	Units
699-42-37	1,1,1-Trichloroethane	2/23/93	B08712	.50	U	ppb
	1,1,2-Trichloroethane	12/22/92	B07TC4	5.00	U	ppb
		2/23/93	B08712	.50	U	ppb
	1,1-Dichloroethane	12/22/92	B07TC4	5.00	U	ppb
		2/23/93	B08712	1.00	U	ppb
	1,2-Dichloroethane	12/22/92	B07TC4	5.00	U	ppb
		2/23/93	B08712	.50	U	ppb
	1,4-Dichlorobenzene	12/22/92	B07TC4	5.00	U	ppb
		2/23/93	B08712	2.00	U	ppb
	1-Butanol	12/22/92	B07TC4	1.00	U	ppm
	2-Methylphenol	12/22/92	B07TC4	10.00	U	ppb
		2/23/93	B08712	10.00	U	ppb
	4,4'-DDD	12/22/92	B07TC4	.10	U	ppb
		2/23/93	B08712	.10	U	ppb
	4,4'-DDE	12/22/92	B07TC4	.05	U	ppb
		2/23/93	B08712	.05	U	ppb
	4,4'-DDT	12/22/92	B07TC4	.10	U	ppb
		2/23/93	B08712	.10	U	ppb
	4-Methyl-2-pentanone	12/22/92	B07TC4	50.00	U	ppb
	4-Methylphenol	12/22/92	B07TC4	10.00	U	ppb
2/23/93		B08712	10.00	U	ppb	

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Well	Constituent Name	Sample Date	Sample Number	Result	Qualifiers	Units	
699-42-37	Acetone	12/22/92	B07TC4	100.00	U	ppb	
	Aldrin	12/22/92 2/23/93	B07TC4 B08712	.05 .05	U U	ppb ppb	
	Alpha-BHC	12/22/92 2/23/93	B07TC4 B08712	.05 .05	U U	ppb ppb	
	Ammonium ion	12/22/92 2/23/93	B07TC4 B08712	100.00 100.00	U U	ppb ppb	
	Antimony	12/22/92 2/23/93	B07TC4 B08712	200.00 200.00	U U	ppb ppb	
	Antimony, Filtered	12/22/92 2/23/93	B07TC8 B08716	Y Y	200.00 200.00	U U	ppb ppb
	Arsenic	12/22/92 2/23/93	B07TC4 B08712	5.00 5.00	U U	ppb ppb	
	Arsenic, Filtered	12/22/92 2/23/93	B07TC8 B08716	Y Y	5.00 5.00	U U	ppb ppb
	Barium	12/22/92 2/23/93	B07TC4 B08712	70.00 70.00		ppb ppb	
	Barium, Filtered	12/22/92 2/23/93	B07TC8 B08716	Y Y	60.00 70.00		ppb ppb
	Benzene	12/22/92 2/23/93	B07TC4 B08712	5.00 2.00	U U	ppb ppb	
	Beryllium	12/22/92 2/23/93	B07TC4 B08712	3.00 3.00	U U	ppb ppb	

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699-42-37	Beryllium, Filtered	12/22/92	B07TC8	Y	3.00	U	ppb
		2/23/93	B08716	Y	3.00	U	ppb
	Beta-BHC	12/22/92	B07TC4		.05	U	ppb
		2/23/93	B08712		.05	U	ppb
	Bromide	12/22/92	B07TC4		500.00	U	ppb
		2/23/93	B08712		500.00	U	ppb
	Cadmium	12/22/92	B07TC4		10.00	U	ppb
		2/23/93	B08712		10.00	U	ppb
	Cadmium, Filtered	12/22/92	B07TC8	Y	10.00	U	ppb
		2/23/93	B08716	Y	10.00	U	ppb
	Calcium	12/22/92	B07TC4		23000.00		ppb
		2/23/93	B08712		24000.00		ppb
	Calcium, Filtered	12/22/92	B07TC8	Y	23000.00		ppb
		2/23/93	B08716	Y	25000.00		ppb
	Carbon tetrachloride	12/22/92	B07TC4		5.00	U	ppb
		2/23/93	B08712		1.00	U	ppb
	Chlordane	12/22/92	B07TC4		.10	U	ppb
		2/23/93	B08712		.10	U	ppb
	Chloride	12/22/92	B07TC4		7800.00		ppb
		2/23/93	B08712		7900.00		ppb
	Chloroform	12/22/92	B07TC4		5.00	U	ppb
		2/23/93	B08712		.50	U	ppb

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Well	Constituent Name	Sample Date	Sample Number		Result	Qualifiers	Units
699-42-37	Chromium	12/22/92	B07TC4		30.00		ppb
		2/23/93	B08712		50.00		ppb
	Chromium, Filtered	12/22/92	B07TC8	Y	20.00	U	ppb
		2/23/93	B08716	Y	20.00	U	ppb
	Cobalt	12/22/92	B07TC4		20.00	U	ppb
		2/23/93	B08712		20.00	U	ppb
	Cobalt, filtered	12/22/92	B07TC8	Y	20.00	U	ppb
		2/23/93	B08716	Y	20.00	U	ppb
	Coliforms	2/23/93	B08712		1.00	U	COL
	Copper	12/22/92	B07TC4		20.00	U	ppb
		2/23/93	B08712		20.00	U	ppb
	Copper, Filtered	12/22/92	B07TC8	Y	20.00	U	ppb
		2/23/93	B08716	Y	20.00	U	ppb
	Cyanide	12/22/92	B07TC4		20.00	U	ppb
		2/23/93	B08712		20.00	U	ppb
	Decane	12/22/92	B07TC4		10.00	U	ppb
		2/23/93	B08712		10.00	U	ppb
	Delta-BHC	12/22/92	B07TC4		.10	U	ppb
		2/23/93	B08712		.10	U	ppb
	Dieldrin	12/22/92	B07TC4		.05	U	ppb
		2/23/93	B08712		.05	U	ppb
	Dodecane	12/22/92	B07TC4		10.00	U	ppb

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Well	Constituent Name	Sample Date	Sample Number	Result	Qualifiers	Units
699-42-37	Dodecane	2/23/93	B08712	10.00	U	ppb
	Endosulfan I	12/22/92	B07TC4	.10	U	ppb
		2/23/93	B08712	.10	U	ppb
	Endosulfan II	12/22/92	B07TC4	.05	U	ppb
		2/23/93	B08712	.05	U	ppb
	Endosulfan sulfate	12/22/92	B07TC4	.50	U	ppb
		2/23/93	B08712	.50	U	ppb
	Endrin	12/22/92	B07TC4	.10	U	ppb
		2/23/93	B08712	.10	U	ppb
	Endrin Aldehyde	12/22/92	B07TC4	.20	U	ppb
		2/23/93	B08712	.20	U	ppb
	Ethylbenzene	2/23/93	B08712	2.00	U	ppb
	Fluoride	12/22/92	B07TC4	700.00		ppb
		2/23/93	B08712	900.00		ppb
	Gross alpha	12/22/92	B07TC4	6.09		pci/L
		2/23/93	B08712	4.03		pci/L
	Gross beta	12/22/92	B07TC4	4.32		pci/L
		2/23/93	B08712	5.23		pci/L
	Heptachlor	12/22/92	B07TC4	.05	U	ppb
		2/23/93	B08712	.05	U	ppb
	Heptachlor epoxide	12/22/92	B07TC4	1.00	U	ppb
		2/23/93	B08712	1.00	U	ppb

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Well	Constituent Name	Sample Date	Sample Number		Result	Qualifiers	Units
699-42-37	Hydrazine	12/22/92	B07TC4		30.00	U	ppb
		2/23/93	B08712		30.00	U	ppb
	Iodine-129, low detec	12/22/92	B07TC4		.43		pCi/L
	Iron	12/22/92	B07TC4		1200.00		ppb
		2/23/93	B08712		870.00		ppb
	Iron, Filtered	12/22/92	B07TC8	Y	60.00		ppb
		2/23/93	B08716	Y	40.00		ppb
	Lead	12/22/92	B07TC4		5.00	U	ppb
		2/23/93	B08712		5.00	U	ppb
	Lead, filtered	12/22/92	B07TC8	Y	5.00	U	ppb
		2/23/93	B08716	Y	5.00	U	ppb
	Magnesium	12/22/92	B07TC4		9800.00		ppb
		2/23/93	B08712		10000.00		ppb
	Magnesium, Filtered	12/22/92	B07TC8	Y	9400.00		ppb
		2/23/93	B08716	Y	10000.00		ppb
	Manganese	12/22/92	B07TC4		140.00		ppb
		2/23/93	B08712		130.00		ppb
	Manganese, Filtered	12/22/92	B07TC8	Y	120.00		ppb
		2/23/93	B08716	Y	120.00		ppb
	Mercury	12/22/92	B07TC4		.20	U	ppb
		2/23/93	B08712		.20	U	ppb
	Mercury, filtered	12/22/92	B07TC8	Y	.20	U	ppb

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Well	Constituent Name	Sample Date	Sample Number		Result	Qualifiers	Units
699-42-37	Mercury, filtered	2/23/93	B08716	Y	.20	U	ppb
	Methoxychlor	12/22/92	B07TC4		2.00	U	ppb
		2/23/93	B08712		2.00	U	ppb
	Methyl ethyl ketone	12/22/92	B07TC4		100.00	U	ppb
	Methylene chloride	12/22/92	B07TC4		5.00	U	ppb
		2/23/93	B08712		5.00	U	ppb
	Naphthalene	12/22/92	B07TC4		10.00	U	ppb
		2/23/93	B08712		10.00	U	ppb
	Nickel	12/22/92	B07TC4		30.00		ppb
		2/23/93	B08712		50.00		ppb
	Nickel, Filtered	12/22/92	B07TC8	Y	30.00	U	ppb
		2/23/93	B08716	Y	30.00	U	ppb
	Nitrate	12/22/92	B07TC4		4300.00		ppb
		2/23/93	B08712		3900.00		ppb
	Nitrite	12/22/92	B07TC4		200.00	U	ppb
		2/23/93	B08712		200.00	U	ppb
	Pentachlorophenol	12/22/92	B07TC4		50.00	U	ppb
		2/23/93	B08712		50.00	U	ppb
	Phenol	12/22/92	B07TC4		10.00	U	ppb
		2/23/93	B08712		10.00	U	ppb
	Phosphate	12/22/92	B07TC4		400.00	U	ppb
		2/23/93	B08712		400.00	U	ppb

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Well	Constituent Name	Sample Date	Sample Number		Result	Qualifiers	Units
699-42-37	Potassium	12/22/92	B07TC4		4600.00		ppb
		2/23/93	B08712		5100.00		ppb
	Potassium, Filtered	12/22/92	B07TC8	Y	4800.00		ppb
		2/23/93	B08716	Y	4600.00		ppb
	Selenium	12/22/92	B07TC4		10.00	U	ppb
		2/23/93	B08712		10.00	U	ppb
	Selenium, Filtered	12/22/92	B07TC8	Y	10.00	U	ppb
		2/23/93	B08716	Y	10.00	U	ppb
	Silver	12/22/92	B07TC4		20.00	U	ppb
		2/23/93	B08712		20.00	U	ppb
	Silver, Filtered	12/22/92	B07TC8	Y	20.00	U	ppb
		2/23/93	B08716	Y	20.00	U	ppb
	Sodium	12/22/92	B07TC4		35000.00		ppb
		2/23/93	B08712		38000.00		ppb
	Sodium, Filtered	12/22/92	B07TC8	Y	35000.00		ppb
		2/23/93	B08716	Y	40000.00		ppb
	Specific conductance	12/22/92	B07TC4		361.00		umhos
			B07TC5		360.00		umhos
			B07TC6		359.00		umhos
			B07TC7		356.00		umhos
		2/23/93	B08712		381.00		umhos
			B08713		382.00		umhos
			B08714		382.00		umhos
			B08715		382.00		umhos
	Sulfate	12/22/92	B07TC4		25000.00		ppb
		2/23/93	B08712		25000.00		ppb

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Well	Constituent Name	Sample Date	Sample Number	Result	Qualifiers	Units	
699-42-37	Temperature, field	12/22/92	B07TC4	17.30		DegC	
		2/23/93	B08712	16.50		DegC	
			B08713	16.60		DegC	
			B08714	16.60		DegC	
			B08715	16.60		DegC	
	Tetrachloroethene	12/22/92	B07TC4	5.00	U	ppb	
		2/23/93	B08712	.50	U	ppb	
	Tetradecane	12/22/92	B07TC4	10.00	U	ppb	
		2/23/93	B08712	10.00	U	ppb	
	Tetrahydrofuran	12/22/92	B07TC4	10.00	U	ppb	
	Tin	12/22/92	B07TC4	100.00	U	ppb	
		2/23/93	B08712	100.00	U	ppb	
	Tin, Filtered	12/22/92	B07TC8	Y	100.00	U	ppb
		2/23/93	B08716	Y	100.00	U	ppb
	Toluene	12/22/92	B07TC4	5.00	U	ppb	
		2/23/93	B08712	2.00	U	ppb	
	Total Organic Carbon	12/22/92	B07TC4	1000.00	U	ppb	
			B07TC5	1000.00	U	ppb	
			B07TC6	1000.00	U	ppb	
			B07TC7	1000.00	U	ppb	
2/23/93		B08712	1000.00	U	ppb		
		B08713	1000.00	U	ppb		
		B08714	1000.00	U	ppb		
		B08715	1000.00	U	ppb		
Total Organic Halogen	12/22/92	B07TC4	10.00	U A	ppb		
		B07TC5	40.00	A	ppb		
		B07TC6	20.00	A	ppb		

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Well	Constituent Name	Sample Date	Sample Number	Result	Qualifiers	Units	
699-42-37	Total Organic Halogen	12/22/92	B07TC7	20.00	B A	ppb	
		2/23/93	B08712	10.00	U A	ppb	
			B08713	10.00	A	ppb	
			B08714	20.00	A	ppb	
			B08715	10.00	U A	ppb	
	Toxaphene	12/22/92	B07TC4	2.00	U	ppb	
		2/23/93	B08712	2.00	U	ppb	
	Tributyl Phosphate	12/22/92	B07TC4	10.00	U	ppb	
		2/23/93	B08712	10.00	U	ppb	
	Trichloroethene	12/22/92	B07TC4	5.00	U	ppb	
		2/23/93	B08712	1.00	U	ppb	
	Tritium	12/22/92	B07TC4	186.00	U	pCi/L	
		2/23/93	B08712	-18.20	U	pCi/L	
	Vanadium	12/22/92	B07TC4	30.00	U	ppb	
		2/23/93	B08712	30.00	U	ppb	
	Vanadium, Filtered	12/22/92	B07TC8	Y	30.00	U	ppb
		2/23/93	B08716	Y	30.00	U	ppb
	Vinyl chloride	12/22/92	B07TC4	10.00	U	ppb	
		2/23/93	B08712	2.00	U	ppb	
	Xylenes (total)	12/22/92	B07TC4	5.00	U	ppb	
2/23/93		B08712	5.00	U	ppb		
Zinc	12/22/92	B07TC4	60.00		ppb		
	2/23/93	B08712	60.00		ppb		
Zinc, Filtered	12/22/92	B07TC8	Y	10.00	U	ppb	
	2/23/93	B08716	Y	10.00	U	ppb	

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Well	Constituent Name	Sample Date	Sample Number	Result	Qualifiers	Units	
699-42-37	cis-1,2-Dichloroethyl	2/23/93	B08712	1.00	U	ppb	
	gamma-BHC (Lindane)	12/22/92	B07TC4	.05	U	ppb	
		2/23/93	B08712	.05	U	ppb	
	m-Cresol	12/22/92	B07TC4	10.00	U	ppb	
		2/23/93	B08712	10.00	U	ppb	
	pH		12/22/92	B07TC4	8.11		
				B07TC5	8.10		
				B07TC6	8.08		
				B07TC7	8.09		
			2/23/93	B08712	8.10		
				B08713	8.10		
				B08714	8.10		
	trans-1,2-Dichloroeth	12/22/92	B07TC4	5.00	U	ppb	
2/23/93		B08712	1.00	U	ppb		

APPENDIX D

**RESULTS OF TESTS TO DETERMINE VERTICAL HYDRAULIC
CONDUCTIVITY AT THE BOTTOM OF THE PROPOSED BASIN**

This appendix describes the tests and methods of analysis to determine the hydraulic conductivity of sediments at the bottom of the proposed 200 Areas TEDB. Two infiltration tests were used to estimate vertical hydraulic conductivity of the sediments in the bottom of a trench 13 ft below the ground surface. Results are provided as graphs of flow rate vs time and as a table of results and test parameters.

Introduction

Infiltration tests were conducted at the site proposed for construction of the 200 Areas treated effluent disposal basin (TEDB) (Davis and Delaney, 1992). The proposed site for the basin is bounded by Hanford Site coordinates N40119, N41595, W35726, and W37202. Infiltration tests were conducted December 11 and 16, 1992. The two tests were used to estimate the vertical hydraulic conductivity of the sediments in the bottom of a trench 13 ft below the ground surface.

Information provided by the two tests was used to estimate the baseline infiltration capacity of sediments at the location and elevation projected to become the bottom of the infiltration basin. This information, in turn, was used to help verify the design of the proposed facility and provide information on initial conditions for use in simulating the effects on the aquifer of operating the TEDB at the site.

Testing

A trench was excavated to a depth of 4 ft in the bottom of a 9-ft deep borrow pit at Hanford Site coordinates N40669 and W378118 on December 10, 1992 (see Figure 2, Section 1.3.7 of this report). The sediments encountered in the bottom of the trench were the Hanford formation gravels that were penetrated by the three TEDB site characterization wells. After the trench was excavated, a 4-ft-diameter culvert was placed on end in the trench. A bentonite seal was placed around the outside of the bottom edge of the culvert and the annulus around the culvert was then backfilled with Hanford formation gravels.

On December 11, 1992, an initial infiltration test was conducted by adding clean, raw water through a calibrated flow-metering system (Figure D-1). The test design required that water from a tank truck be added to the culvert by pressure flow until a relatively constant head was obtained under constant-flow (Q) conditions. A constant head of 1.4 ft was maintained approximately 12 minutes into the test, but Q did not reach a steady-state condition before the water supply was depleted (Figure D-2). The discharge rate decreased from 150 gal/min to 124 gal/min over a duration of 1 hr (Figure D-3). Because the steady-state criterion for the infiltration test was not met, a second test was conducted.

The diameter of the infiltration surface was reduced on December 15, 1992 by installing a 20-in-diameter (~51 cm) casing inside the original 4-ft-diameter (~1.2 m) casing. A bentonite seal was placed around the outside of the bottom edge of this casing and the annulus between the two casings was then backfilled with sand. The smaller casing extended the duration of the test by reducing the volume of water per unit time that needed to be discharged to the casing to achieve steady-state Q.

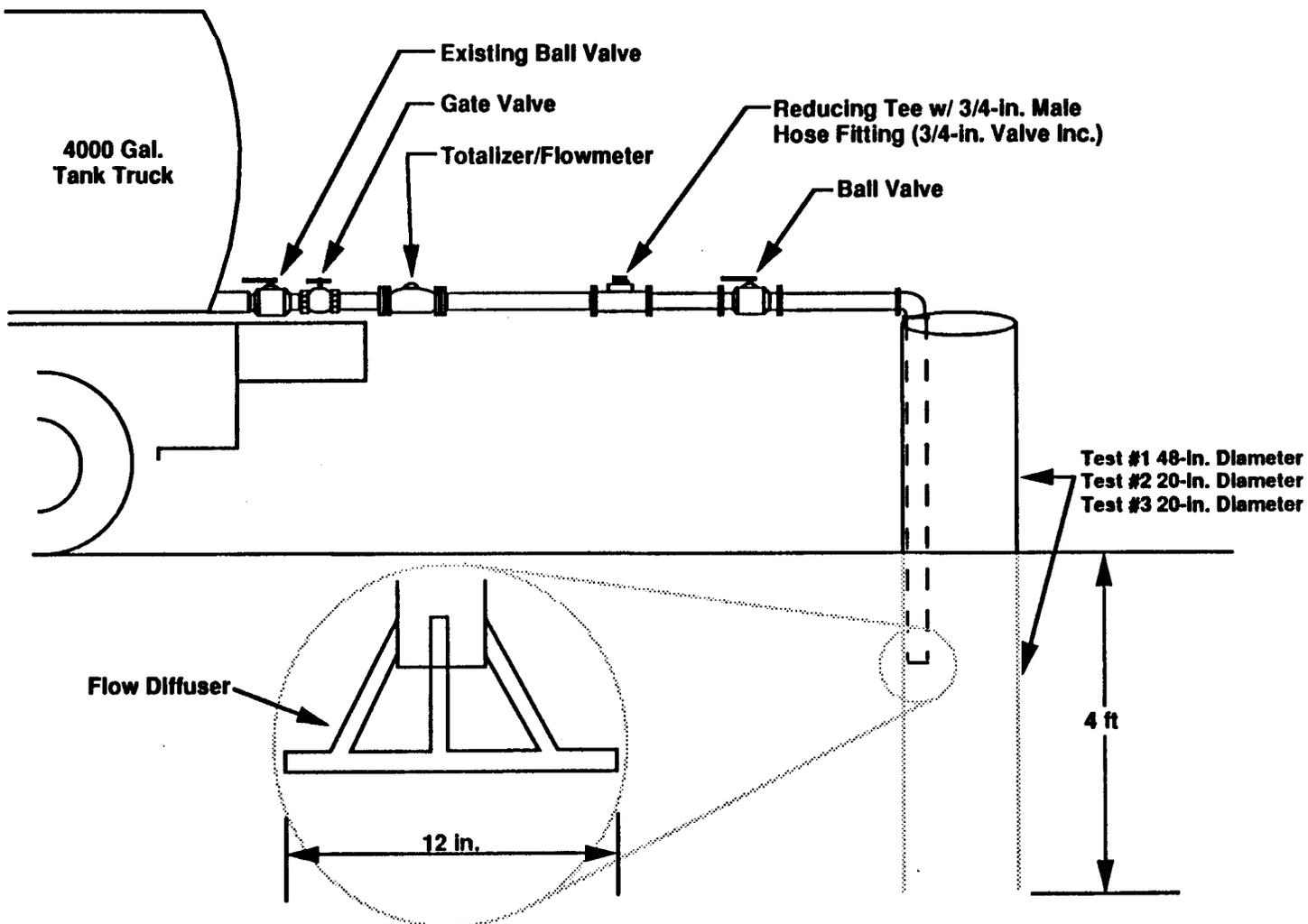


Figure D-1. Schematic of Equipment Configuration for Permeability Tests.

D-2

Not to Scale

JDDM051793-A

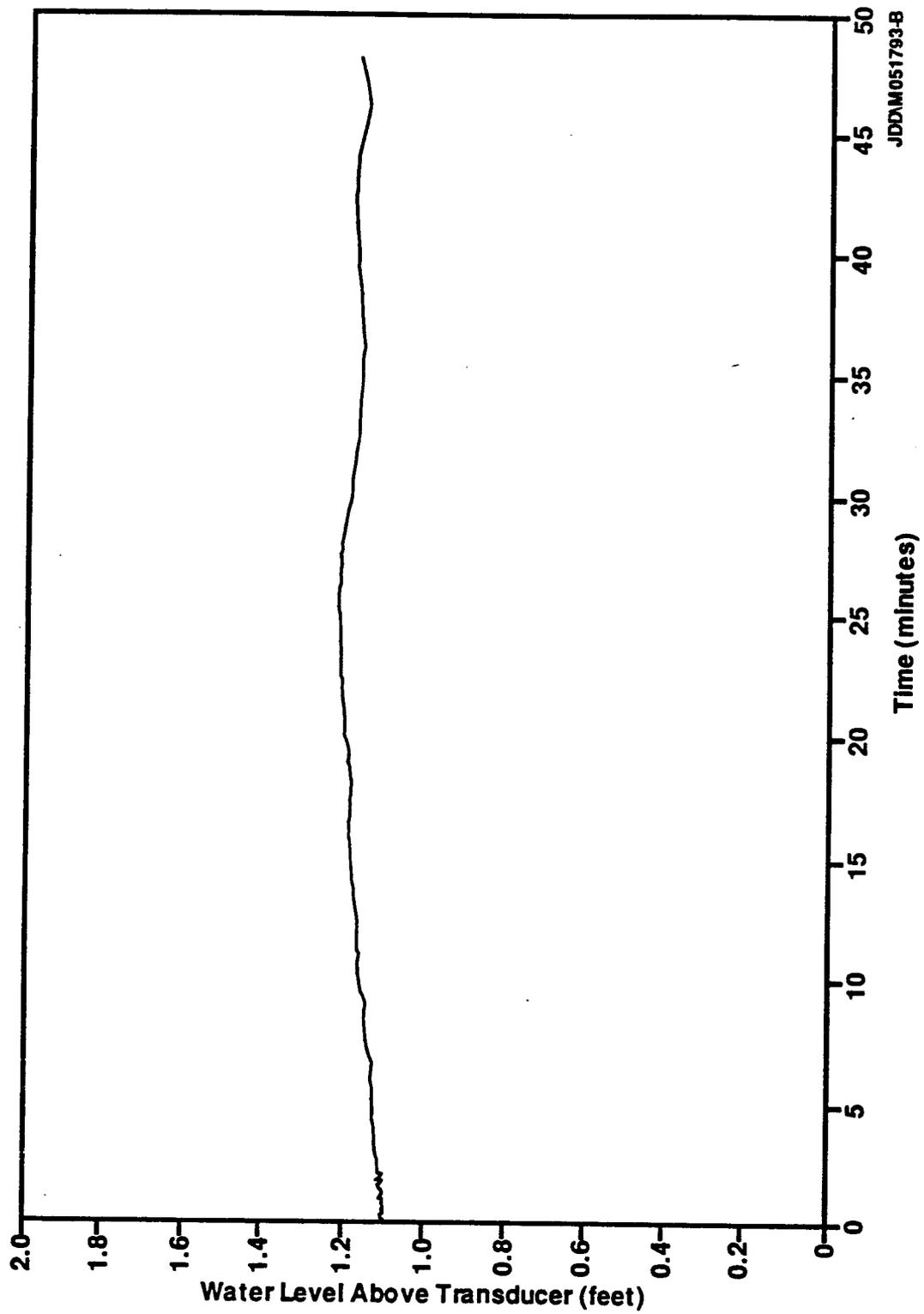


Figure D-2. Water Level as a Function of Time for Test #1.

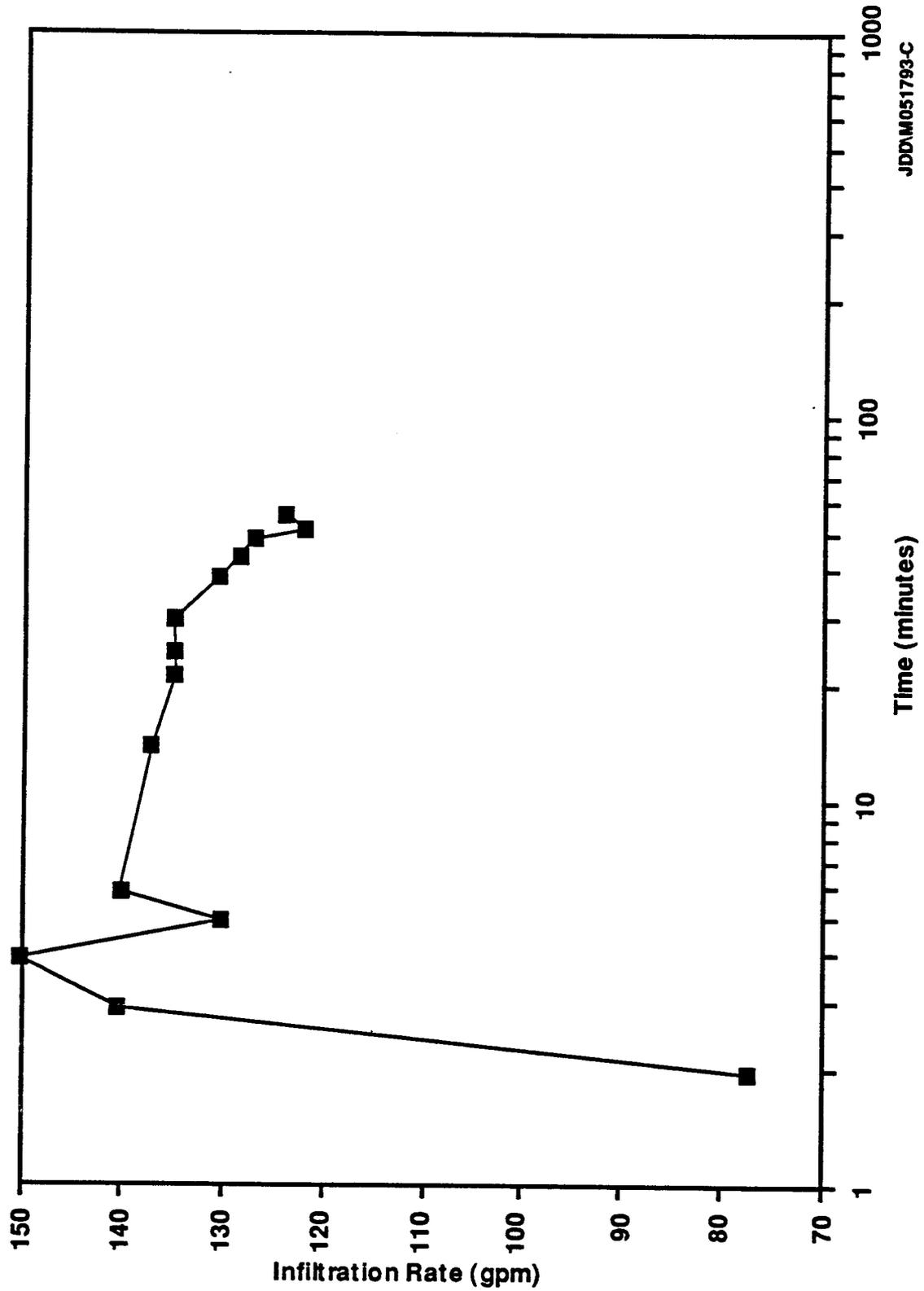


Figure D-3. Flow Rate (Q) as a Function of Time for Test #1.

On December 16, 1992, a second infiltration test was initiated by adding clean, raw water through the same calibrated flow metering system as was used for the initial test. Water from a tank truck was added to the hole by pressure flow until a relatively constant head was obtained. A constant head of 4.9 ft was achieved after 10 min. A relatively constant Q of 35 gpm was also maintained 10 min into the test. The flow rate remained constant for the 1-hr test duration (Figure D-4). The test was terminated after 1 hr by discontinuing the flow of water. After the water was shut off, a falling-head test was conducted to record the dissipation of the hydraulic head as a function of time (Figure D-5).

Data Analysis

Of the several empirical methods of analysis available to estimate hydraulic conductivity, three were used by this study to cross verify the analytical results. Measurements of hydraulic head (Q) and diameters of the casings were recorded for the two constant-head tests. The change in head as a function of time and the diameter of the casing were recorded for the falling-head test.

The saturated hydraulic conductivity was then calculated using the following Darcy equation (U. S. Bureau of Reclamation, 1974):

$$K = \frac{Q}{5.5rH}$$

where: K = hydraulic conductivity (function of horizontal and vertical flow) (L/T)
 Q = constant rate of flow into the opening (L³/T)
 r = internal radius of culvert or casing (L), and
 H = total feet of differential head in casing (L).

Infiltration of water into the soil from surface inundations can also be described by the Green-Ampt theory (Klute 1986), which considers the infiltrated water to move downward as "piston flow". Applying Darcy's equation to this concept yields:

$$K_w = \frac{v_i(L_f)}{(H_w + L_f - h)}$$

where: K_w = hydraulic conductivity of wetted zone (L/T)
 v_i = infiltration rate (L/T)
 H_w = water depth above soil (L)
 h_f = pressure head of water at wetting front (L)
 L_f = depth of wetting front (L).

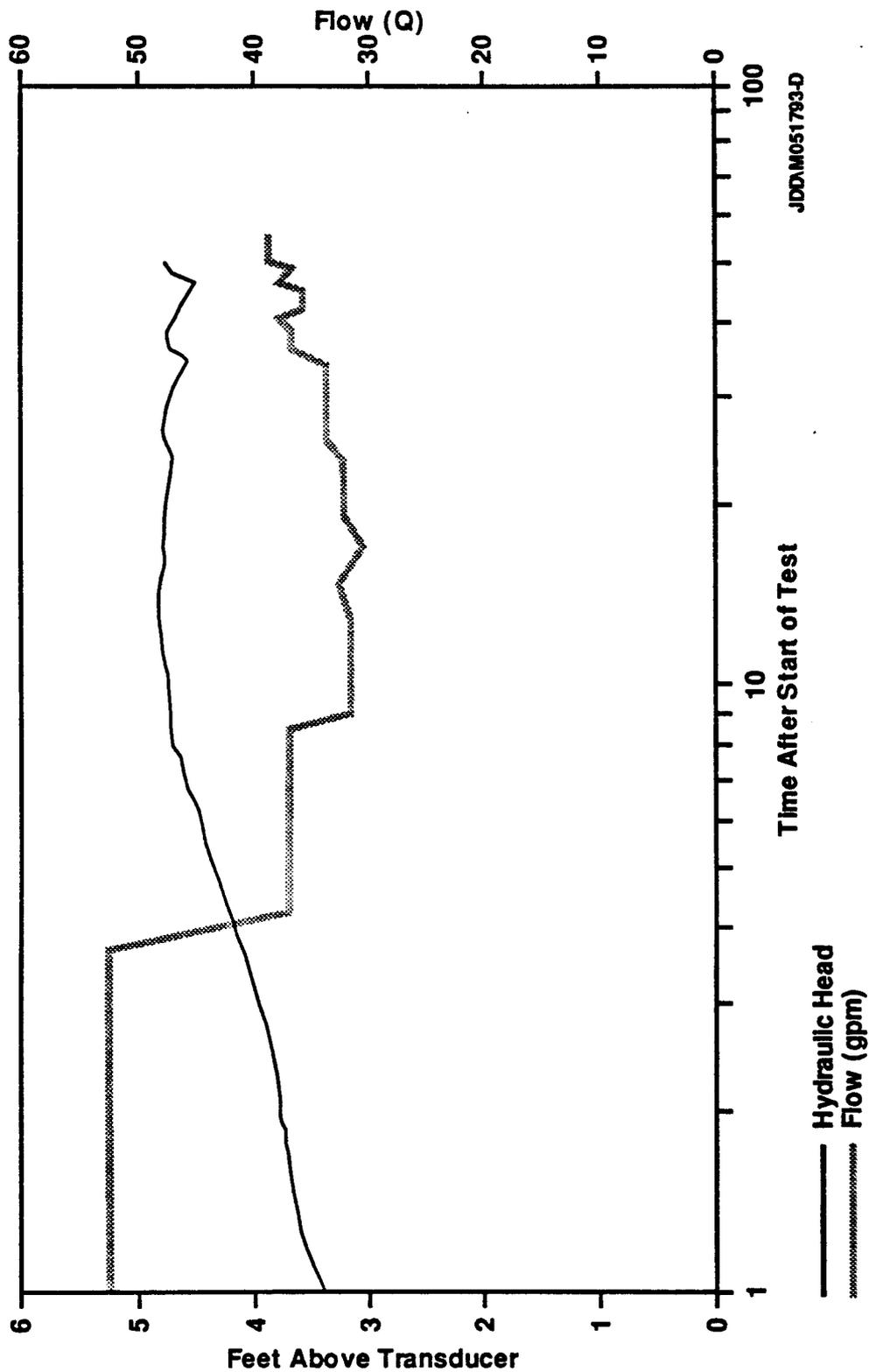


Figure D-4. Water Level and Flow Rate (Q) as a Function of Time for Test #2.

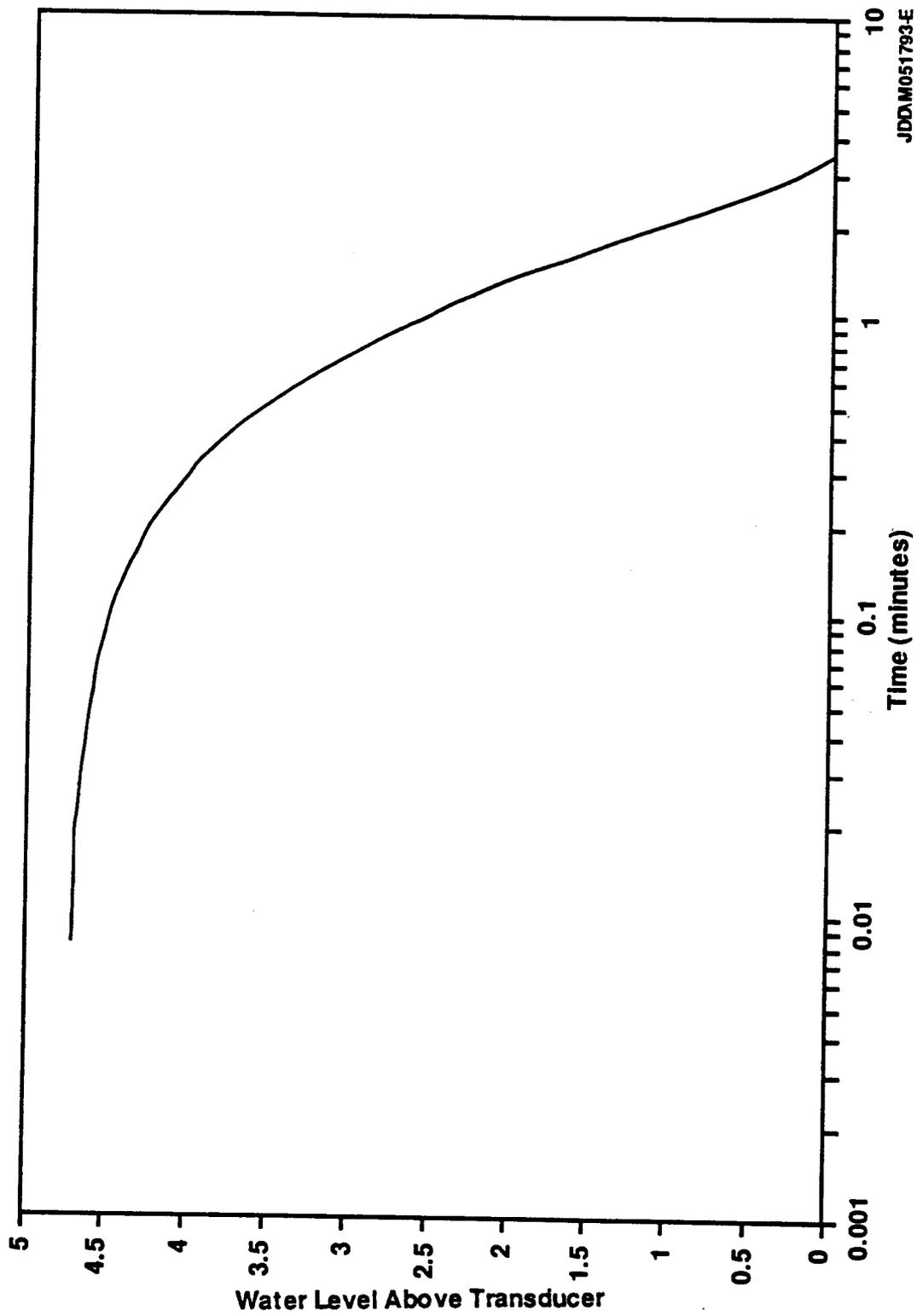


Figure D-5. Water Level above Transducer as a Function of Time for Test #3.

In addition to estimating hydraulic conductivity based on data from the two constant-head tests, falling-head data were also analyzed to estimate hydraulic conductivity (Cedergren 1989). The equation to analyze the falling head test data is:

$$K_m = \frac{D}{11(t_2 - t_1)} \ln \frac{h_1}{h_2}$$

where:

- K_m = mean hydraulic conductivity (horizontal and vertical flow) (L/T)
- D = diameter of intake opening (L)
- h_1 = hydraulic head at $t = t_1$
- h_2 = hydraulic head at $t = t_2$
- t = time.

Test Results

Test parameters and results of the data analysis for the one variable-head and two constant-head infiltration tests at the proposed site and depth of the TEDB are in Table D-1.

Table D-1. Test Parameters and Results.

Test No.	r	Area	Q	h	K ₁	K ₂	K _w	K _m
1 constant head	2	12.57	135	1.4	10.7 (2060)	8.8 (1700)	8.4 (1617)	
2 constant head	0.8	2.01	35	4.9	17.4 (3350)	1.6 (308)	8.8 (1694)	
3 falling head	0.8	2.01	35	4.9				2.1 (404)
K ₁ = Q/A			Test 1 conducted Friday, December 11, 1992					
K ₂ = Q/5.5rh			Test 2 conducted Wednesday, December 16, 1992					
K _w = K of the wetting front			Test 3 conducted Wednesday, December 16, 1992					
K _m = mean K (falling-head test)								

A range of 1 to 10 gal/min/ft² was estimated for the hydraulic conductivity of the Hanford formation for a depth of 13 ft below the land surface at the proposed TEDB site. This range is not representative of the fine-grained eolian sand that occurs from the surface to a depth of 2 to 3 ft at the proposed site. Hanford formation sediments encountered in the three boreholes drilled to characterize the proposed TEDB site are analogous in appearance to the sediments encountered in the bottom of the test trench. Consequently, the results of the tests in the trench are believed to be representative of the entire TEDB site.

Infiltration tests were previously conducted at the B Pond complex, ~4,500 ft northwest of the TEDB site (Fuchs 1984). These tests were in boreholes drilled in May of 1984 to provide access for neutron probe access. Results of these tests ranged from 24 to 45 gal/ft²/d -- i.e., much lower than the hydraulic conductivities indicated by the results of the tests reported here. This difference is likely primarily a function of the higher percentage of silt in the Hanford formation in the vicinity of the B Pond and secondarily a function of the difference in test methods used.

Limitations of Test Results

Based on past experience with similar facilities at the Hanford Site, the highest rate of infiltration can generally be expected at the beginning of facility operation. The initial rate (i.e., the baseline rate) of infiltration can be expected to gradually decrease by ~50% or more during the first 6 mo of operation due to clogging of pore space by wind-blown silt and/or algae at the land-water interface on the bottom of the pond (Bianchi 1984).

Infiltration tests of the type reported here are subject to error because the potential for lateral divergence of flow resulting from lithologic heterogeneities and hydraulic anisotropy. These effects may lead to inaccuracies in the determination of saturated hydraulic conductivity.

Conclusions

Infiltration tests were performed at the site proposed for construction and operation of the 200 Areas TEDB. The tests were used to estimate the vertical hydraulic conductivity of sediments in the bottom of a trench 13 ft below the original ground surface. Three empirical models were used to cross verify the results. Hydraulic conductivities of 1 to 10 gal/min/ft² are estimated for the Hanford formation at the depth and location projected to become the bottom of the pond. These results are believed to be applicable for the entire area of the proposed TEDB site.

References

- Bianchi, W. C., 1984, A Method for Prediction of the Waste Water Percolation Capacity for the Extension of the Pond B Facility -- DOE Hanford Reservation, (unnumbered), Rockwell Hanford Operations Historical Document No. 0002, Westinghouse Hanford Company, Richland, Washington.
- Cedergren, H. R., 1989, Seepage, Drainage and Flow Nets, John Wiley & Sons, New York, New York.

Davis, J. D. and C. D. Delaney, 1992, Site Characterization Work Plan - 200 Areas Treated Effluent Disposal Basin, Project W-049H, Westinghouse Hanford Company, Richland, Washington.

Fuchs, M. R., 1984, B Pond 3rd Lobe Expansion Sediment and Percolation Investigation, Internal Letter No. 65633-088, Rockwell Hanford Operations, Richland, Washington.

Klute, A., Edit., 1986, Methods of Soil Analysis, 2nd Edit., American Society of Agronomy, Inc., Madison, Wisconsin.

U. S. Dept. of the Interior, U. S. Bureau of Reclamation, 1974, Earth Manual, 2nd Edit., p. 573-578.

Hermit Environment Data Logger Unit# 193
 Test# 1 Water Level (ft) above transducer (Head)
 Type: Constant Head Test Start time: 12:48 12/11/92
 Scale Factor: 9.987
 Offset: -0.015
 Delay mSec: 50.0

DATA FOR TEST #1

<u>Time:min</u>	<u>Time:hrs</u>	<u>HEAD(ft)</u>
0.000	0.00000	1.10
0.008	0.00014	1.10
0.017	0.00028	1.10
0.025	0.00042	1.10
0.033	0.00056	1.10
0.042	0.00069	1.10
0.050	0.00083	1.10
0.058	0.00097	1.10
0.067	0.00111	1.10
0.075	0.00125	1.09
0.083	0.00139	1.10
0.100	0.00167	1.11
0.117	0.00194	1.09
0.133	0.00222	1.10
0.150	0.00250	1.10
0.167	0.00278	1.10
0.183	0.00306	1.10
0.200	0.00333	1.10
0.217	0.00361	1.10
0.233	0.00389	1.10
0.250	0.00417	1.10
0.267	0.00444	1.10
0.283	0.00472	1.10
0.300	0.00500	1.10
0.317	0.00528	1.10
0.333	0.00556	1.09
0.417	0.00694	1.10
0.500	0.00833	1.10
0.583	0.00972	1.10
0.667	0.01111	1.10
0.750	0.01250	1.10
0.833	0.01389	1.10
0.917	0.01528	1.10

DATA FOR TEST #1

1.000	0.01667	1.11
1.083	0.01806	1.10
1.167	0.01944	1.10
1.250	0.02083	1.10
1.333	0.02222	1.10
1.417	0.02361	1.11
1.500	0.02500	1.11
1.583	0.02639	1.10
1.667	0.02778	1.10
1.750	0.02917	1.11
1.833	0.03056	1.11
1.917	0.03194	1.10
2.000	0.03333	1.11
2.500	0.04167	1.11
3.000	0.05000	1.12
3.500	0.05833	1.12
4.000	0.06667	1.13
4.500	0.07500	1.13
5.000	0.08333	1.13
5.500	0.09167	1.13
6.000	0.10000	1.14
6.500	0.10833	1.13
7.000	0.11667	1.14
7.500	0.12500	1.15
8.000	0.13333	1.15
8.500	0.14167	1.15
9.000	0.15000	1.15
9.500	0.15833	1.16
10.000	0.16667	1.17
12.000	0.20000	1.17
14.000	0.23333	1.18
16.000	0.26667	1.19
18.000	0.30000	1.19
20.000	0.33333	1.20
22.000	0.36667	1.21
24.000	0.40000	1.22
26.000	0.43333	1.22
28.000	0.46667	1.22
30.000	0.50000	1.20
32.000	0.53333	1.18
34.000	0.56667	1.17
36.000	0.60000	1.17

DATA FOR TEST #1

38.000	0.63333	1.18
40.000	0.66667	1.19
42.000	0.70000	1.19
44.000	0.73333	1.19
46.000	0.76667	1.16
48.000	0.80000	1.18
50.000	0.83333	0.03

Hermit Environment Data Logger Unit# 193
Test# 2 Water Level (Head) in feet above transducer
Type: Constant Head
Scale: 9.987 Test started at 09:33 12/16/92
Offset: -0.015

DATA FOR TEST #2
Time:min Time:hrs HEAD(ft)*

0.000	0.00000	2.36
0.008	0.00014	2.40
0.017	0.00028	2.43
0.025	0.00042	2.46
0.033	0.00056	2.49
0.042	0.00069	2.52
0.050	0.00083	2.54
0.058	0.00097	2.57
0.067	0.00111	2.59
0.075	0.00125	2.63
0.083	0.00139	2.65
0.100	0.00167	2.71
0.117	0.00194	2.76
0.133	0.00222	2.82
0.150	0.00250	2.87
0.167	0.00278	2.93
0.183	0.00306	2.98
0.200	0.00333	3.01
0.217	0.00361	3.04
0.233	0.00389	3.04
0.250	0.00417	3.01
0.267	0.00444	2.99
0.283	0.00472	2.96
0.300	0.00500	2.93
0.317	0.00528	2.90
0.333	0.00556	2.88
0.417	0.00694	2.78
0.500	0.00833	2.77
0.583	0.00972	2.88
0.667	0.01111	2.99
0.750	0.01250	3.10
0.833	0.01389	3.19
0.917	0.01528	3.28
1.000	0.01667	3.37

DATA FOR TEST #2

1.083	0.01806	3.44
1.167	0.01944	3.50
1.250	0.02083	3.55
1.333	0.02222	3.58
1.417	0.02361	3.62
1.500	0.02500	3.64
1.583	0.02639	3.65
1.667	0.02778	3.67
1.750	0.02917	3.68
1.833	0.03056	3.70
1.917	0.03194	3.71
2.000	0.03333	3.73
2.500	0.04167	3.81
3.000	0.05000	3.91
3.500	0.05833	4.02
4.000	0.06667	4.14
4.500	0.07500	4.23
5.000	0.08333	4.32
5.500	0.09167	4.38
6.000	0.10000	4.43
6.500	0.10833	4.48
7.000	0.11667	4.53
7.500	0.12500	4.59
8.000	0.13333	4.66
8.500	0.14167	4.67
9.000	0.15000	4.67
9.500	0.15833	4.68
10.000	0.16667	4.69
12.000	0.20000	4.76
14.000	0.23333	4.78
16.000	0.26667	4.72
18.000	0.30000	4.72
20.000	0.33333	4.71
22.000	0.36667	4.68
24.000	0.40000	4.64
26.000	0.43333	4.72
28.000	0.46667	4.71
30.000	0.50000	4.66
32.000	0.53333	4.59
34.000	0.56667	4.51
36.000	0.60000	4.66
38.000	0.63333	4.68

DATA FOR TEST #2

40.000	0.66667	4.63
42.000	0.70000	4.58
44.000	0.73333	4.50
46.000	0.76667	4.43
48.000	0.80000	4.64
50.000	0.83333	4.70

Hermit Environment Data Logger # 193
Test# 3 Water Level (Head) in feet above transducer
Type: Falling Head
Pump Shut off: 10:24 12/16/92
Scale: 9.987
Offset: -0.015

DATA FOR TEST #3Time:min Time:hrs HEAD(ft)*

0.00	0.0000	4.71
0.01	0.0001	4.71
0.02	0.0003	4.70
0.03	0.0004	4.68
0.03	0.0006	4.65
0.04	0.0007	4.63
0.05	0.0008	4.61
0.06	0.0010	4.60
0.07	0.0011	4.58
0.08	0.0013	4.56
0.08	0.0014	4.55
0.10	0.0017	4.50
0.12	0.0019	4.46
0.13	0.0022	4.42
0.15	0.0025	4.38
0.17	0.0028	4.34
0.18	0.0031	4.29
0.20	0.0033	4.26
0.22	0.0036	4.22
0.23	0.0039	4.17
0.25	0.0042	4.13
0.27	0.0044	4.09
0.28	0.0047	4.05
0.30	0.0050	4.01
0.32	0.0053	3.97
0.33	0.0056	3.93
0.42	0.0069	3.76
0.50	0.0083	3.57
0.58	0.0097	3.38
0.67	0.0111	3.21
0.75	0.0125	3.03
0.83	0.0139	2.86
0.92	0.0153	2.70

DATA FOR TEST #3

1.00	0.0167	2.57
1.08	0.0181	2.45
1.17	0.0194	2.33
1.25	0.0208	2.18
1.33	0.0222	2.04
1.42	0.0236	1.91
1.50	0.0250	1.78
1.58	0.0264	1.66
1.67	0.0278	1.54
1.75	0.0292	1.42
1.83	0.0306	1.31
1.92	0.0319	1.21
2.00	0.0333	1.11
2.50	0.0417	0.58
3.00	0.0500	0.21
3.50	0.0583	0.00

APPENDIX E
ANALYTICAL METHODS USED FOR AQUIFER TEST ANALYSIS

WHC-SD-EN-SE-004, Rev. 0

This appendix briefly describes the methods of analysis used to interpret the aquifer test data from wells 699-40-36, 699-41-35, and 699-42-37. It also contains the remainder of the analysis plots not shown in Section 4.5. Test data were issued as part of the borehole data package for the 200 Areas Treated Effluent Disposal Basin, Project W-049H (WHC 1993a).

Description of Test Methods

The single-well discharge tests were evaluated using the Cooper and Jacob (1946) straight-line analysis method for the drawdown and recovery data. This method entails plotting the data on semi-log paper and fitting a best-fit line to that portion of the data (i.e., drawdown or recovery) where radial flow conditions are present.

The Bourdet et al. (1989) pressure-derivative method was used to determine when radial flow conditions were present. The pressure derivative provides a semi-quantitative means to assess the influence of wellbore storage, hydraulic boundaries, and non-horizontal groundwater flow.

Using the pressure-derivative method, a derivative function of the data is plotted on log-log paper and the data interval is identified where the slope as a function of time approximates zero. Radial flow is present over this data interval; hence, the data in this interval are used to calculate the transmissivity.

Recovery data from the constant-discharge tests were analyzed using the traditional t/t' method for recovery data and the Agarwal (1980) equivalent-time analysis. All data were corrected for pre-test trends and barometric changes prior to analyzing the recovery data. The t/t' method is explained in detail in the technical literature (e.g., Kruseman and De Ridder, 1983; Domenico and Schwartz, 1990). The t/t' method follows the same general analysis procedure as the Cooper and Jacob (1946) straight-line method except that time is plotted as a dimensionless parameter and increases toward the left side of the plot. Consequently, a best-fit line is matched to the data toward the left side of the figure.

For the Agarwal method, the recovery buildup pressure; i.e., water-level rise, is plotted against an equivalent time function. This time function is defined as $t \cdot t' / (t + t')$, where t is the time since pumping was initiated and t' is the time since pumping was terminated. Data plotted in this manner can be analyzed using the exact same approach used to analyze the drawdown data; i.e., the Cooper and Jacob straight-line analysis. Spane (1993) explains the application of this technique.

Slug tests were analyzed using the Cooper, Bredehoeft, and Papadopoulos (1967) method for confined aquifers. Lohman (1972) provides an example application of this method. The slug-test analyses were performed using a commercially available hydrologic software package.

References

- Agarwal, R. G., 1980, A New Method to Account for Producing-Time Effects When Drawdown Type Curves Are Used to Analyze Pressure Buildup and Other Test Data, Society of Petroleum Engineers, SPE Paper 9289, presented at the 1980 SPE Annual Technical Conference and Exhibition, Dallas, TX, Sept. 21-24.
- Bourdet, K. , J. A. Ayoub and U. M. Pirard, 1989, Use of Pressure Derivative in Well Test Interpretation, Society of Petroleum Engineers, SPE Formation Evaluation, June 1989, p. 293-302.
- Cooper, H. H., Jr. and C. E. Jacob, 1946, A Generalized Graphical Method for Evaluating Formation Constants and Summarizing Well-Field History, Am. Geophys. Union Trans., Vol. 27, No. 4, p. 526-534.
- Cooper, H. H., J. D. Bredehoeft and I. S. Papadopoulos, 1967, Response of a Finite-Diameter Well to an Instantaneous Charge of Water: Water Resources Research., Vol. 3, p. 263-269.
- Domenico, P. A. and F. W. Schwartz, 1990, Physical and Chemical Hydrogeology, John Wiley and Sons, New York, New York.
- Kruseman, G. P. and N. A. De Ridder, 1983, Analysis and Evaluation of Pumping Test Data: International Institute for Land Reclamation and Improvement (ILRI), The Netherlands, 300 p.
- Lohman, S. W., 1972, Groundwater Hydraulics, U. S. Geological Survey Professional Paper 708, Reston, Virginia.
- Spane, F. A., 1993, Selected Hydraulic Test Analysis Techniques for Constant-Rate Discharge Tests, PNL-8539, Pacific Northwest Laboratory, Richland, Washington.

Drawdown Analysis
Well 40-36; March 29, 1993

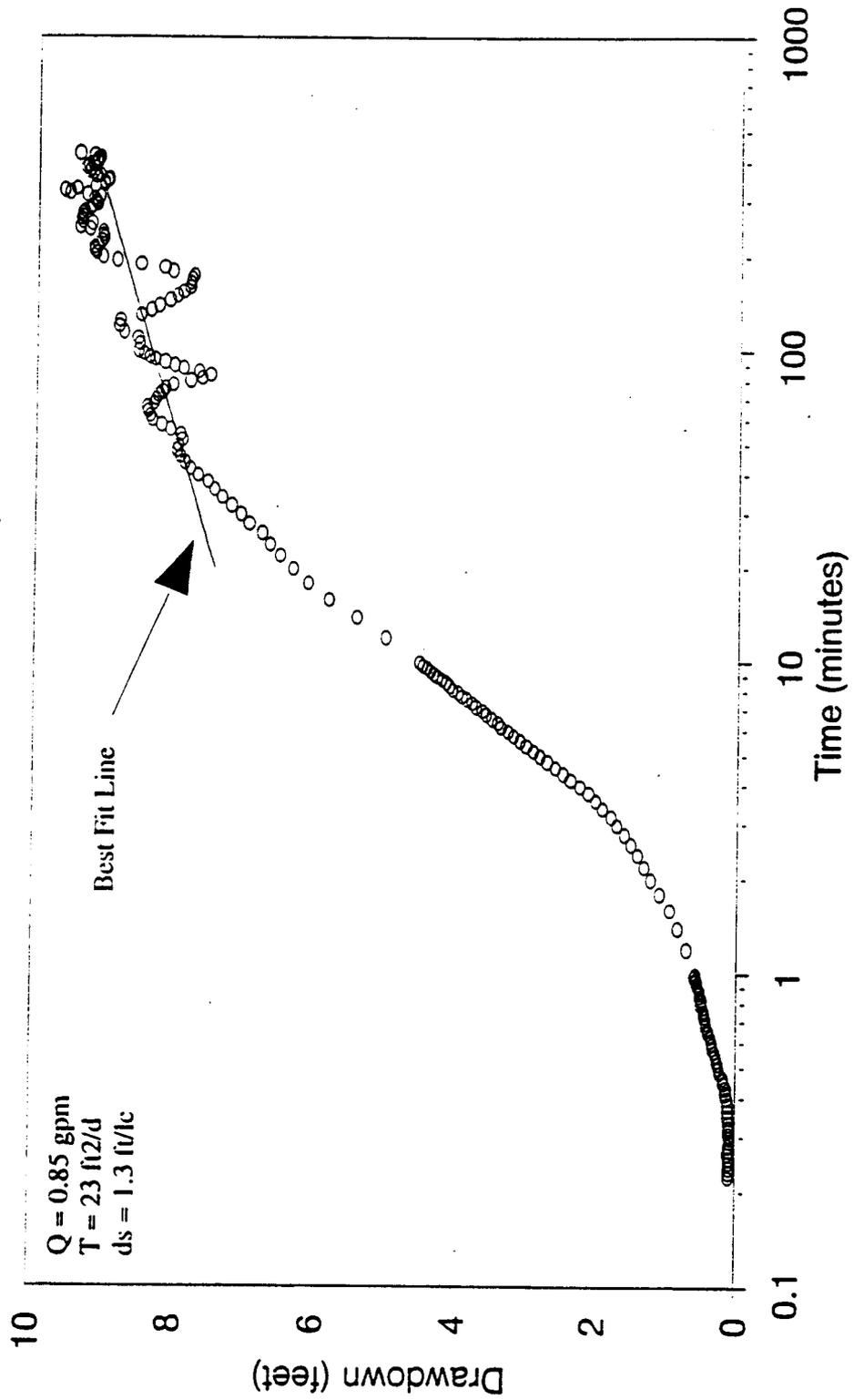


Figure E-1. Straight-Line Analysis of Drawdown Data for Well 699-40-36.

Drawdown Pressure Derivative Analysis Well 40-36; March 29, 1993

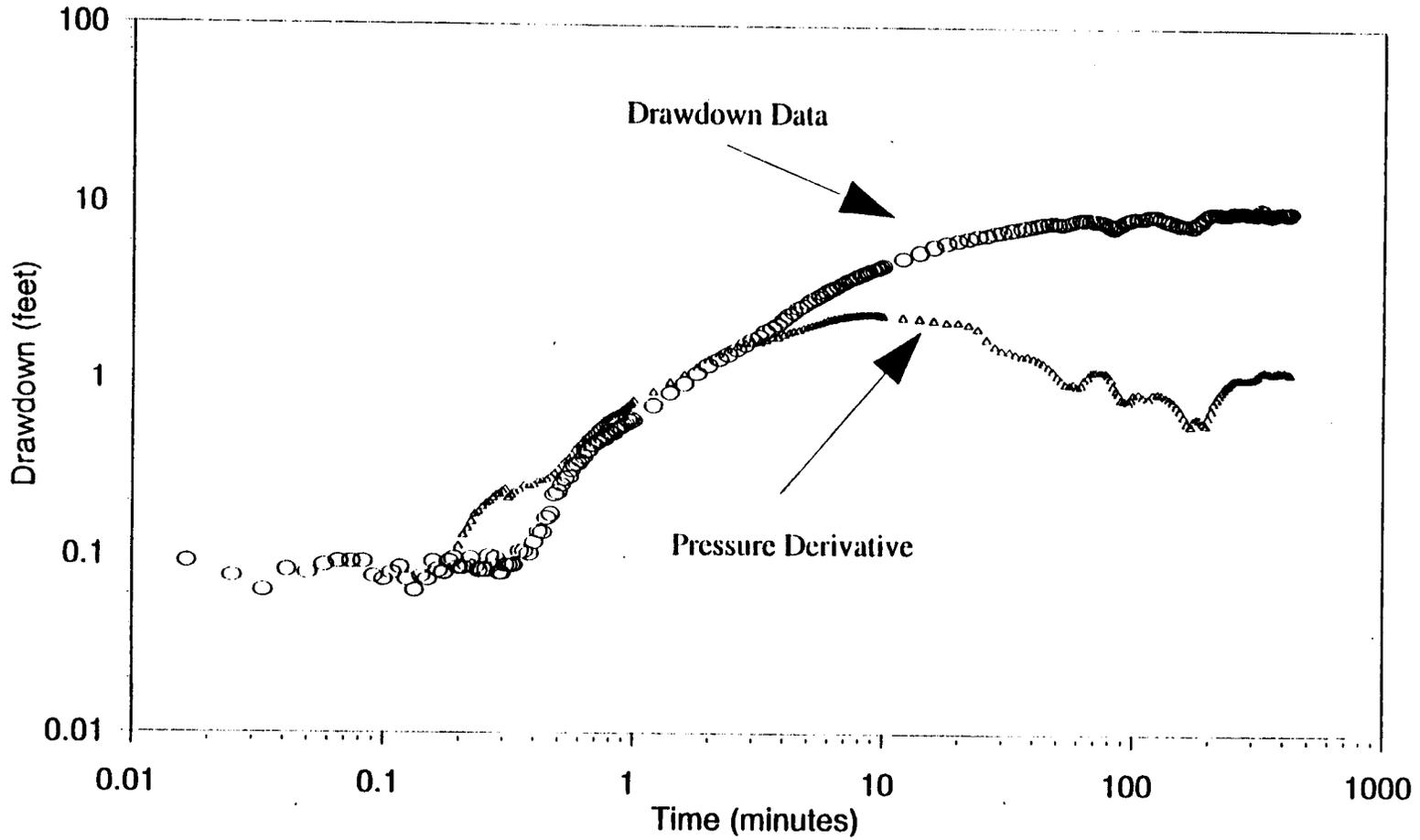


Figure E-2. Pressure Derivative Analysis of Drawdown Data for Well 699-40-36.

Recovery Plot
Well 40-36; March 29-30, 1993

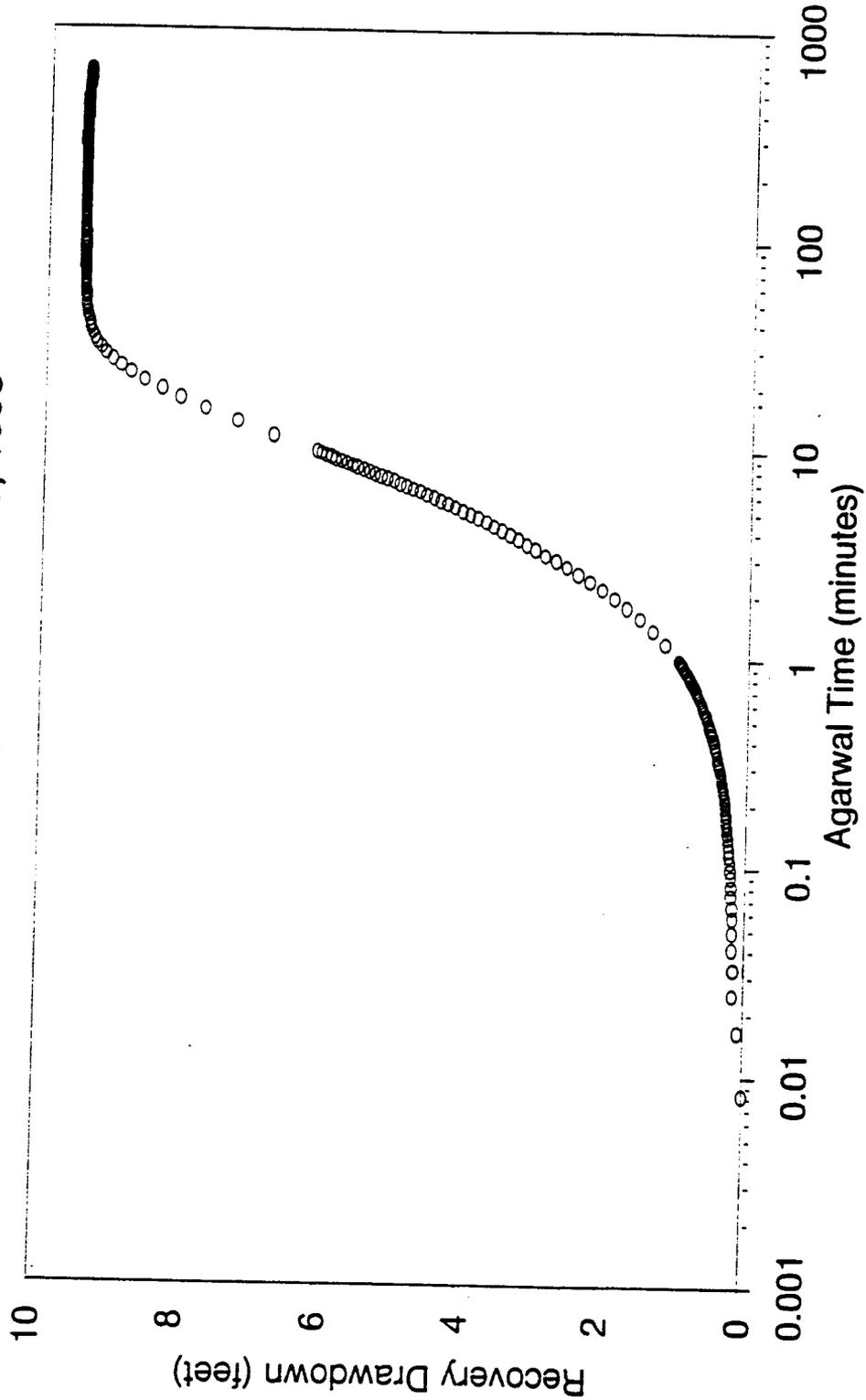


Figure E-3. Agarwal Recovery Data for Well 699-40-36 Showing the Rapid Recovery to the Static Water Level.

Recovery Pressure Derivative Analysis Well 40-36; March 29-30, 1993

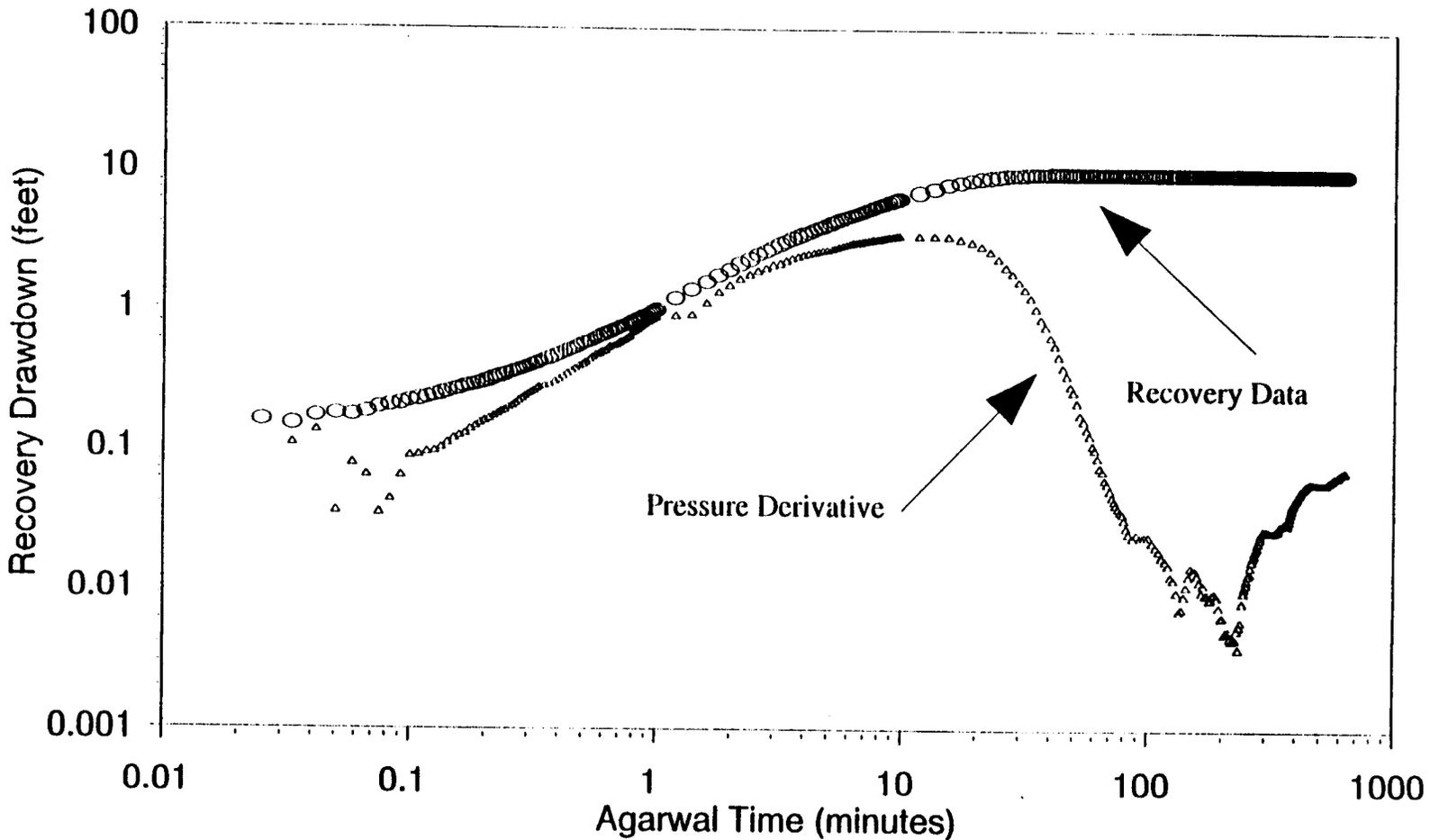


Figure E-4. Pressure Derivative Analysis of Recovery Data for Well 699-40-36.

Trend Analysis Well 40-36; March 18-22, 1993

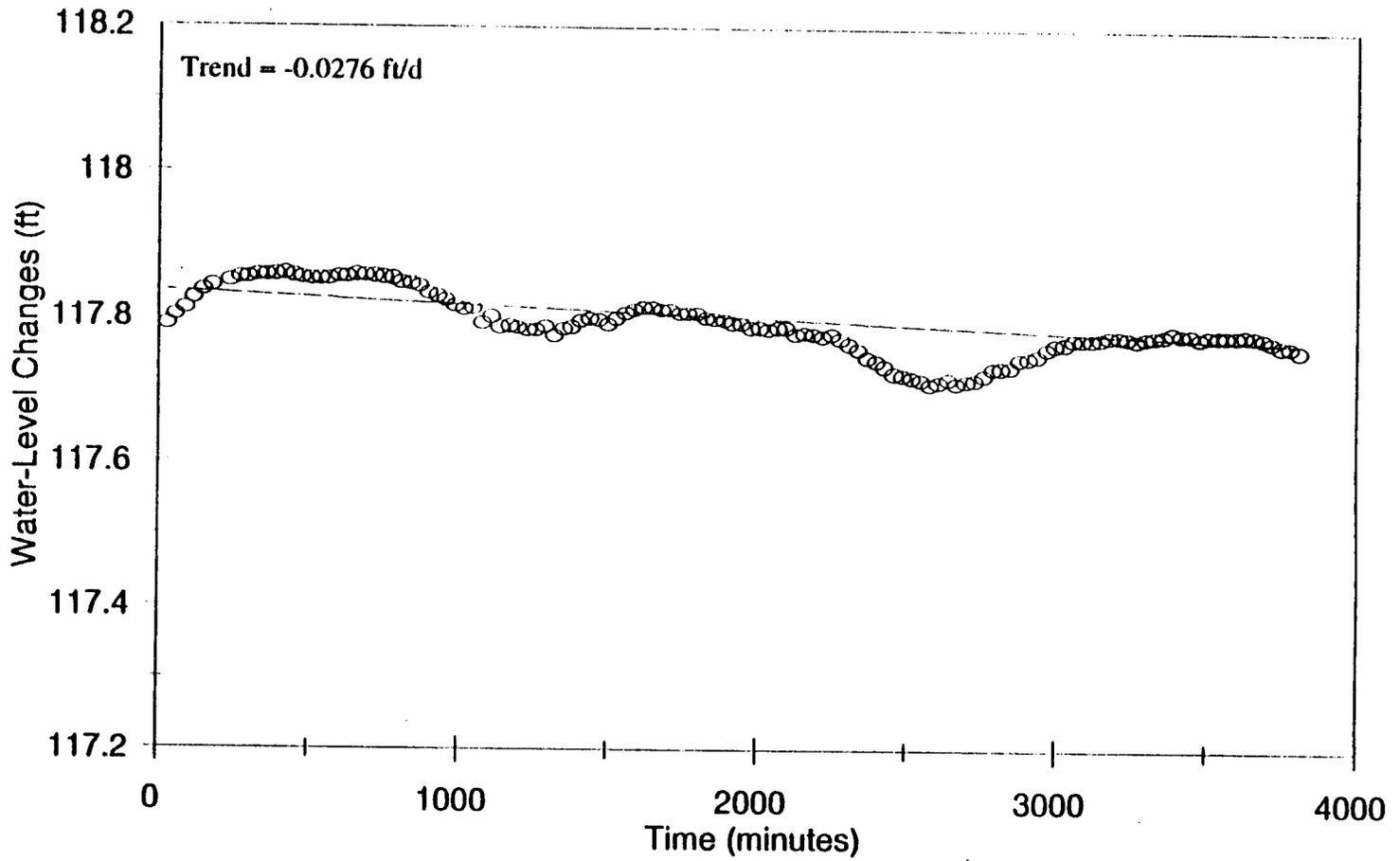


Figure E-5. Water-Level Trend Analysis for Well 699-40-36.

Barometric Efficiency Analysis Well 40-36; March 26-29, 1993

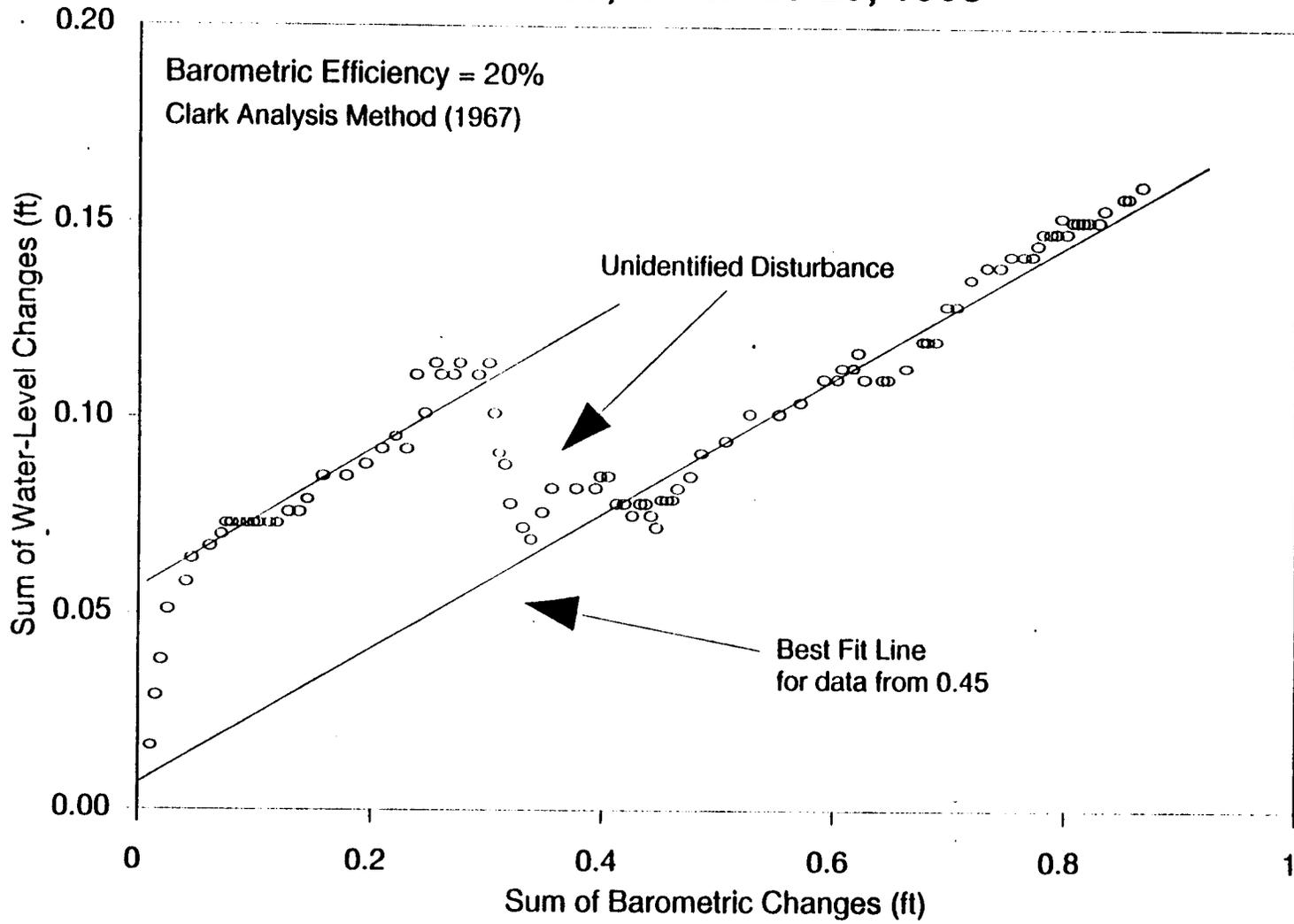


Figure E-6. Barometric Efficiency Analysis for Well 699-40-36, March 1993.

Barometric Efficiency Analysis Well 40-36; April 1993 Data

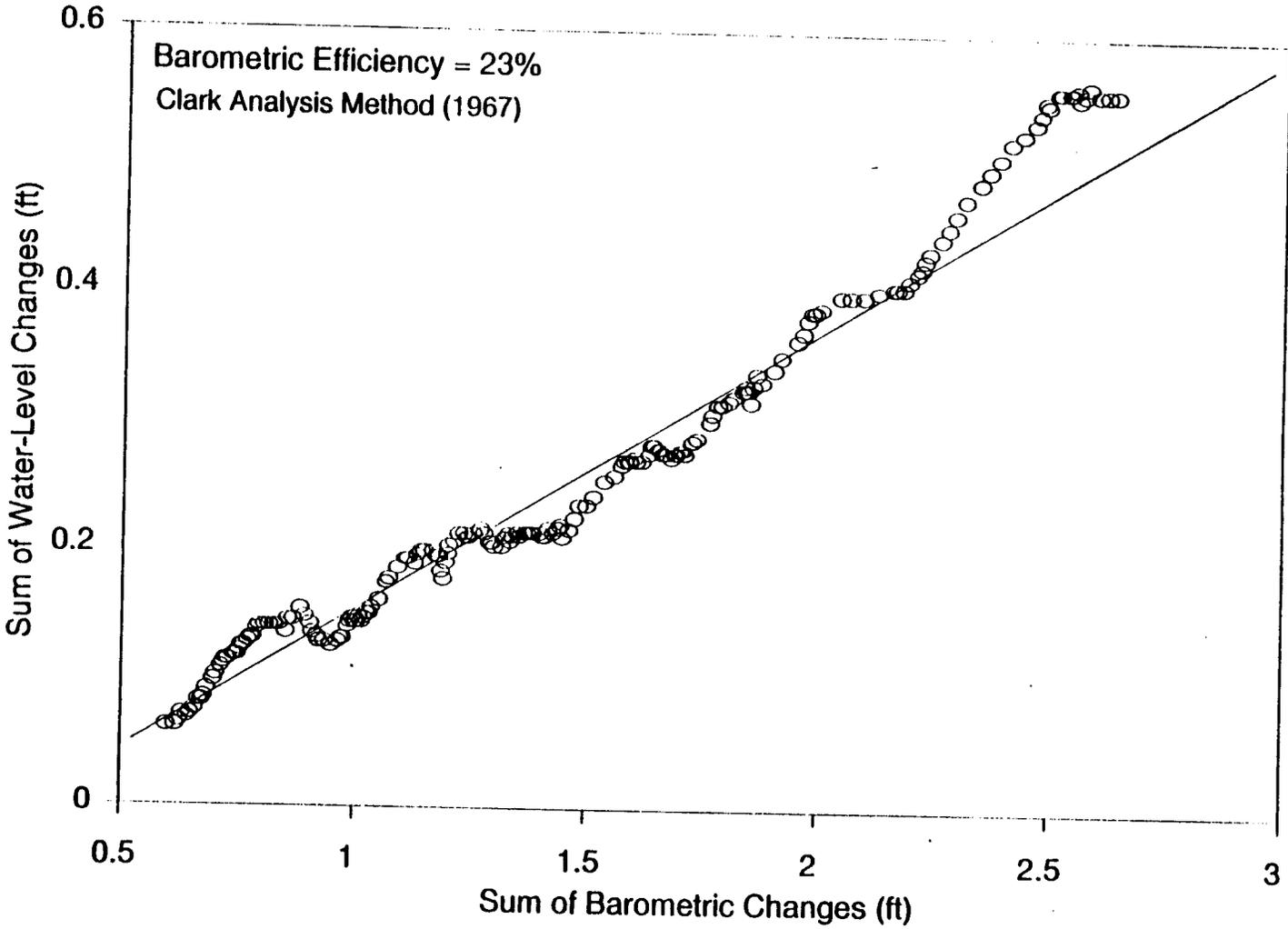


Figure E-7. Barometric Efficiency Analysis for Well 699-40-36, April 1993.

$T = 22 \text{ ft}^2/\text{d}; S = 7.4\text{E}-4$
 $rc = 0.167 \text{ ft}; rw = 0.333 \text{ ft}; Ho = 2.22 \text{ ft}$

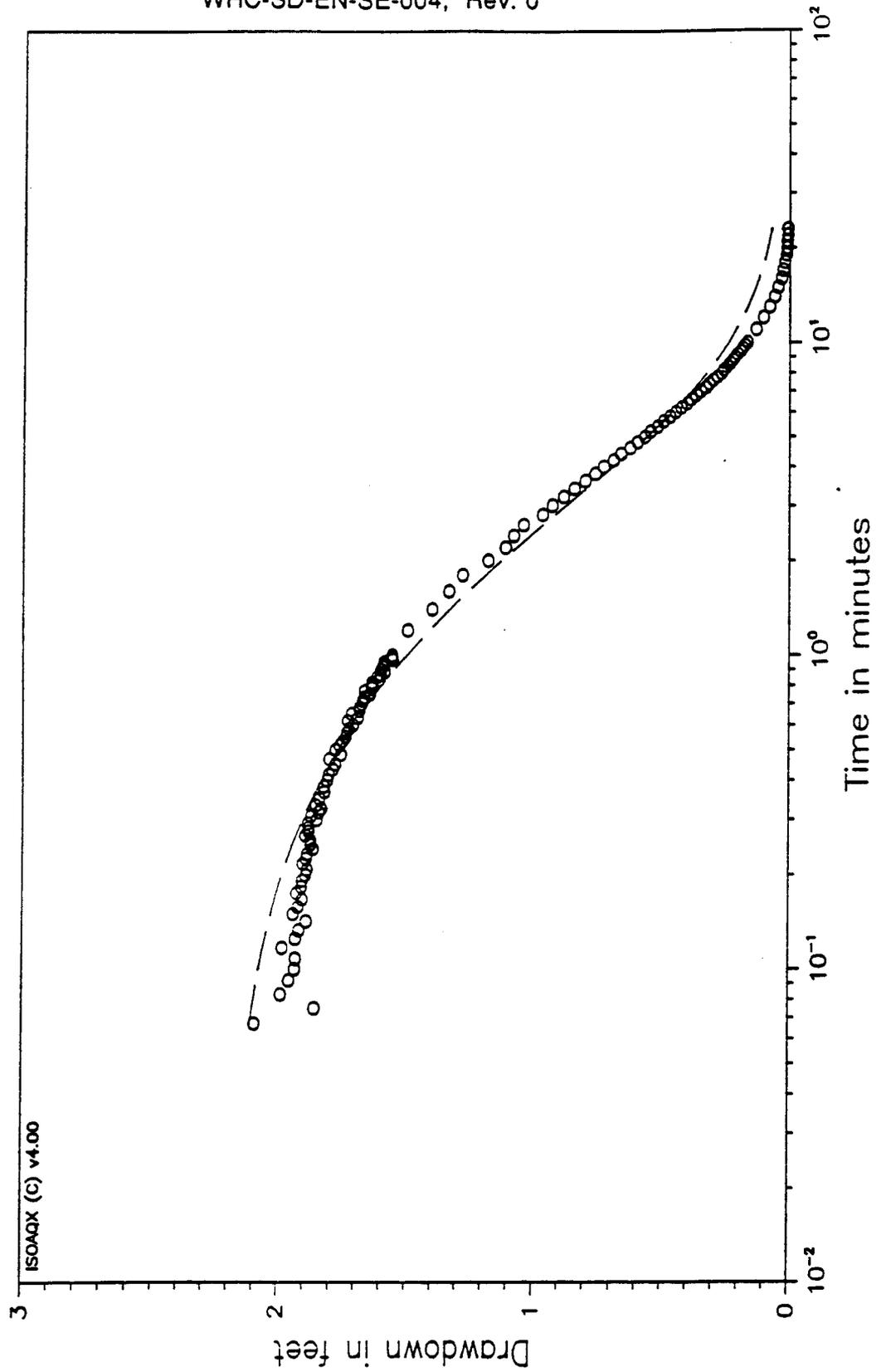


Figure E-8. Slug Injection Analysis for Well 699-40-36.

$T = 13 \text{ ft}^2/\text{d}; S = 4.2\text{E}-3$
 $rc = 0.167 \text{ ft}; r_w = 0.333 \text{ ft}; H_o = 2.22 \text{ ft}$

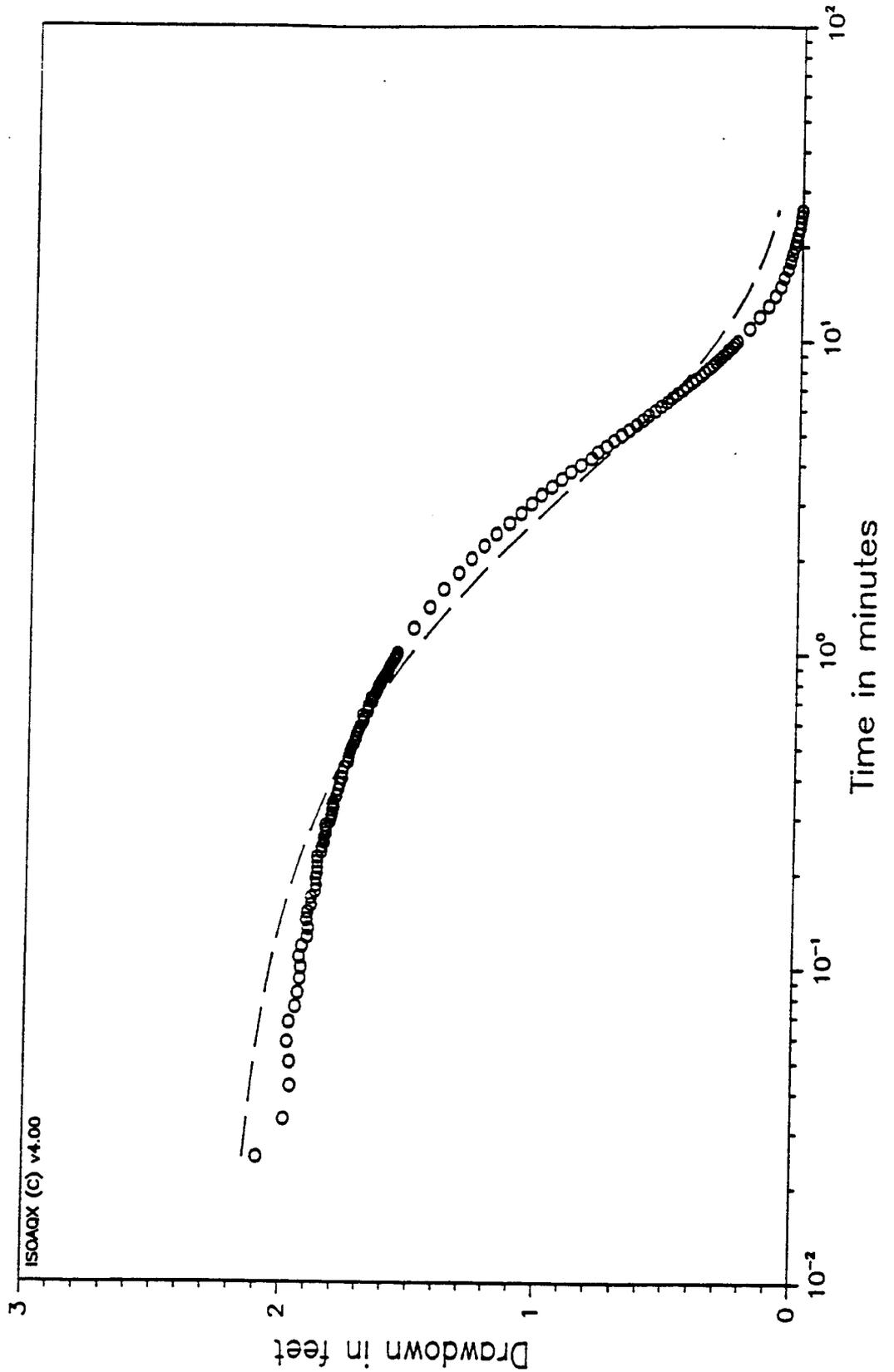


Figure E-9. Slug Withdrawal Analysis for Well 699-40-36.

Drawdown Analysis
Well 699-41-35; March 26, 1993

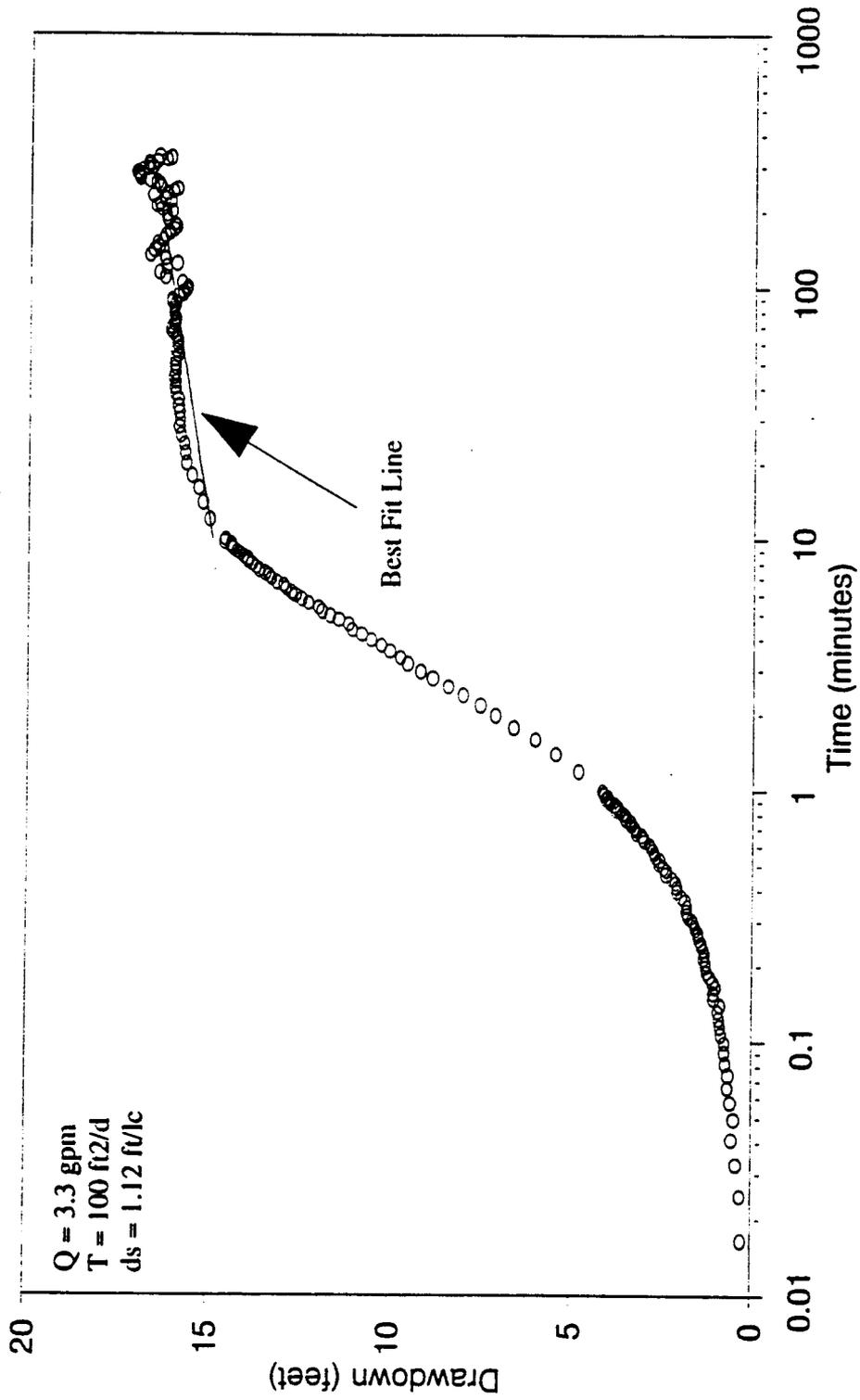


Figure E-10. Straight-Line Analysis of Drawdown Data for Well 699-41-35.

Drawdown Pressure Derivative Analysis Well 41-35; March 26, 1993

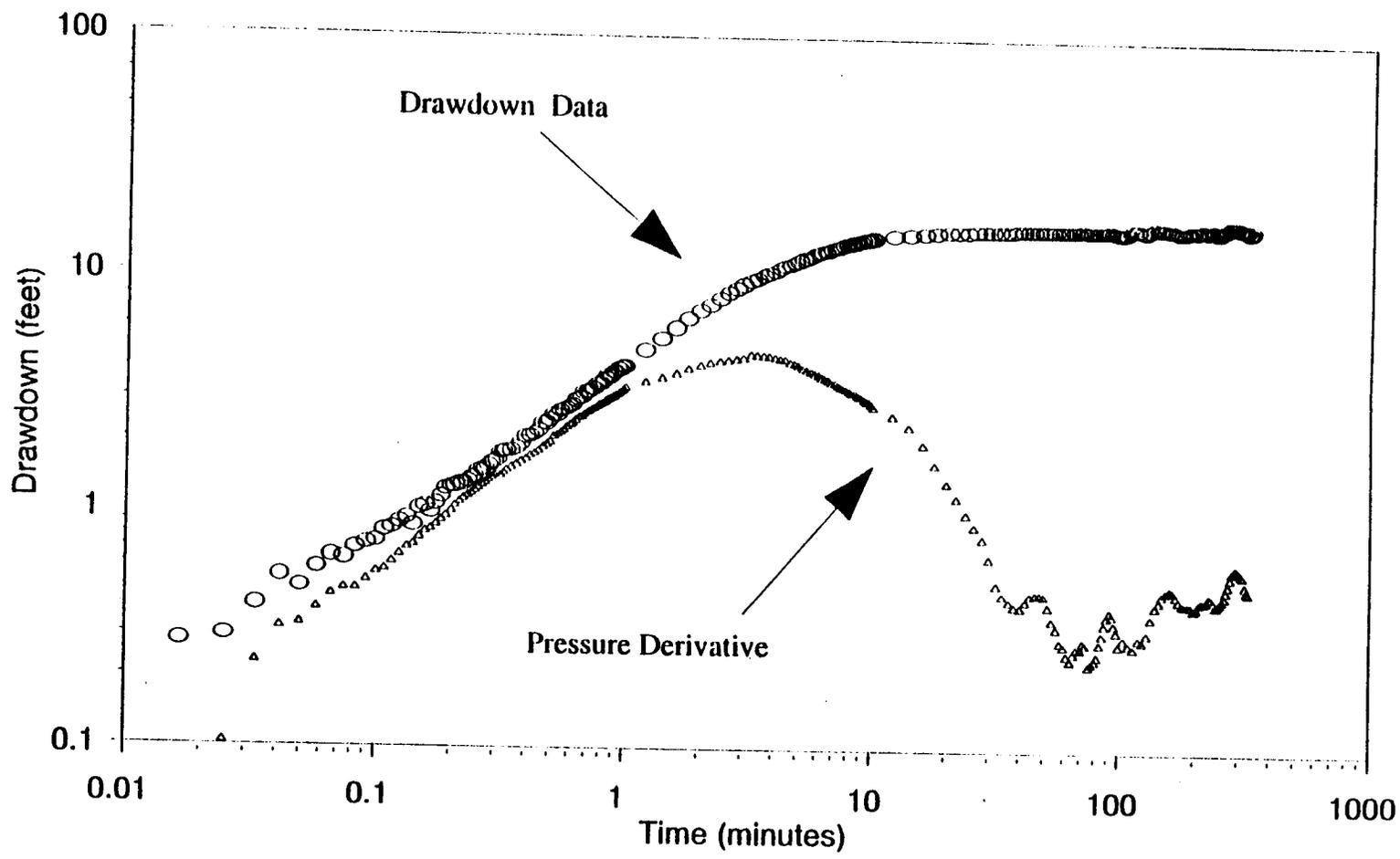


Figure E-11. Pressure Derivative Analysis of Drawdown Data for Well 699-41-35.

Recovery Analysis
Well 41-35; March 29-30, 1993

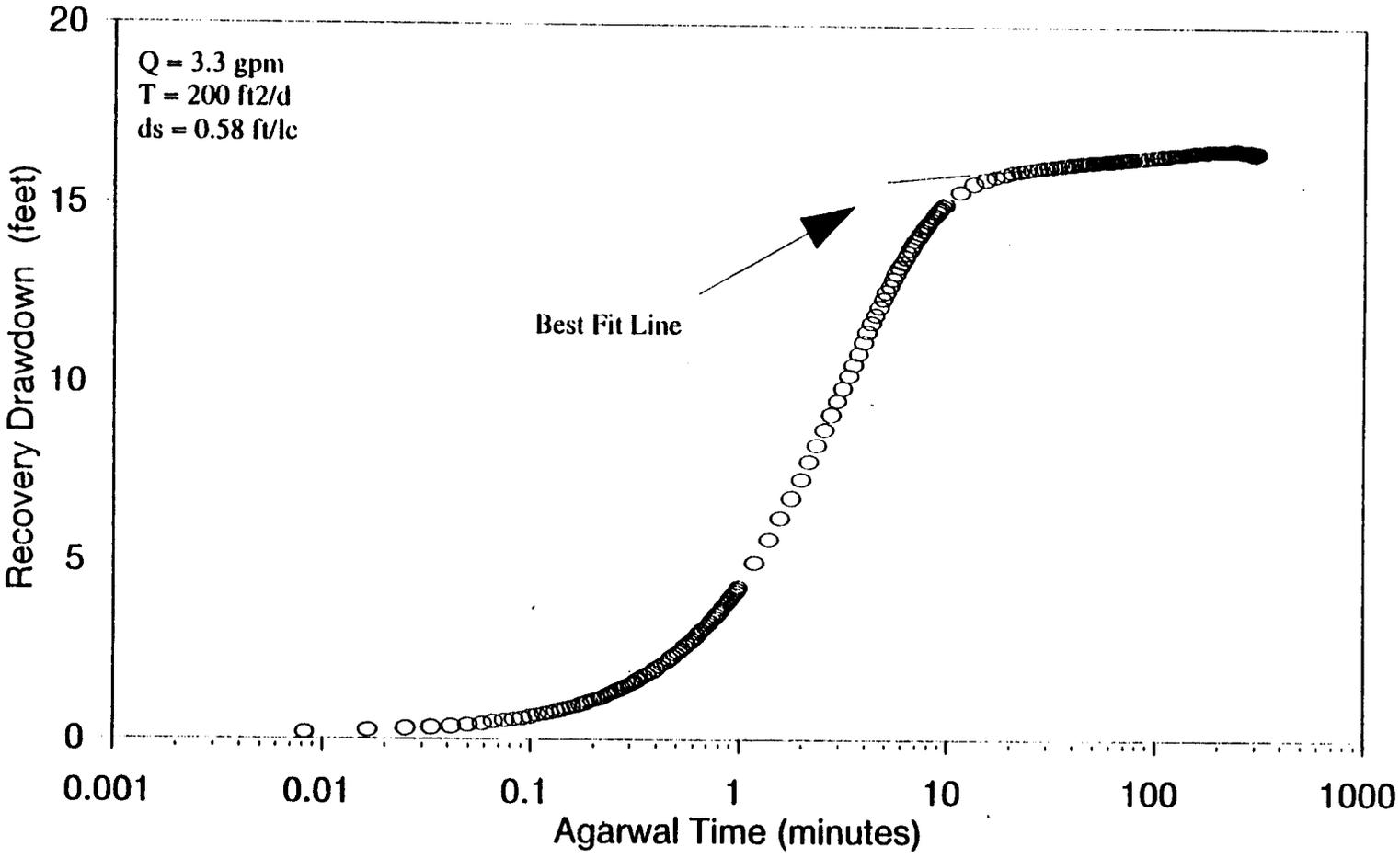


Figure E-12. Straight-Line Analysis of Agarwal Recovery Data for Well 699-41-35.

Residual Drawdown Analysis Well 41-35; March 29-30, 1993

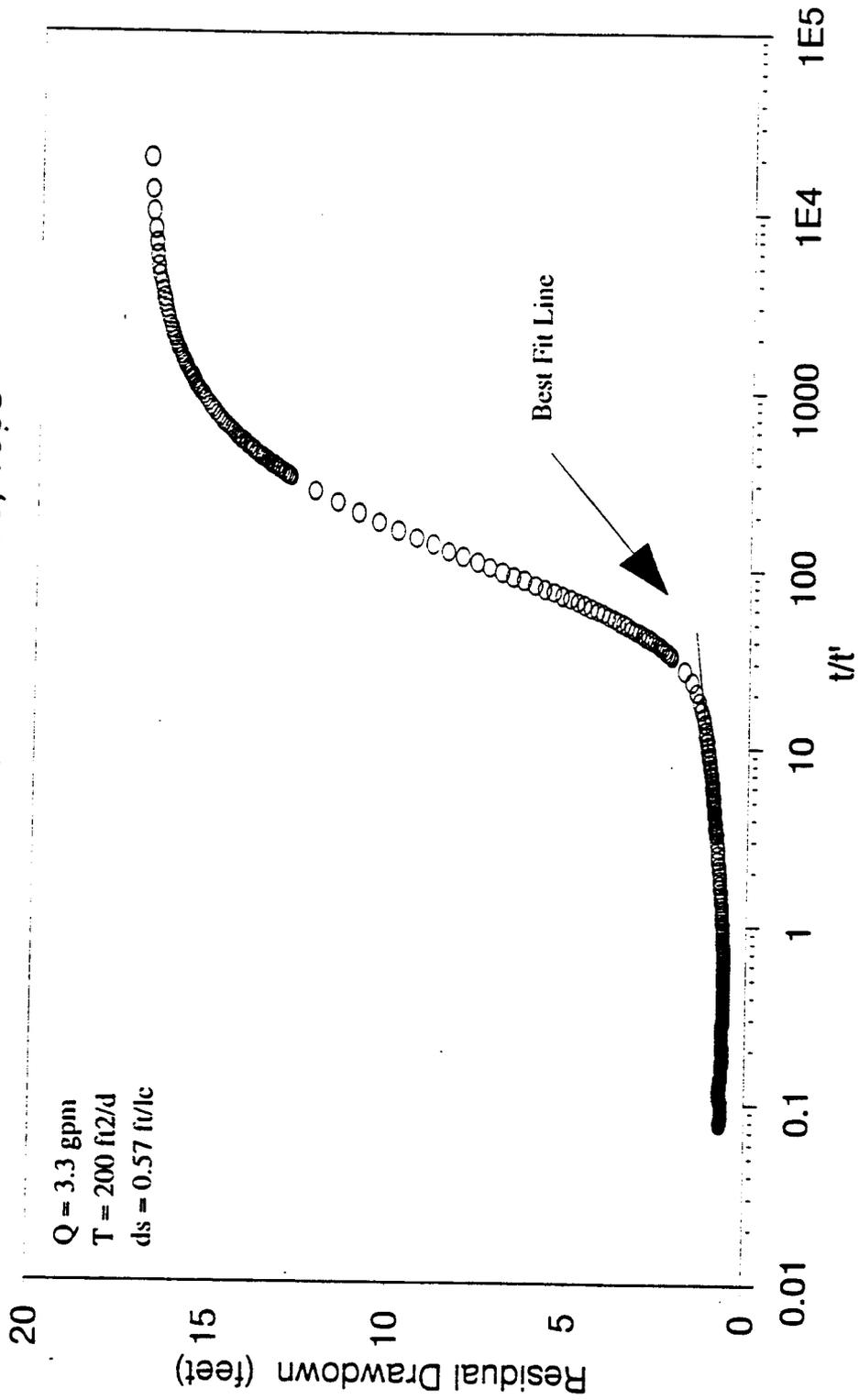


Figure E-13. Straight-Line Analysis of t/t' Residual Data for Well 699-41-35.

Recovery Pressure Derivative Analysis Well 41-35; March 29-30, 1993

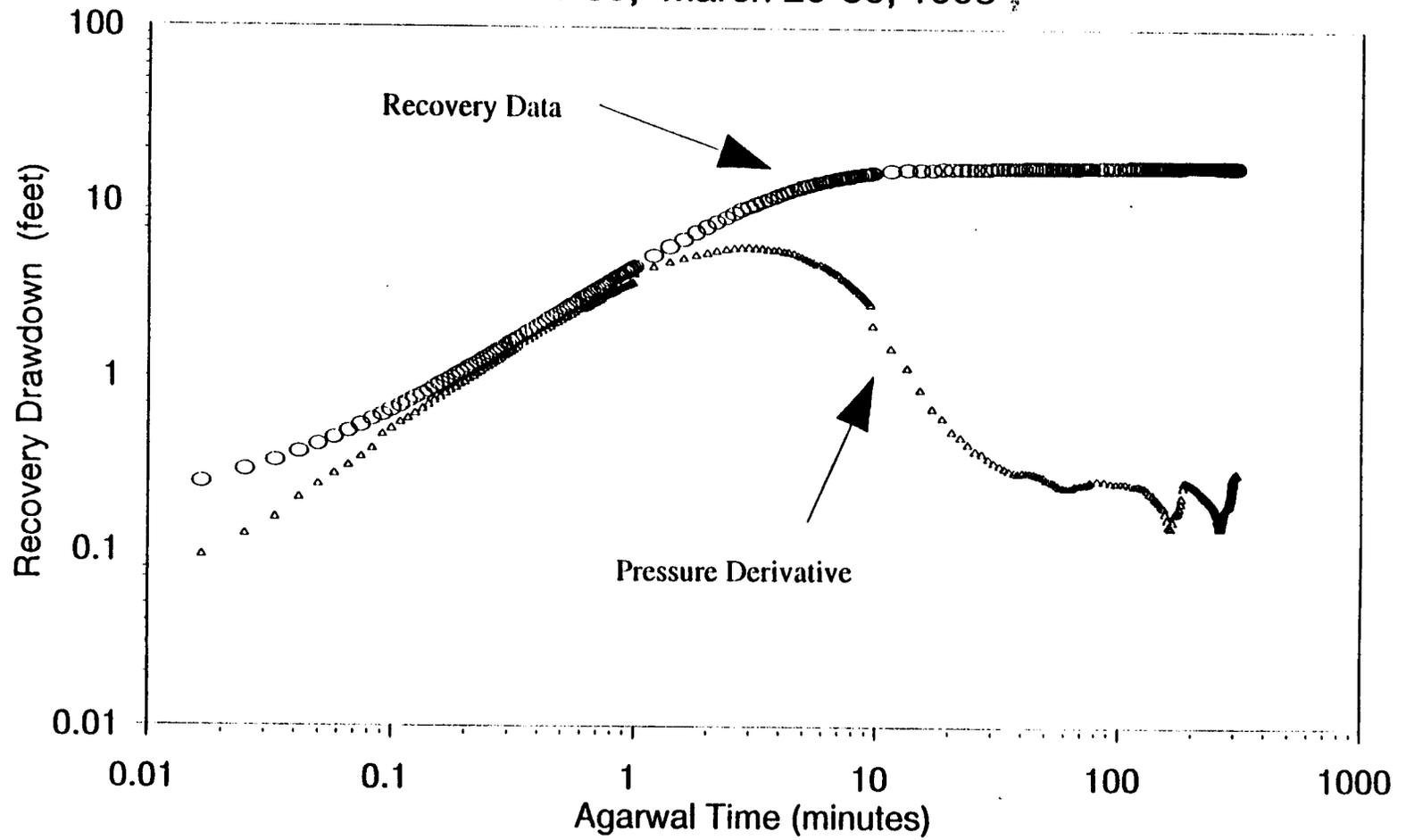


Figure E-14. Pressure Derivative Analysis of Recovery Data for Well 699-41-35.

Trend Analysis Well 41-35; March 18-22, 1993

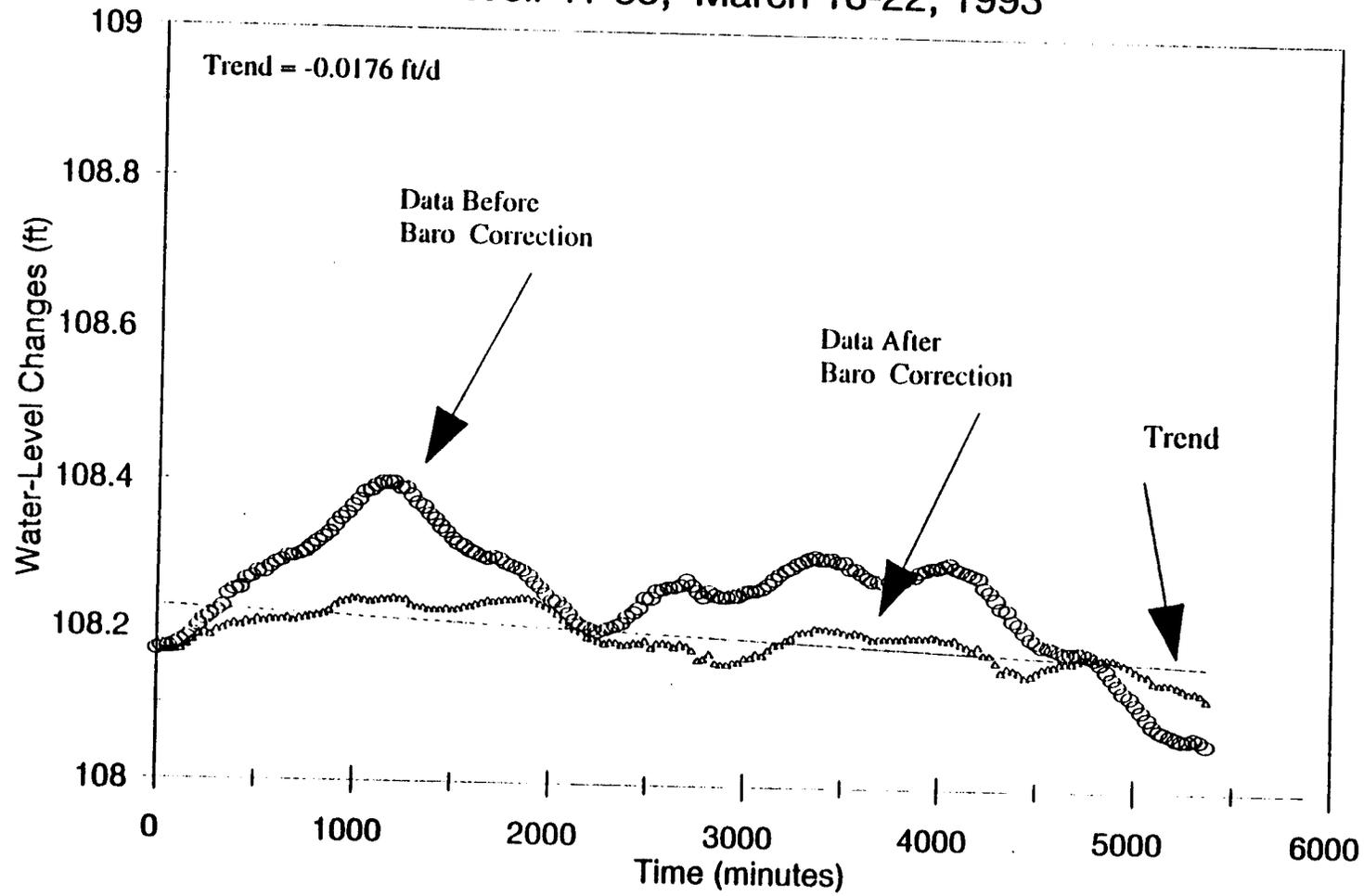


Figure E-15. Water-Level Trend Analysis for Well 699-41-35.

Barometric Efficiency Analysis Well 41-35; March 18-22, 1993

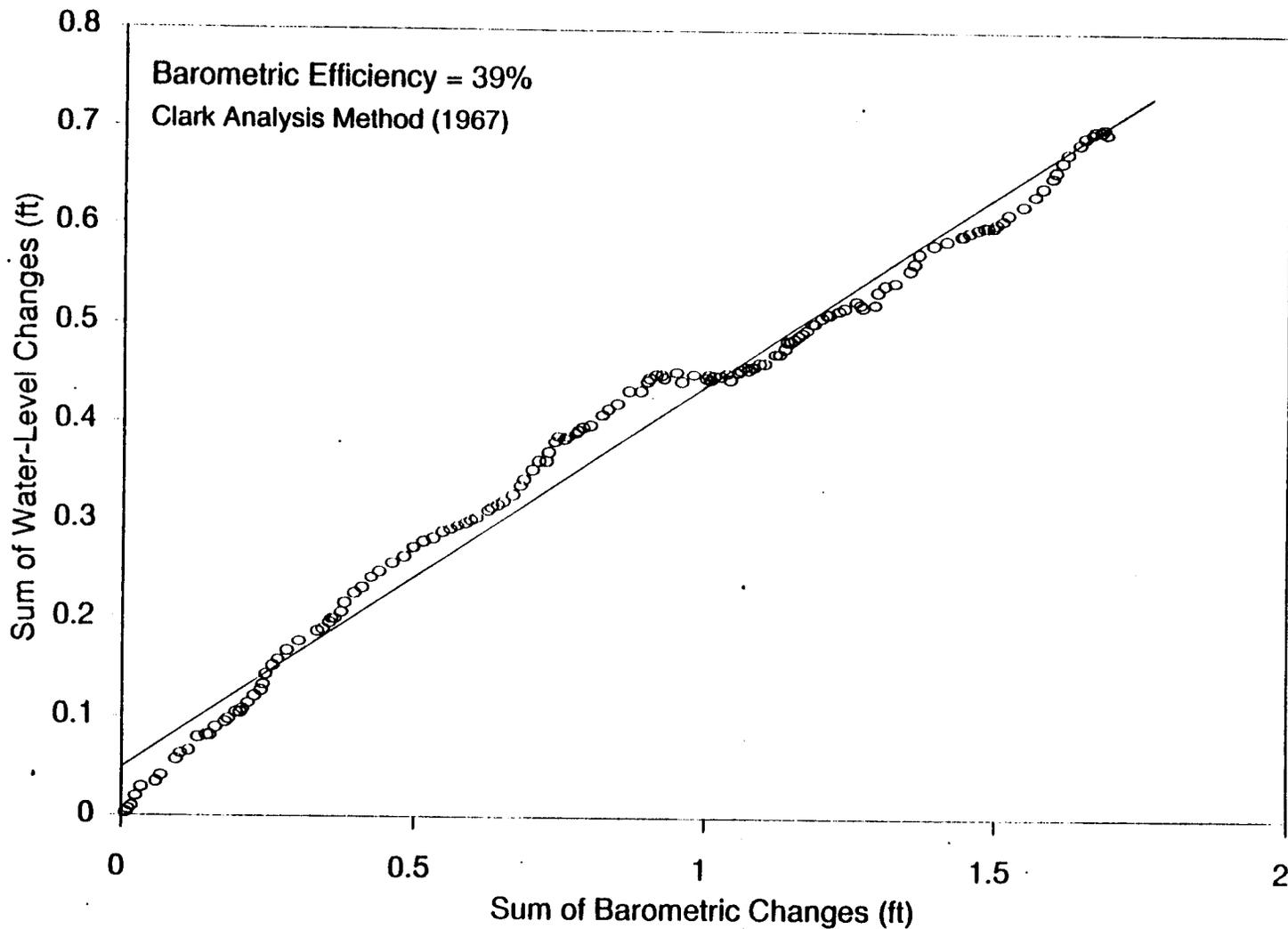


Figure E-16. Barometric Efficiency Analysis for Well 699-41-35, March 1993.

Barometric Efficiency Analysis Well 41-35; April 1993 Data

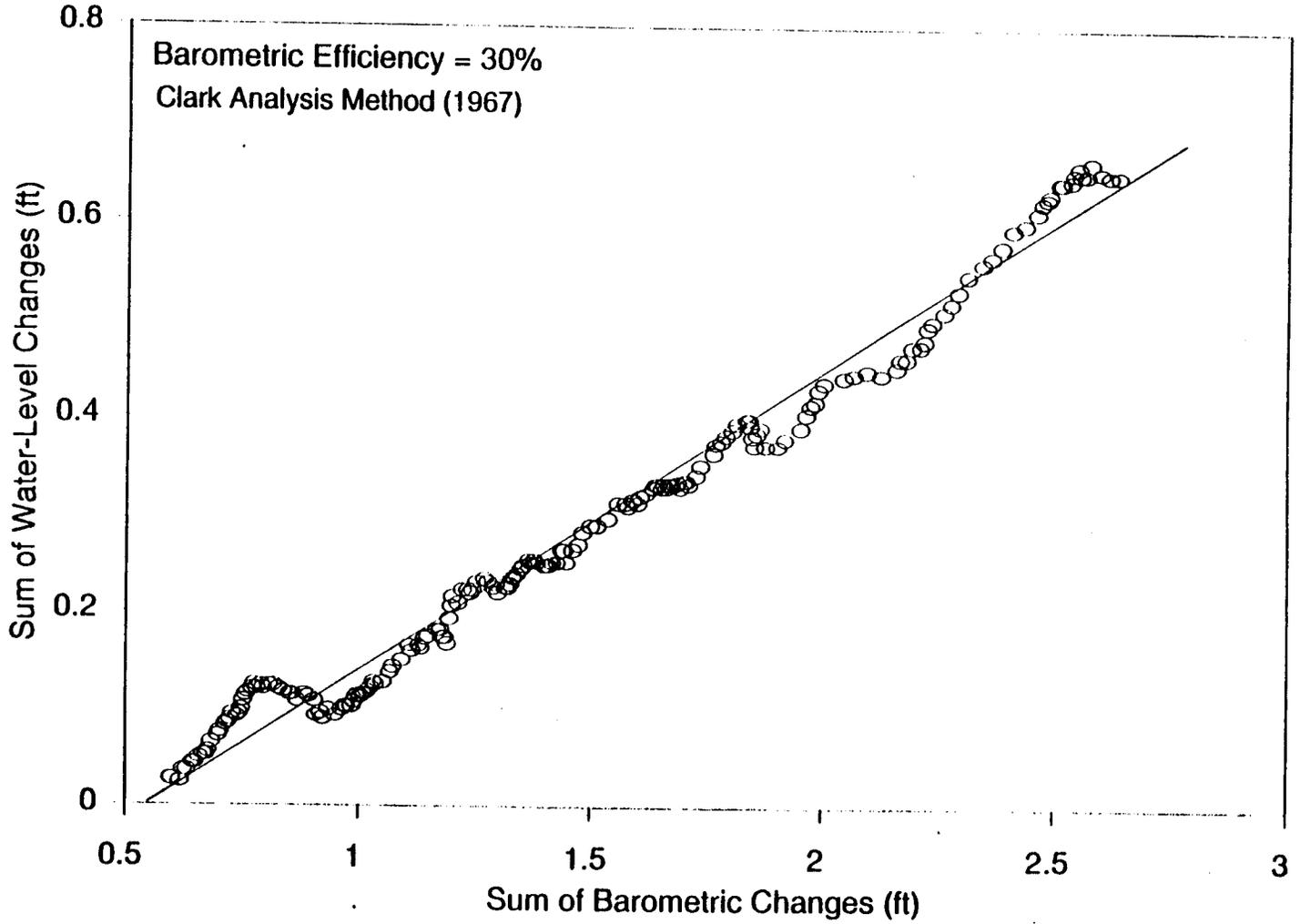


Figure E-17. Barometric Efficiency Analysis for Well 699-41-35, April 1993.

$T = 29 \text{ ft}^2/\text{d}; S = 4.6\text{E}-4$
 $rc = 0.167 \text{ ft}; rw = 0.333; Ho = 2.22 \text{ ft}$

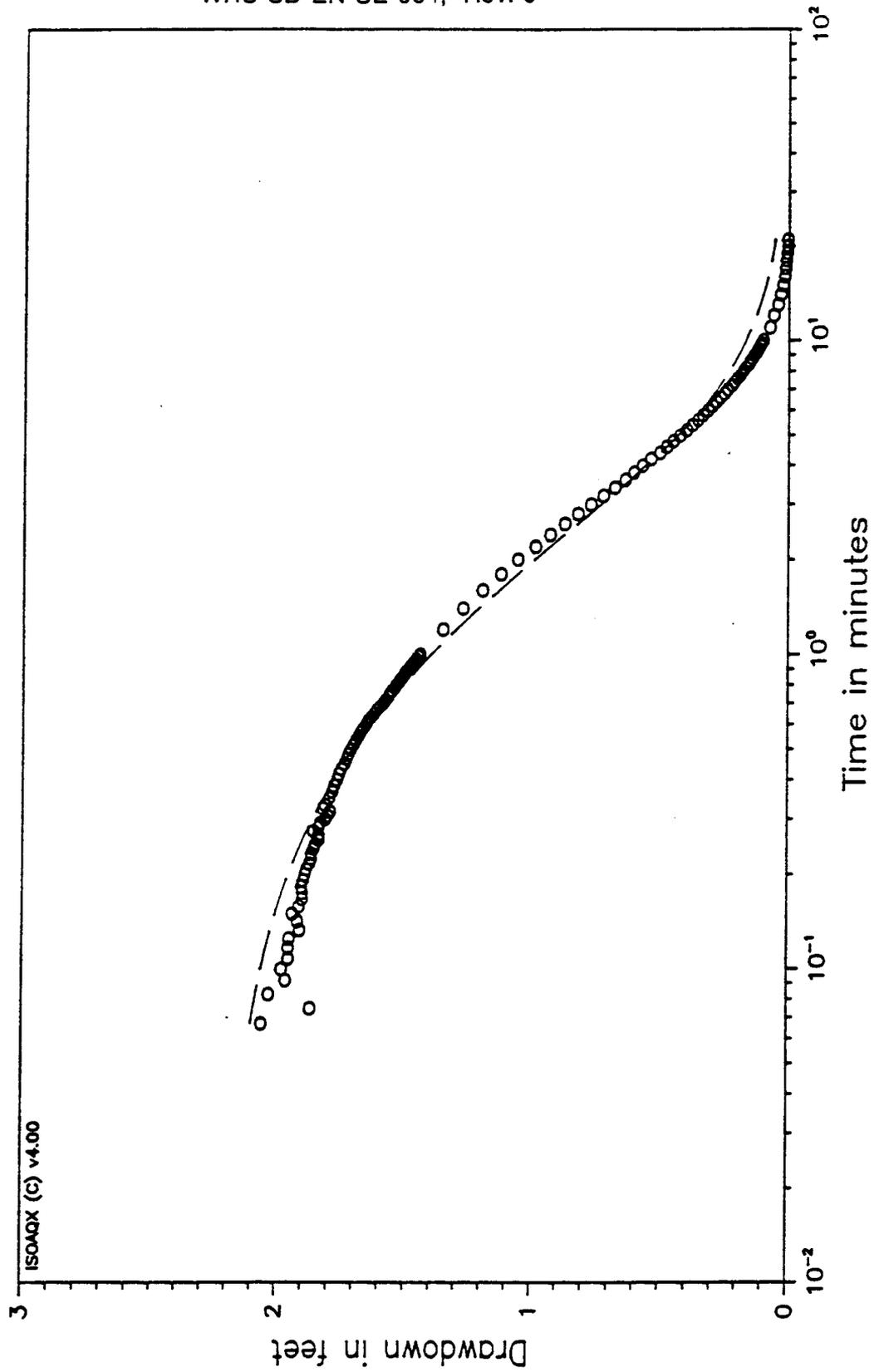


Figure E-18. Slug Injection Analysis for Well 699-41-35.

$T = 37 \text{ ft}^2/\text{d}$; $S = 1.6\text{E}-5$
 $rc = 0.167 \text{ ft}$; $r_w = 0.333$; $H_0 = 4.44 \text{ ft}$

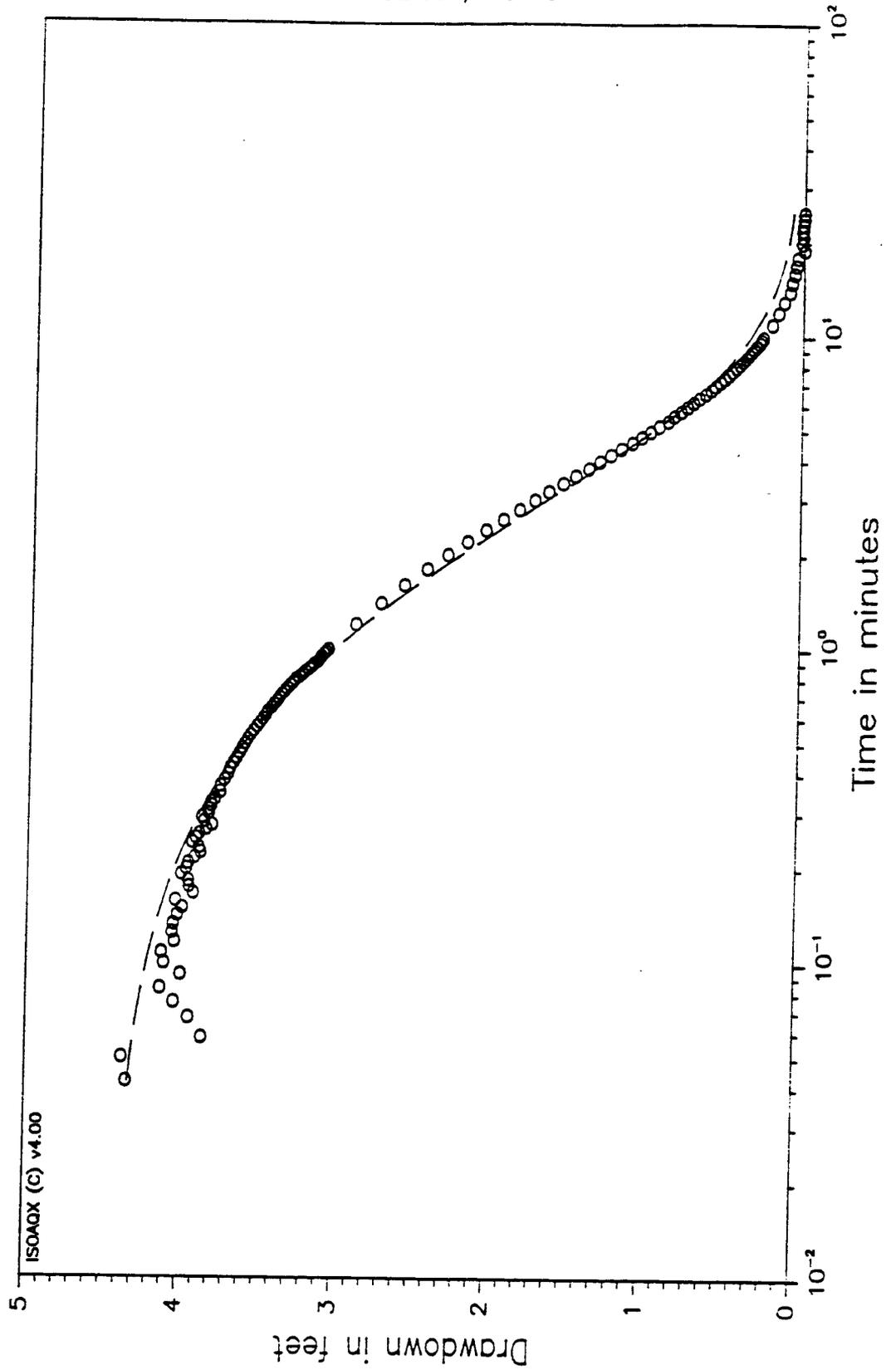


Figure E-19. Slug Injection Analysis for Well 699-41-35 Using the 0.388 ft³ Slug Rod.

$T = 23 \text{ ft}^2/\text{d}$; $S = 1.4\text{E}-3$
 $rc = 0.167 \text{ ft}$; $rw = 0.333$; $H_0 = 2.22 \text{ ft}$

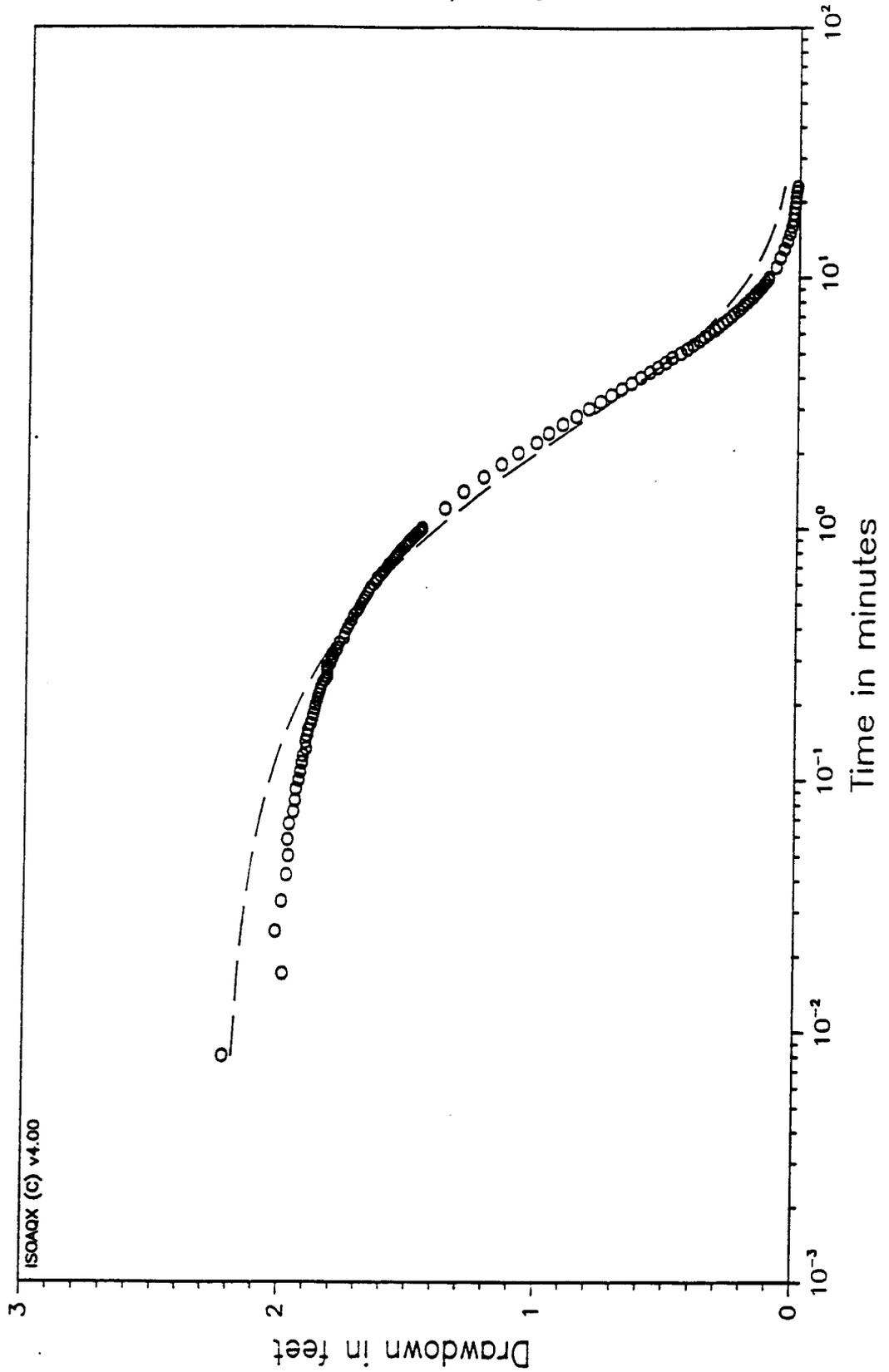


Figure E-20. Slug Withdrawal Analysis for Well 699-41-35 Using the 0.194 ft³ Slug Rod.

$T = 30 \text{ ft}^2/\text{d}; S = 1.2\text{E}-4$
 $rc = 0.167 \text{ ft}; rw = 0.333; Ho = 4.44 \text{ ft}$

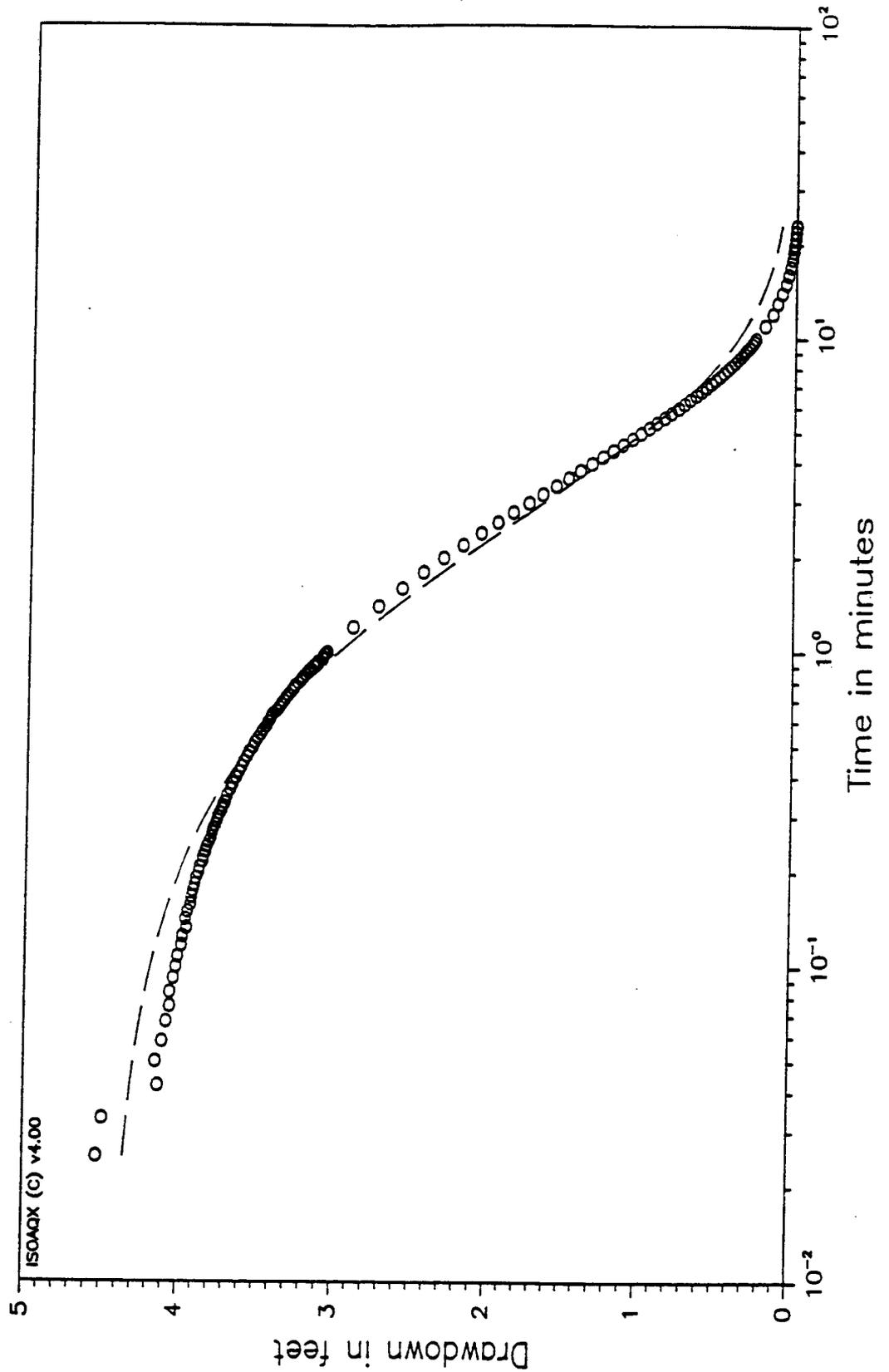


Figure E-21. Slug Withdrawal Analysis for Well 699-41-35 Using the 0.388 ft³ Slug Rod.

Drawdown Analysis
Well 42-37; March 24, 1993

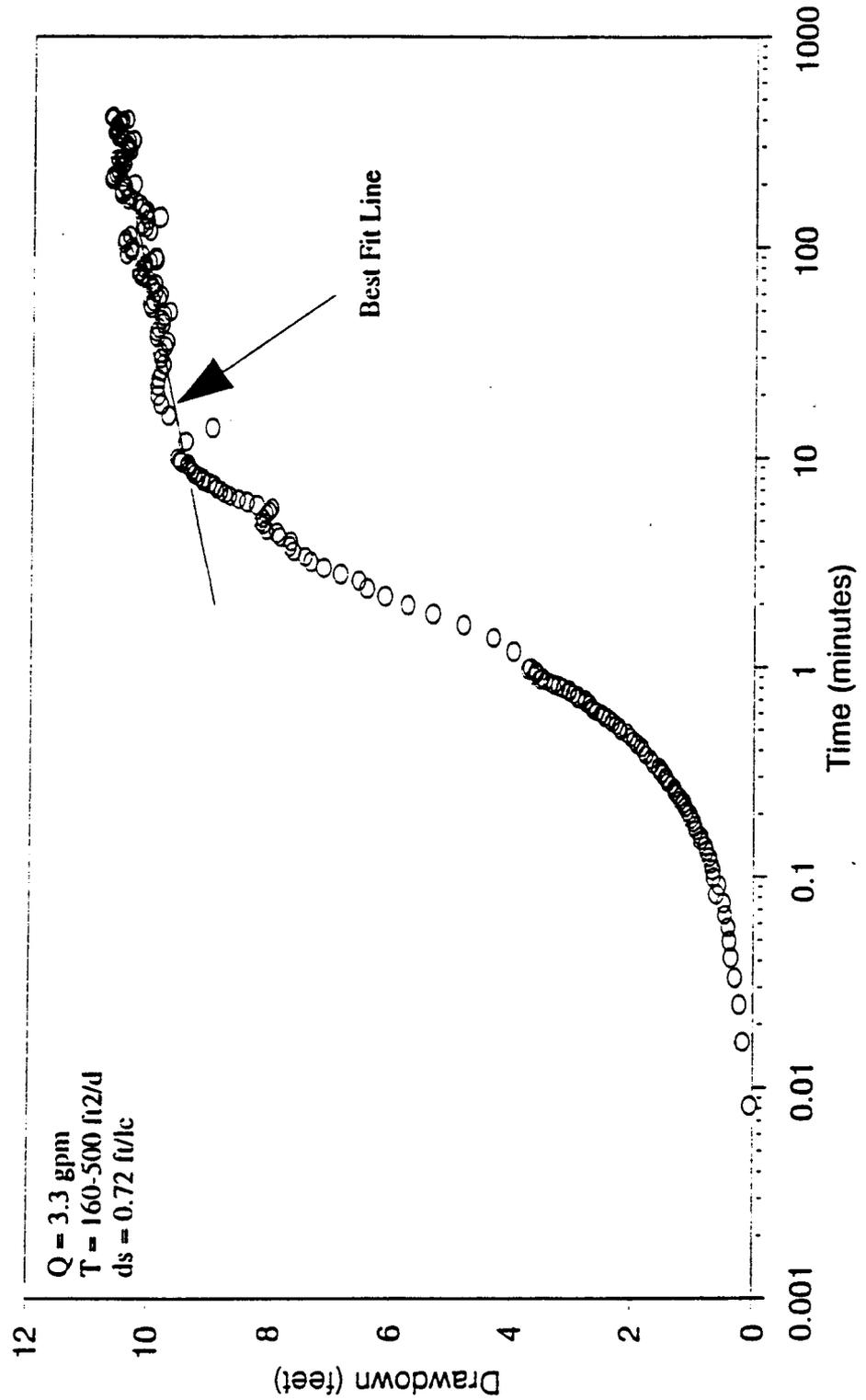


Figure E-22. Straight-line Analysis of Drawdown Data for Well 699-42-37.

Drawdown Pressure Derivative Analysis Well 42-37; March 24, 1993

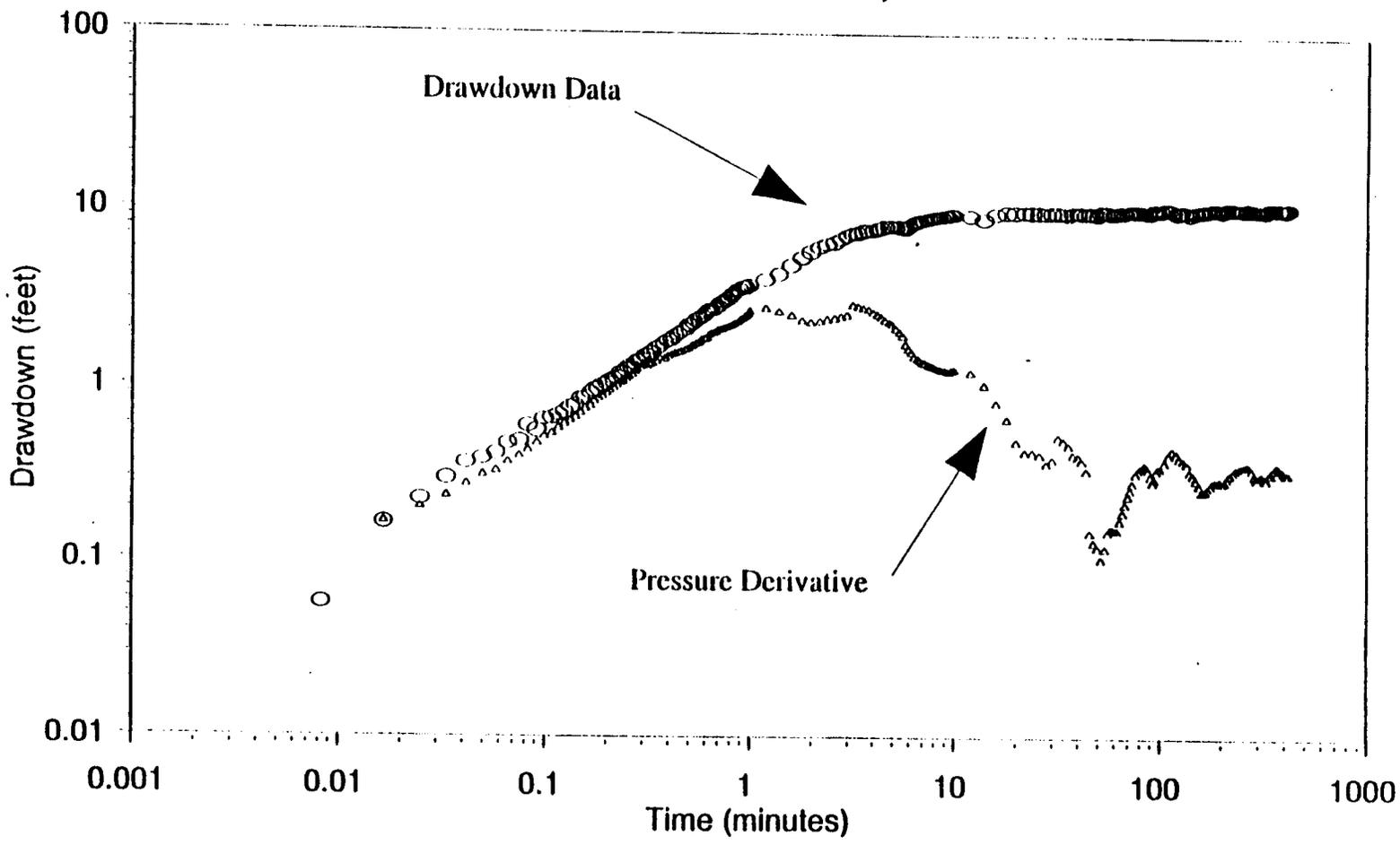


Figure E-23. Pressure Derivative Analysis of Drawdown Data for Well 699-42-37.

Recovery Analysis
Well 42-37; March 24, 1993

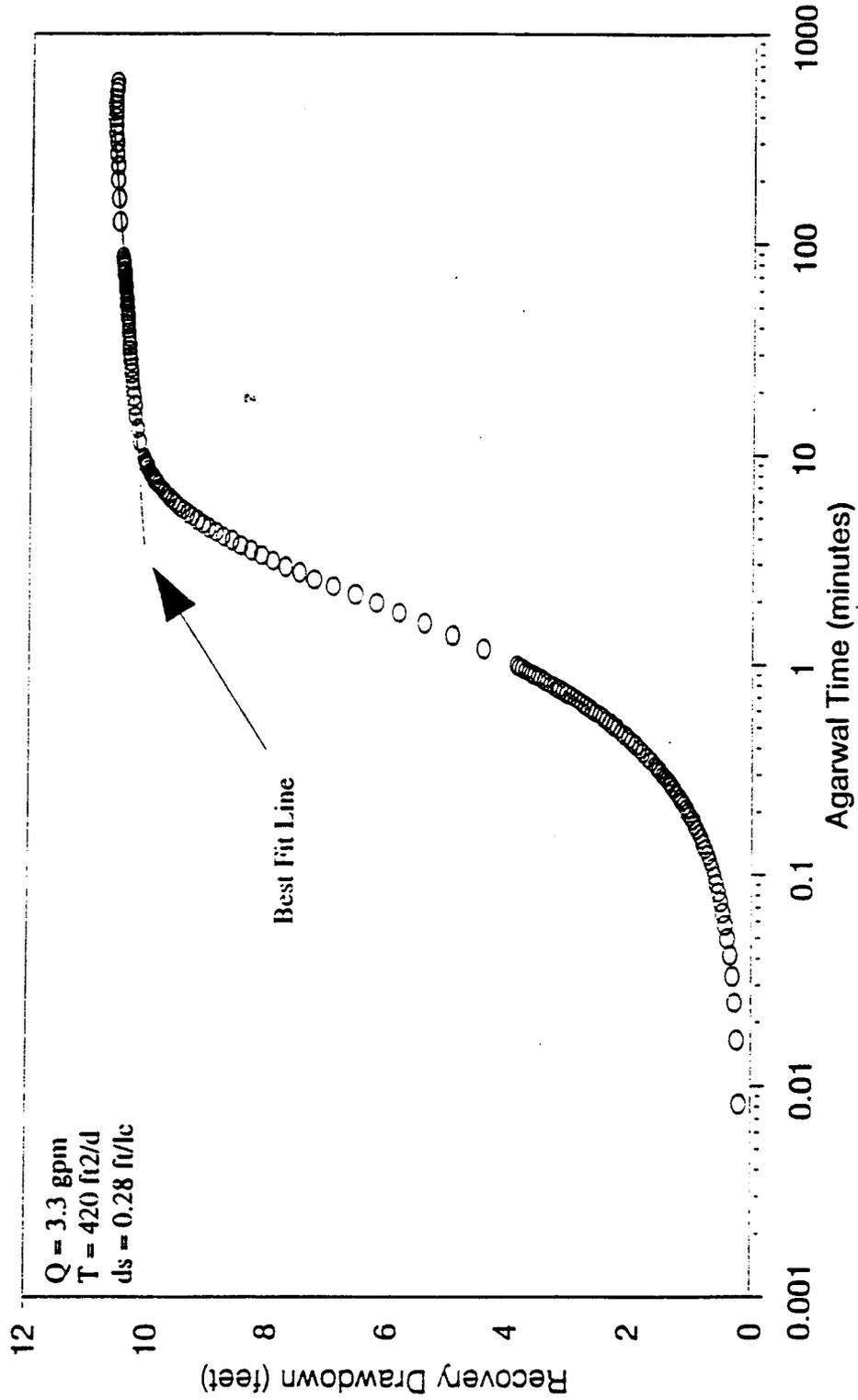


Figure E-24. Straight-Line Agarwal Analysis of Recovery Data for Well 699-42-37.

Residual Drawdown Analysis Well 42-37; March 24, 1993

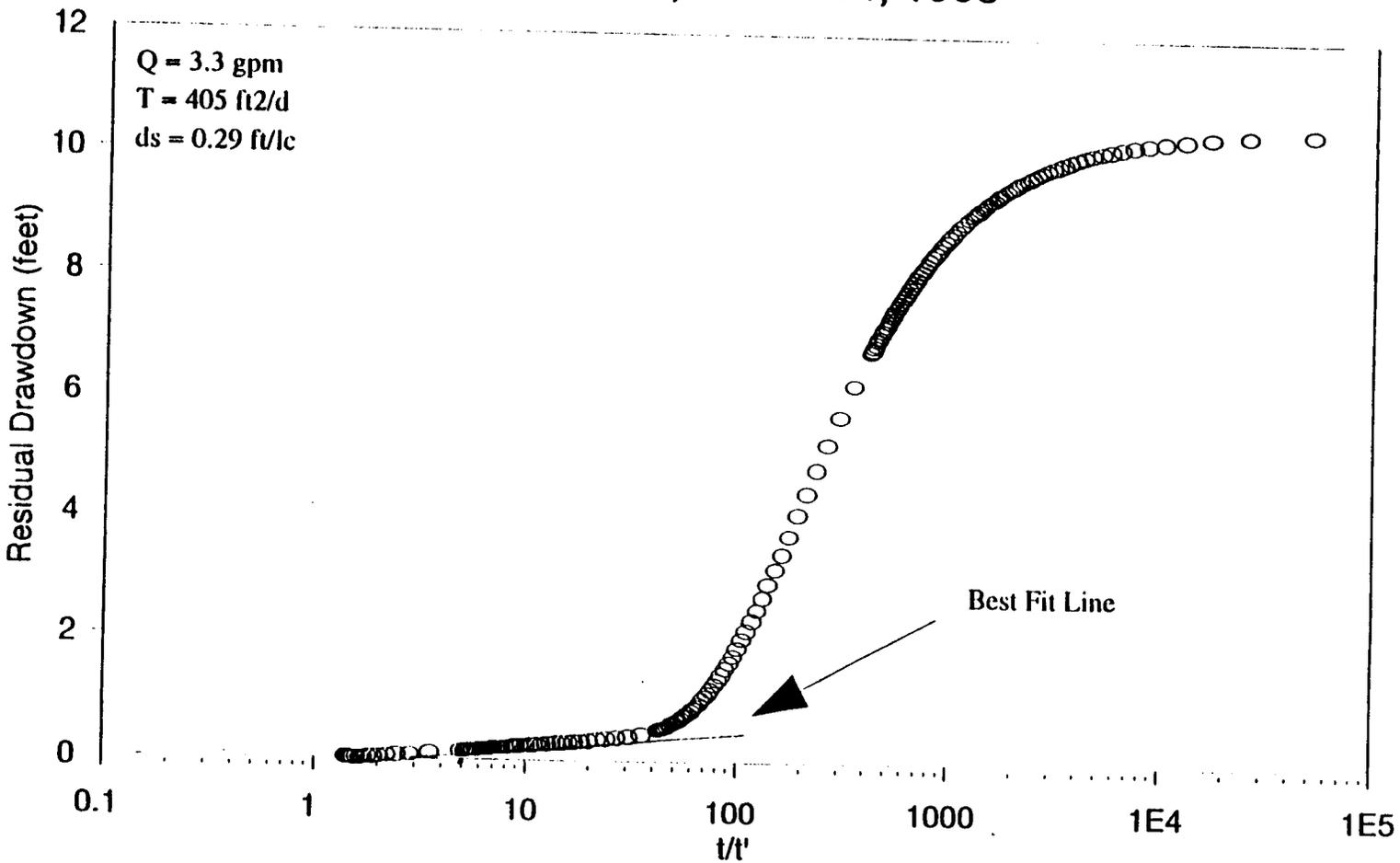
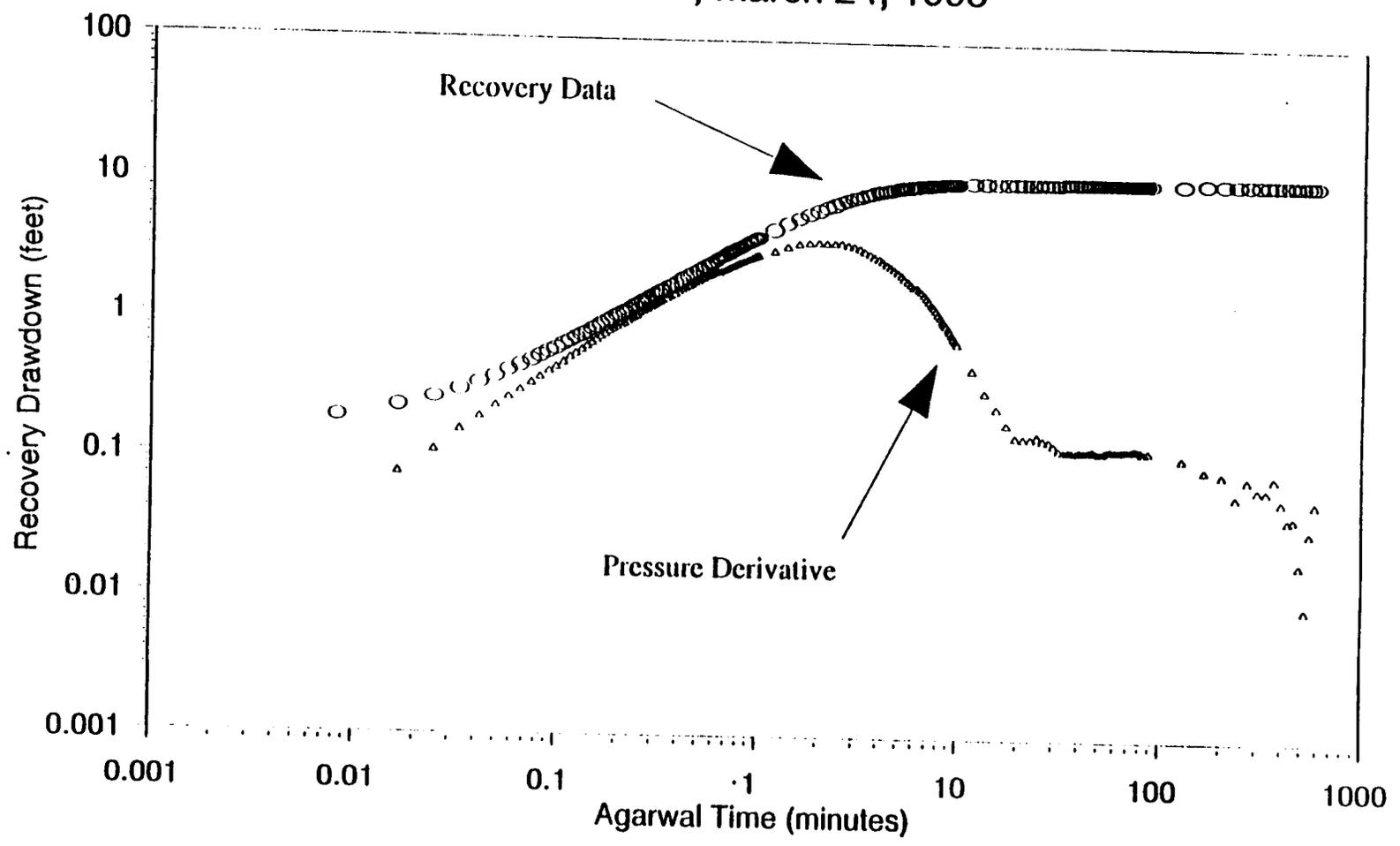


Figure E-25. Straight-Line Analysis of t/t' Residual Data for Well 699-42-37.

E-27

Recovery Pressure Derivative Analysis Well 42-37; March 24, 1993



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Figure E-26. Pressure Derivative Analysis of Recovery Data for Well 699-42-37.

Trend Analysis Well 42-37; March 18-22, 1993

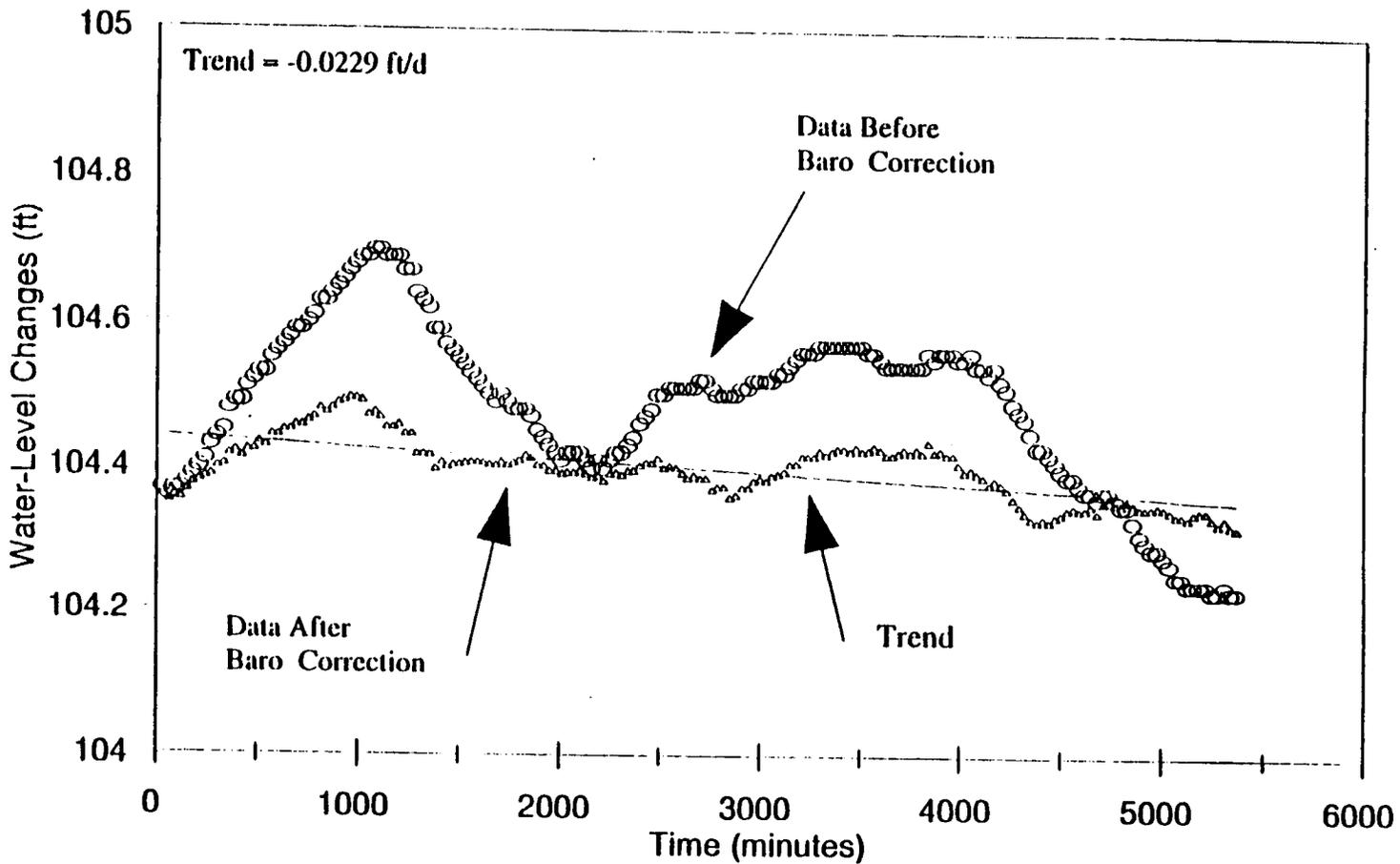


Figure E-27. Water-Level Trend Analysis for Well 699-42-37.

Barometric Efficiency Analysis
Well 42-37; March 18-22, 1993

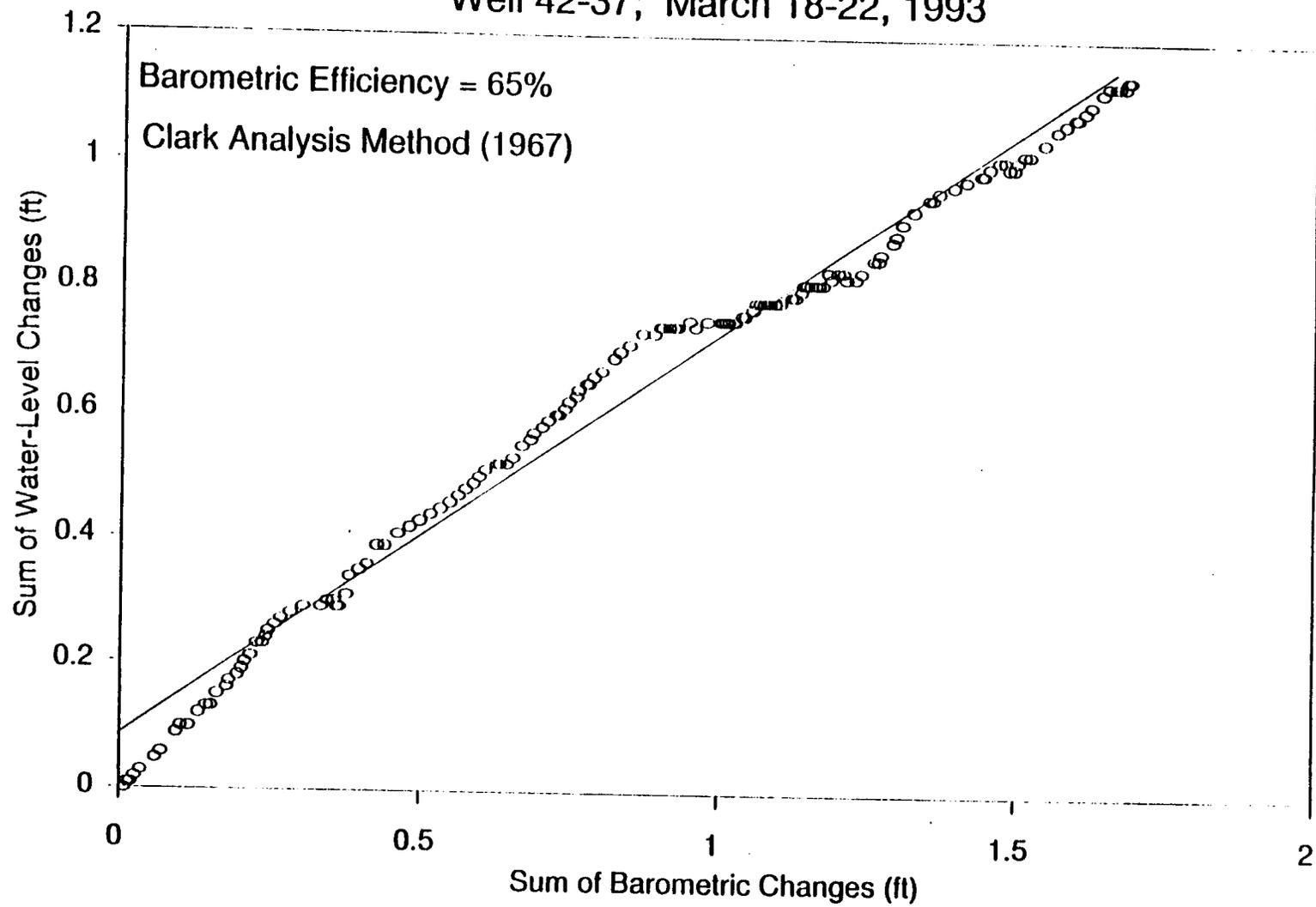


Figure E-28. Barometric Efficiency Analysis for Well 699-42-37, March 1993.

Barometric Efficiency Analysis Well 42-37; April 1993 Data

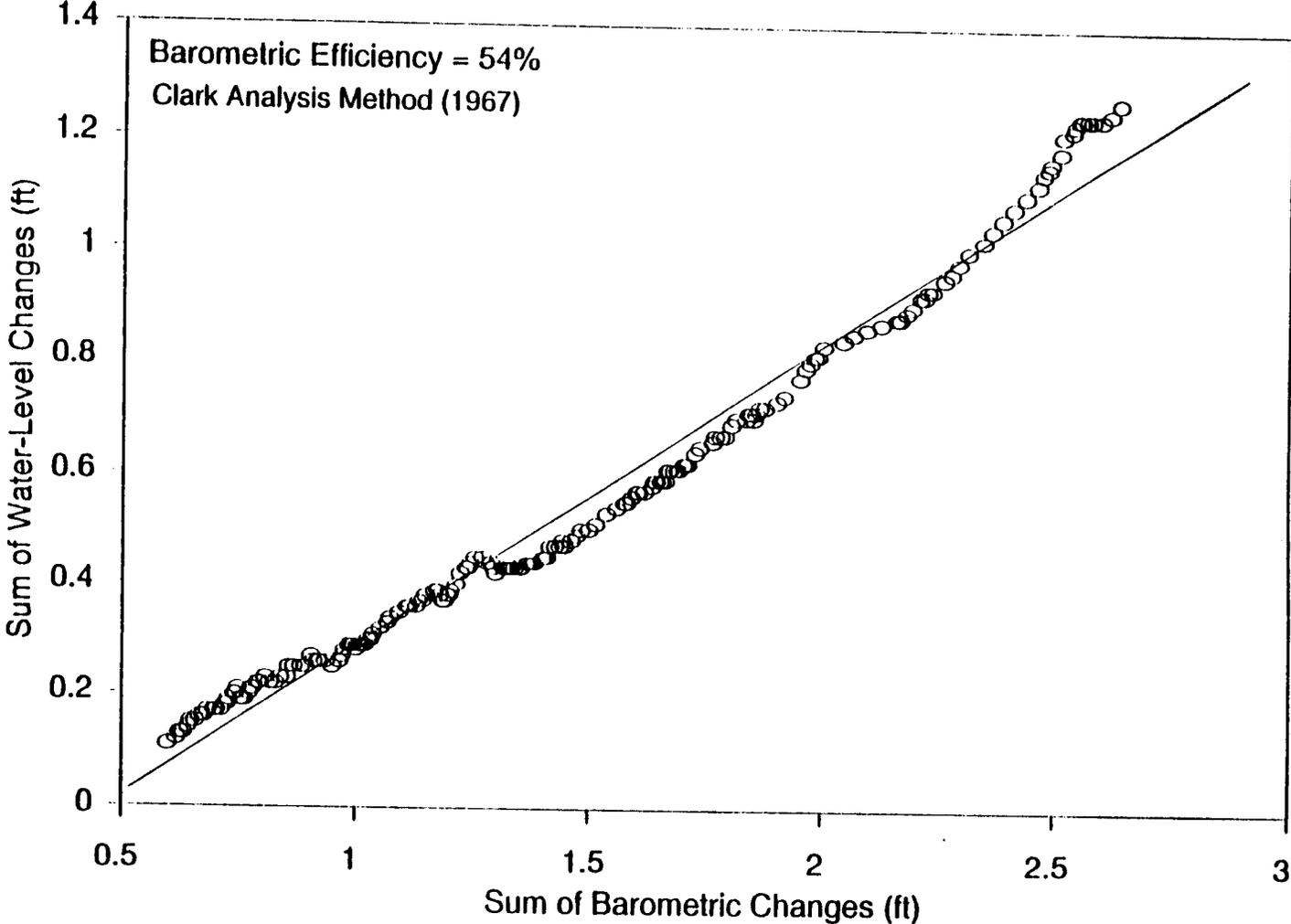


Figure E-29. Barometric Efficiency Analysis for Well 699-42-37, April 1993 Data.

$T = 38 \text{ ft}^2/\text{d}$; $S = 1.1\text{E}-3$
 $rc = 0.167 \text{ ft}$; $r_w = 0.333 \text{ ft}$; $H_o = 2.22 \text{ ft}$

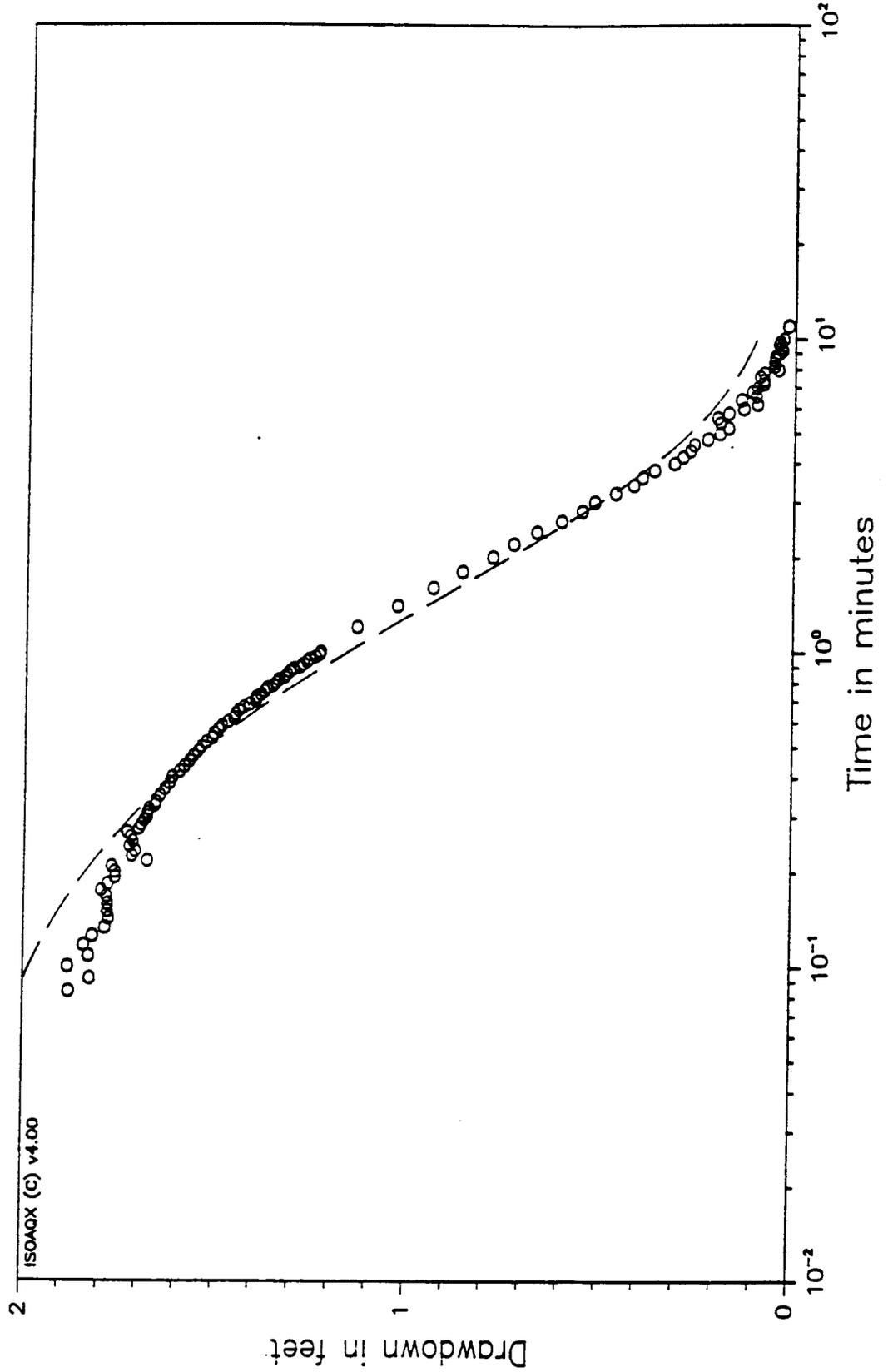


Figure E-30. Slug Injection Analysis for Well 699-42-37 Using the 0.194 ft³ Slug Rod.

$T = 32 \text{ ft}^2/\text{d}$; $S = 2.0\text{E}-3$
 $rc = 0.167 \text{ ft}$; $r_w = 0.333 \text{ ft}$; $H_o = 2.22 \text{ ft}$

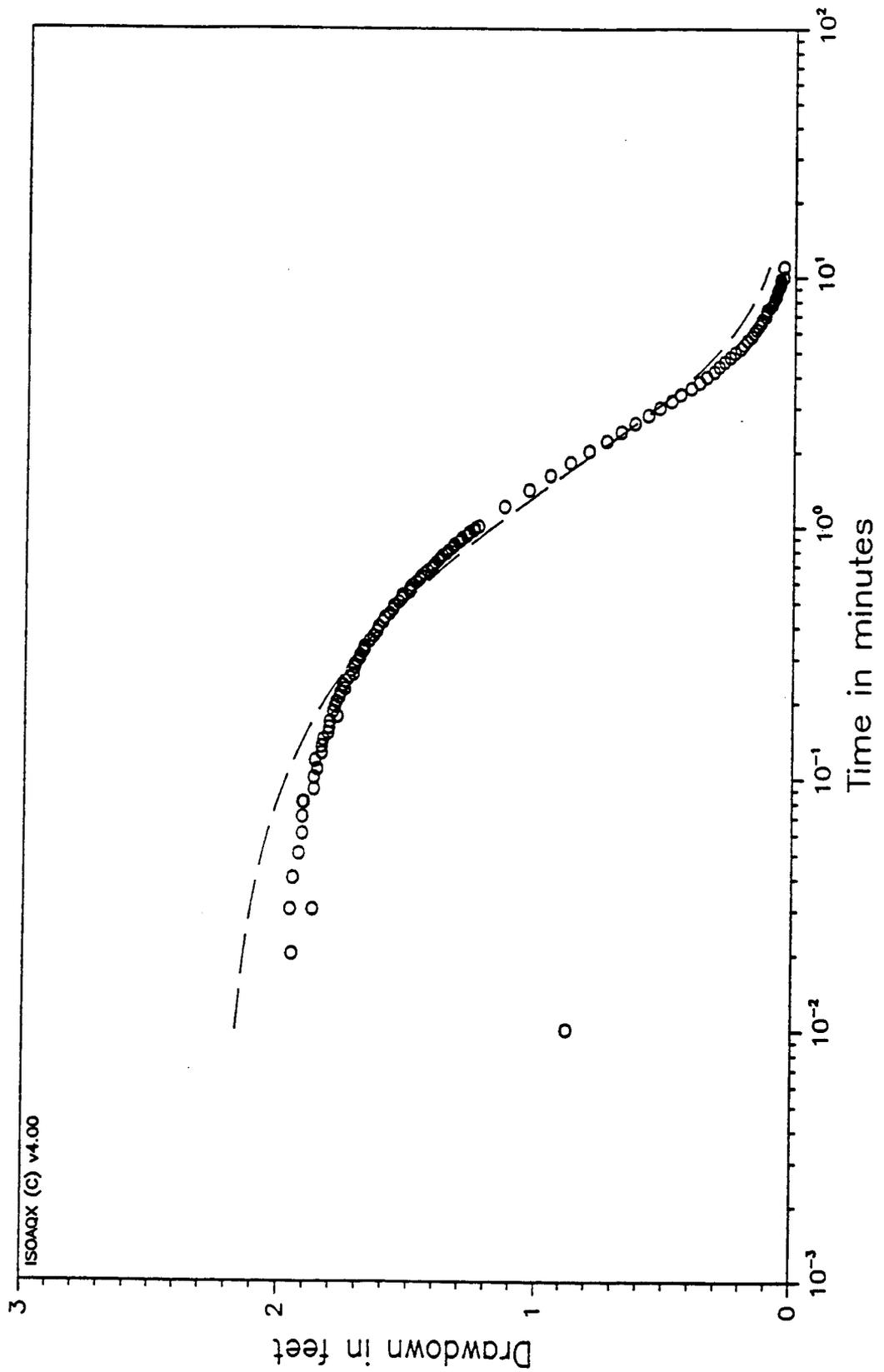


Figure E-32. Slug Withdrawal Analysis for Well 699-42-37 Using 0.194 ft³ Slug Rod.

$T = 34 \text{ ft}^2/d$; $S = 5.3E-4$
 $rc = 0.167 \text{ ft}$; $r_w = 0.333 \text{ ft}$; $H_0 = 4.44 \text{ ft}$

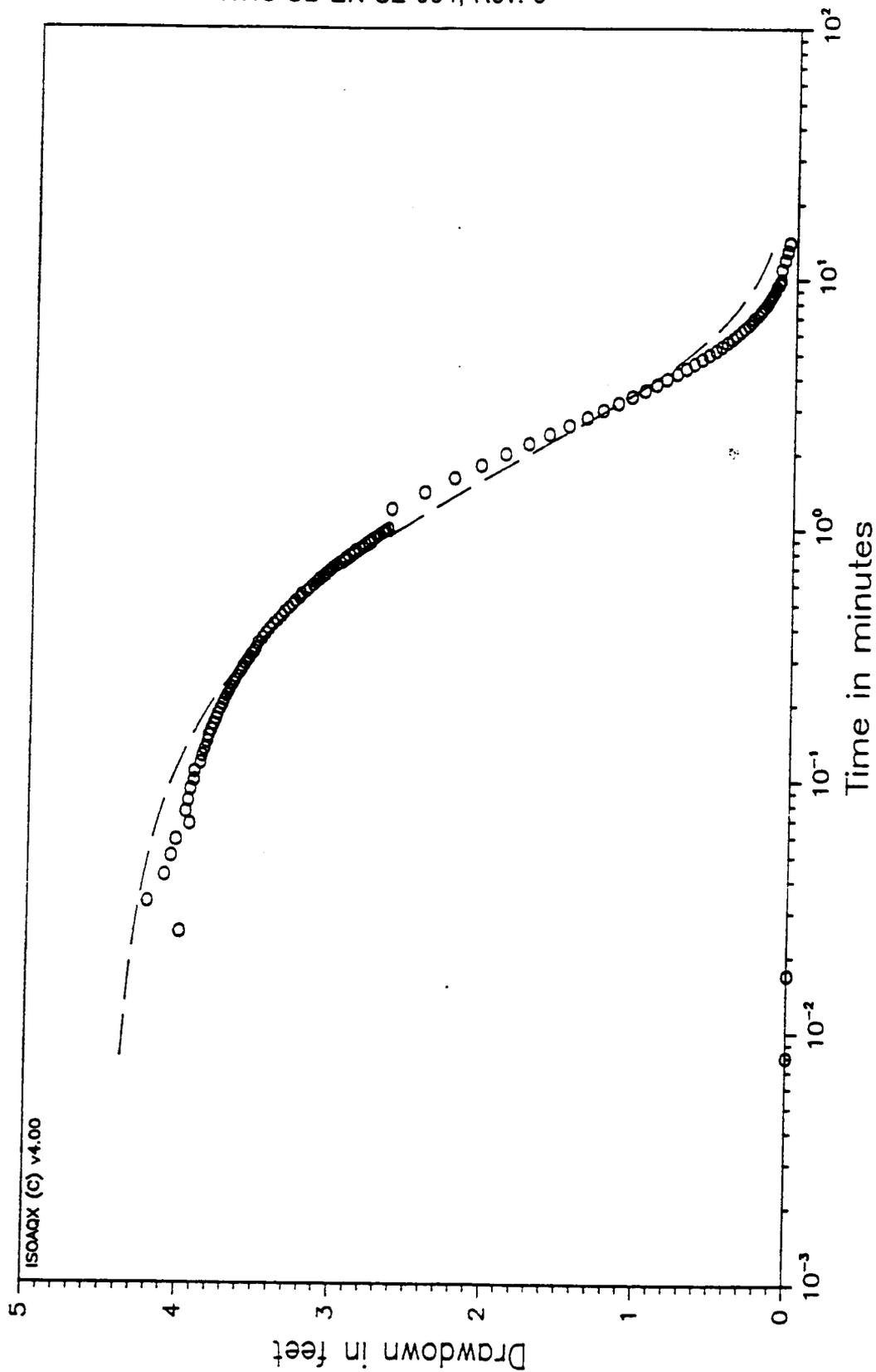


Figure E-33. Slug Withdrawal Analysis for Well 699-42-37 Using 0.388 ft³ Slug Rod.

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