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Geologic, Geochemical, Microbiologic, and Hydrologic Characterization at the In Situ Redox Manipulation Test Site

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Summary

This report documents results from characterization activities at the In Situ Redox Manipulation (ISRM) Field Test Site which is located within the 100-HR-3 Operable Unit of the U.S. Department of Energy's (DOE's) Hanford Site in Richland, Washington. Information obtained during hydrogeologic characterization of the site included sediment physical properties, geochemical properties, microbiologic population data, and aquifer hydraulic properties. The purpose of obtaining this information was to improve the conceptual understanding of the hydrogeology beneath the ISRM test site and provide detailed, site specific hydrogeologic parameter estimates. The resulting characterization data will be incorporated into a numerical model developed to simulate the physical and chemical processes associated with the field experiment and aid in experiment design and interpretation.

The uppermost unconfined aquifer is approximately 3 m (9 ft) thick beneath the ISRM test site and is contained within the sands and sandy gravels of the Hanford formation. The aquifer is underlain by a fine-grained unit of the Ringold Formation, which is typically a sandy clayey silt to clayey silt. The spatial continuity of this uppermost, fine-grained Ringold unit was observed during hydrogeologic characterization activities at the ISRM test site and is supported by hydrochemical data from across the 100-HR-3 Operable Unit that indicates contamination does not extend beyond the uppermost part of the unconfined aquifer. In February and March 1995, 16 wells were drilled and installed within the uppermost unconfined aquifer beneath the ISRM test site.

The ISRM well installation consists of one injection withdrawal well completed over the lower 1.5 m (5 ft) of the aquifer, three upper piezometers, nine lower piezometers, and three downgradient monitoring wells. The screens for the upper and lower piezometers were 0.76 m (2.5 ft) in length and were placed to monitor the upper and lower portions of the aquifer, respectively. The screens for the downgradient monitoring wells were 3 m (10 ft) in length and fully penetrate the uppermost unconfined aquifer. The static water table is located at a depth of 12.5 m (41.1 ft) below ground surface.

Sediment samples were collected during installation of six ISRM test site wells over the depth interval from approximately 12.2 m (40 ft) to total depth (16.5 m [54 ft]). The primary focus of the split-spoon sampling was collection of samples for physical property analyses (i.e., moisture content, sieve, particle density, bulk density, hydrometer, and porosity), chemical analyses (i.e., ferrous/ferric iron, total metals, and bulk mineralogy), and characterization of microbiological populations. Lithologic descriptions were primarily made within the interval sampled (>12.2 m depth).

The uppermost unconfined aquifer beneath the test site can be described as containing two hydrofacies: 1) a lower unit dominated by a sandy gravel (the lower 1.8 to 2.1 m [6 to 7 ft] of the aquifer), and 2) an upper unit dominated by sand (the upper 0.9 to 1.2 m [3 to 4 ft] of the aquifer). Preliminary geochemical analyses indicate available iron(III) ranges from 0.038 to 0.212% by weight for Hanford formation sediments and 0.73% by weight for Ringold Formation sediments. Microbiologic analyses indicate low microbiological populations.

Hydraulic tests conducted at the ISRM test site included several single well slug displacement tests conducted during well installation and a constant-rate discharge test that included pressure response monitoring at 15 locations across the site. Analysis of test response data indicate the following "best estimate" for test site-scale hydraulic properties: transmissivity = 250 m^2/d (2700 ft^2/d); effective hydraulic conductivity = 90 m/d (300 ft/d); storativity = 0.0055; specific yield = 0.037; and vertical anisotropy ($K_D = K_v/K_h$) = 0.06.

Of the hydraulic properties determined, only transmissivity exhibited any spatial dependence. A general dependence between transmissivity and well screen/aquifer depth was indicated. A possible decreasing transmissivity with increasing depth relationship is consistent with geologic descriptions of well logs available for the ISRM test site. In addition, a general relationship of increasing

transmissivity with increased distance from pumping well H5-2 was indicated. This general association was exhibited irrespective of azimuth direction for observation wells at the ISRM test site. The cause for this distance correspondence is not known. This distance dependence may be associated with changes in aquifer characteristics (e.g., increasing aquifer thickness or hydraulic conductivity with distance), or inherent deficiencies in the analytical solution for analyzing tests conducted in shallow thin unconfined aquifers.

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Trademarks

Lexan is a registered trademark of General Electric Company, Pittsfield, Massachusetts.

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1.0 Introduction

Pacific Northwest Laboratory's (PNL) In Situ Redox Manipulation (ISRM) Project began in fiscal year (FY) 1991 through the U.S. Department of Energy's (DOE's) Office of Health and Environmental Research - Subsurface Science Program. As part of this ISRM project, laboratory proof-of-principle abiotic and biotic studies, conceptual design, and preliminary planning documents were prepared (Fruchter et al. 1994). The potential for a remediation technology based on in situ manipulation of subsurface redox conditions has been established through theory and laboratory experiments. However, attempts to control redox potential in an aquifer must overcome various scale-up complications arising from the interaction between contaminants, reducing agents, groundwater, and the natural variability of the subsurface. Ongoing laboratory-scale, intermediate-scale, and field-scale experiments, in addition to design studies that incorporate this multiscale information, are being funded through DOE's Office of Technology Development's (OTD) Integrated Program (IP). This multiscale approach will provide a means to evaluate the ability to scale and extrapolate the laboratory chemistry and microbiology studies under the less controlled (i.e., uncertain) conditions posed by the in situ environment. A more detailed description of the ISRM project and the associated redox manipulation technology can be found in the ISRM test plan (Fruchter et al. 1995).

Interpretation of the field experiment is dependent on the ability to control the conditions of the experiment and monitor performance at the field scale. During FY 1994, a site selection and regulatory approval document was prepared by the ISRM project. Several criteria were developed to provide guidance during the site selection process; site selection criteria included regulatory, well installation cost, hydrogeologic, geochemical, and site access components. These criteria were used during the site selection process to identify the best site for assessing the feasibility of the ISRM concept. The scope of the site selection was limited to the Hanford Site; this was primarily because of logistics (e.g., staff and equipment on site) and favorable regulatory precedents (e.g., existing permits and approvals).

A search of potential locations on the Hanford Site resulted in selection of the 100-H Area for the ISRM field test site. The site is located in the vicinity of Hanford Site well 199-H5-1A (abbreviated H5-1A) and 199-H5-1B (H5-1B), approximately 260 m (850 ft) south of H Reactor (Figure 1.1) and is outside the main contamination plume for constituents of primary concern in the 100-H Area. The site, as configured for the redox manipulation experiment, consists of one 20-cm (8-in) diameter injection/withdrawal well and fifteen 5-cm (2-in) diameter monitoring wells, located at various radial distances from the injection/withdrawal well (Figure 1.2). Two preexisting wells (H5-1A and H5-1B) are located at the ISRM test site; because these wells were not constructed to the same design specifications as wells installed for the field demonstration, they will not be utilized as primary monitoring wells.

The following sections document characterization activities at the ISRM field test site during FY 1995. The report contains brief descriptions of the hydrogeology of the 100-H Area (Section 2.0), the well installations at the field test site (Section 3.0), geologic characterization (Section 4.0), hydrologic characterization (Section 5.0), and groundwater chemistry (Section 6.0). These sections are followed by conclusions (Section 7.0) interpreted from the characterization data and the references used (Section 8.0). More detailed characterization data and descriptions of analytical techniques used are contained in the appendixes.

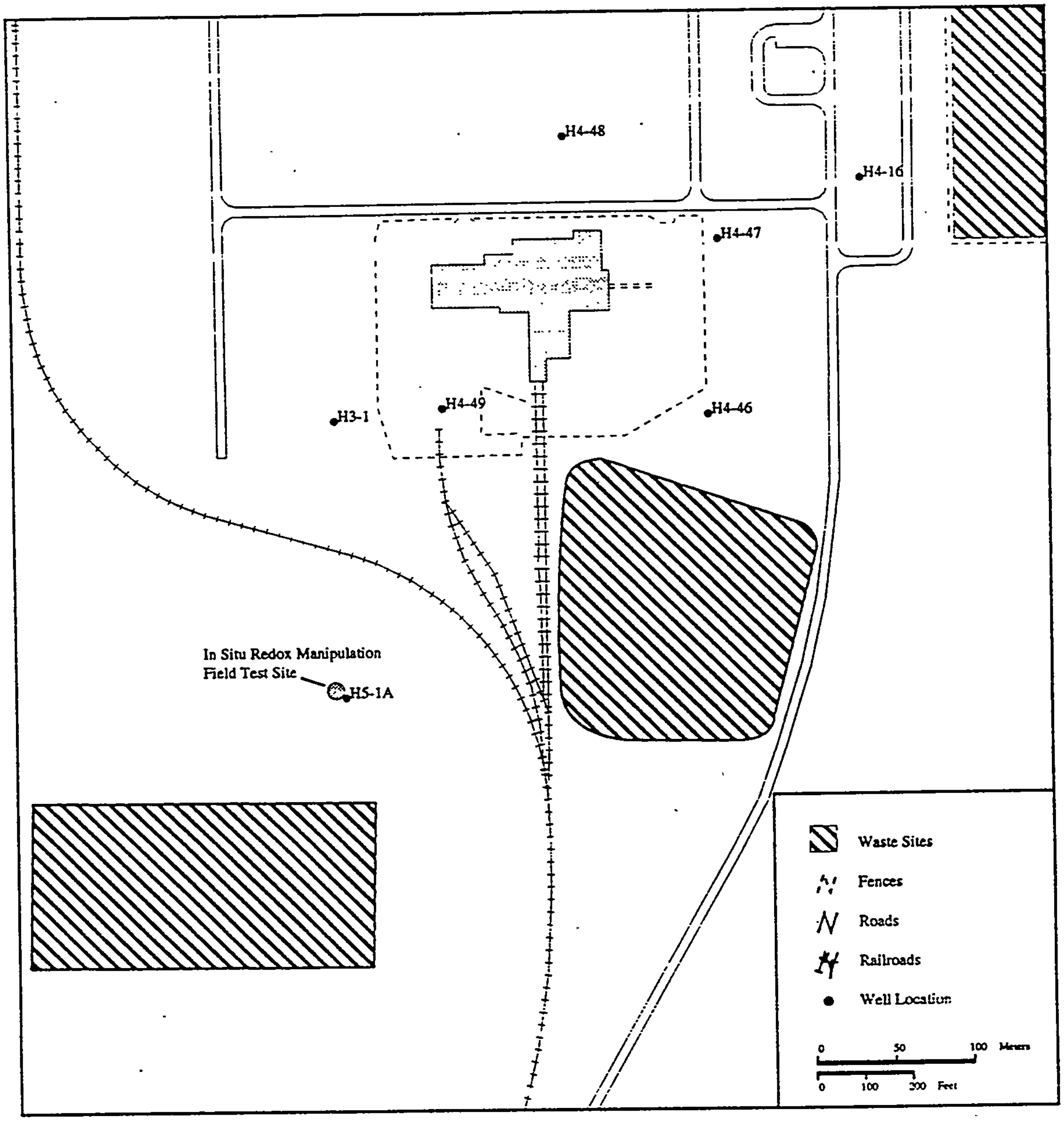

Figure 1.1. Location Map for the In Situ Redox Manipulation Field Test Site. The location is near H Reactor in the 100-H Area of the 100-HR-3 Operable Unit.

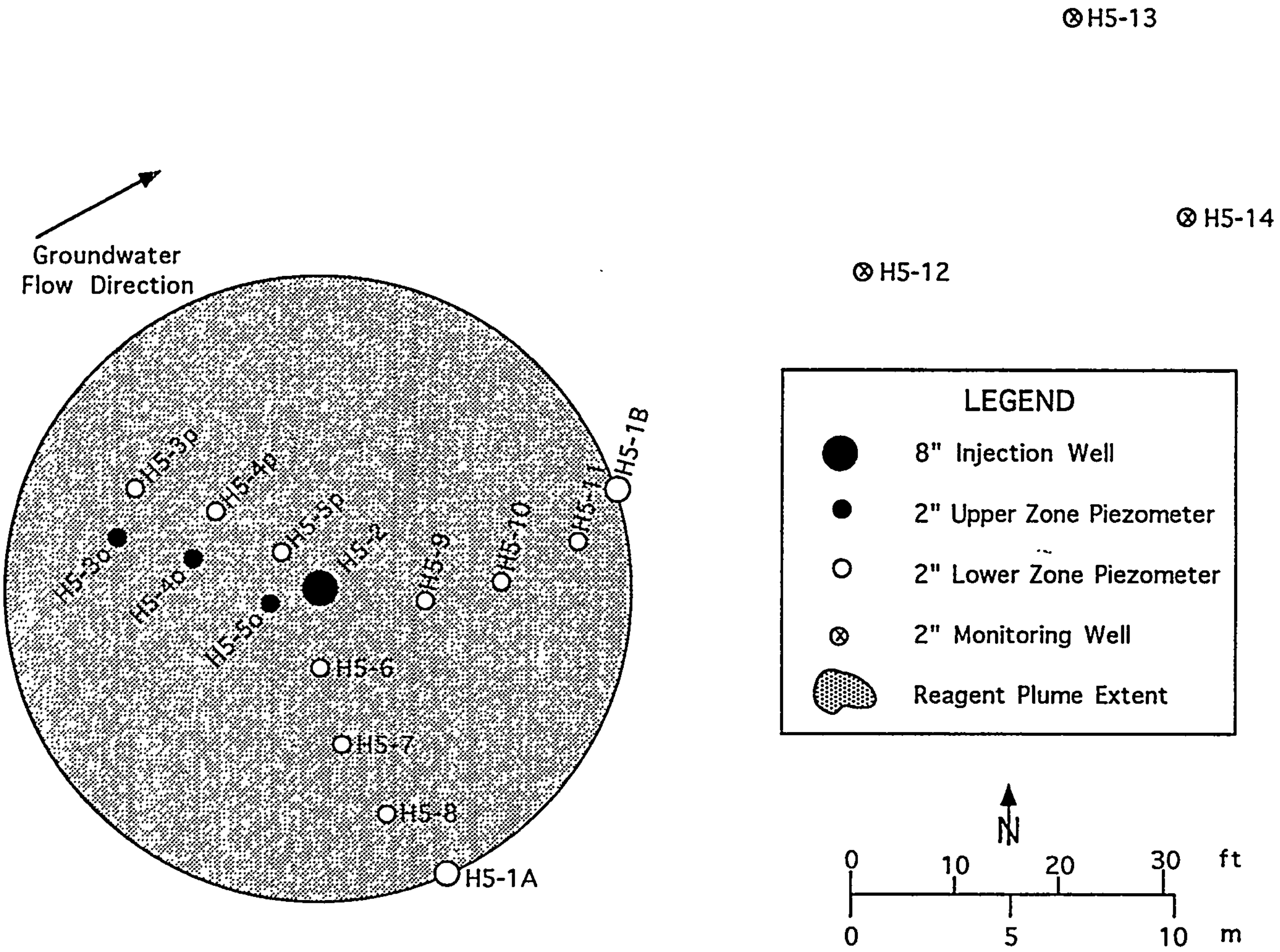

Figure 1.2. Well Location Map for the In Situ Redox Manipulation Field Test Site

2.0 Hydrogeologic Setting

This section briefly describes the geology and hydrology of the 100-H Area, specifically the hydrogeologic setting in the vicinity of the ISRM test site. A more detailed discussion of the geology and hydrology of the area, incorporating recent characterization data, is presented in Sections 4.0 and 5.0.

2.1 Geology of the 100-H Area

The Hanford Site is underlain by the following units (oldest to youngest): 1) pre-Miocene sedimentary and crystalline rocks, 2) Miocene basalts of the Columbia River Basalt Group, 3) Ellensburg Formation, which occurs as sedimentary interbeds between the Columbia River Basalt Group flows, and 4) late Miocene to Holocene sedimentary deposits including the Ringold Formation and the Hanford formation. Numerous reports have been written discussing the geology of the Pasco Basin and the Hanford Site (Lindsey and Jaeger 1993). This section discusses the geology of the 100-H Area as it pertains to the ISRM test site.

2.1.1 Ringold Formation

The main units of interest for this report are the suprabasalt sediments that consist of the Hanford formation and the Ringold Formation. A generalized diagram showing the stratigraphy of these sediments is shown in Figure 2.1. The Ringold Formation directly overlies the Columbia River Basalt Group. Lindsey et al. (1992) subdivided the Ringold Formation on the basis of sediment facies associations. The Ringold Formation, then can be described as containing intervals dominated by fluvial gravel units (designated as A, B, C, D, and E). These gravel units may be separated from each other by basin-wide intervals containing overbank and lacustrine facies deposits. The lowest of these overbank/lacustrine facies deposits is the Lower Mud Unit, which overlies the Unit A gravel (Lindsey et al. 1992).

In the 100-H Area and the ISRM site, the gravel facies of the Ringold Formation are not present. Instead, the Ringold Formation is typically expressed as a reddish brown, sandy clayey silt to clayey silt which corresponds to the Lower Mud Unit. The Lower Mud Unit is 23 to 30.5 m (75 to 100 ft) thick beneath the 100-H Area (Lindsey and Jaeger 1993). The unit appears to be continuous across the site, as observed in the wells installed at the ISRM site in 1995. It also appears to continuously extend westward from the 100-H Area to the 100-N Area (Lindsey and Jaeger 1993).

2.1.2 Hanford Formation

The Hanford formation directly overlies the Ringold Formation. Lithologically, the Hanford formation is dominantly sandy gravel but also may contain some significant sand layers and some minor silt/clay fractions. The contact with the underlying Ringold Formation in the 100-H Area is sharp and easily recognizable because of the much larger median grain size of the Hanford formation. The Hanford formation is approximately 19.8 m (65 ft) thick in the 100-H Area (Liikala et al. 1988).

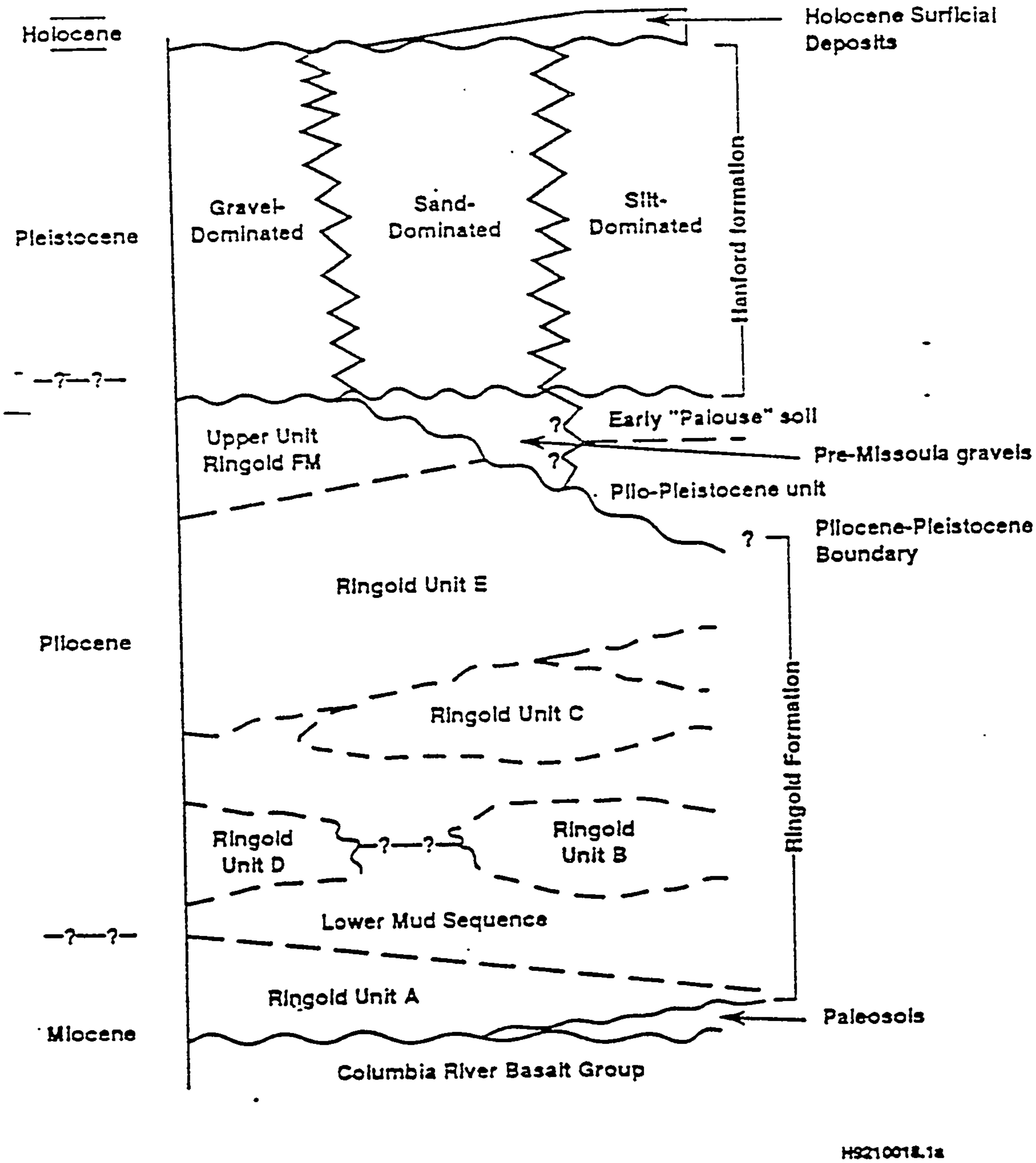

Figure 2.1. Generalized Stratigraphy of the Suprabasalt Sediments in the Pasco Basin (from Lindsey and Jaeger 1993)

2.2 Hydrology of the 100-H Area

In the 100-HR-3 Operable Unit, which encompasses the ISRM test site, the unconfined aquifer includes the unconsolidated sediments of the Hanford formation and Ringold Formation and is underlain by the Columbia River Basalts (Lindsey and Jaeger 1993). The uppermost unconfined aquifer is approximately 3 m (9 ft) thick beneath the ISRM test site and is contained within the sands and sandy gravels of the Hanford formation. The aquifer is underlain by a fine-grained unit of the Ringold Formation, which is typically a sandy clayey silt to clayey silt. The spatial continuity of this uppermost, fine-grained Ringold unit was observed during hydrogeologic characterization activities at the ISRM test site and is supported by hydrochemical data from across the 100-HR-3 Operable Unit that indicates contamination does not extend beyond the uppermost part of the unconfined aquifer (Peterson 1993).

The unconfined aquifer beneath the northern portion of the Hanford Site is laterally bounded by the basalt ridges that surround the basin and the Columbia River to the north and east. The aquifer is recharged by the Cold Creek drainage to the west, by waste water disposal in the 200-Areas, and by natural recharge (Fayer and Walters 1995). Groundwater generally flows from west to east across the Hanford Site and discharges to the Columbia River. In the 100-H Area, groundwater flow direction is generally in the northeast direction under a hydraulic gradient of approximately 0.0009. Water table contour maps of the 100-H Area at high and low Columbia River stage are shown in Figures 2.2 and 2.3, respectively (DOE-RL 1993). Data available from a continuous river stage monitoring station on the Columbia River near the old Hanford Townsite indicate diurnal variations in river stage of up to 2.5 m (8 ft) and seasonal variations of up to 3.5 m (12 ft).

As shown in the site water table contour maps, the effects of seasonal variability in Columbia River stage on the unconfined aquifer have dissipated at distances from the river comparable to that of the ISRM test site. The test site is located approximately 730 m (2400 ft) from the Columbia River. Water-level measurements made at Hanford Site well 199-H5-1A between July 1992, and June 1993, indicated seasonal variations in water-level of approximately 0.37 m (1.2 ft). Prior to hydrologic characterization activities at the ISRM test site, a continuous water-level monitoring system was installed to monitor diurnal water-level variations in 11 of the site monitoring wells. Water-level data collected on a 30-min interval over four days indicated that diurnal water-level fluctuation was less than 0.006 m (0.02 ft).

Previous hydrologic characterization of the uppermost unconfined aquifer in the vicinity of the ISRM test site is limited. Swanson (1994) reported results from a single-well slug test at Hanford Site well 199-H5-1A. Analysis of test response data resulted in a hydraulic conductivity estimate of 34 m/d (110 ft/d).

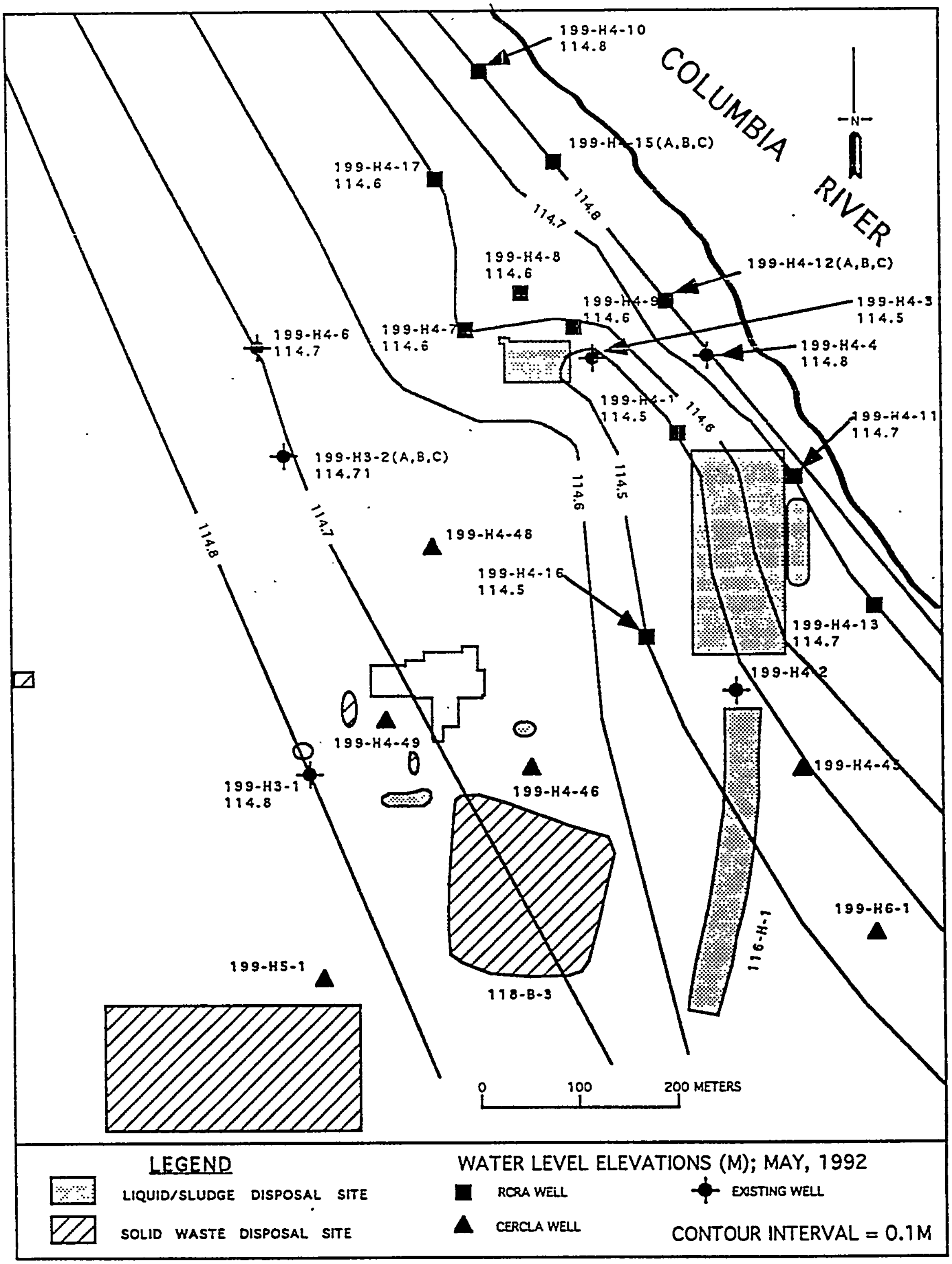

Figure 2.2. Water Table at the 100-H Area During High Columbia River Stage (DOE-RL 1993)

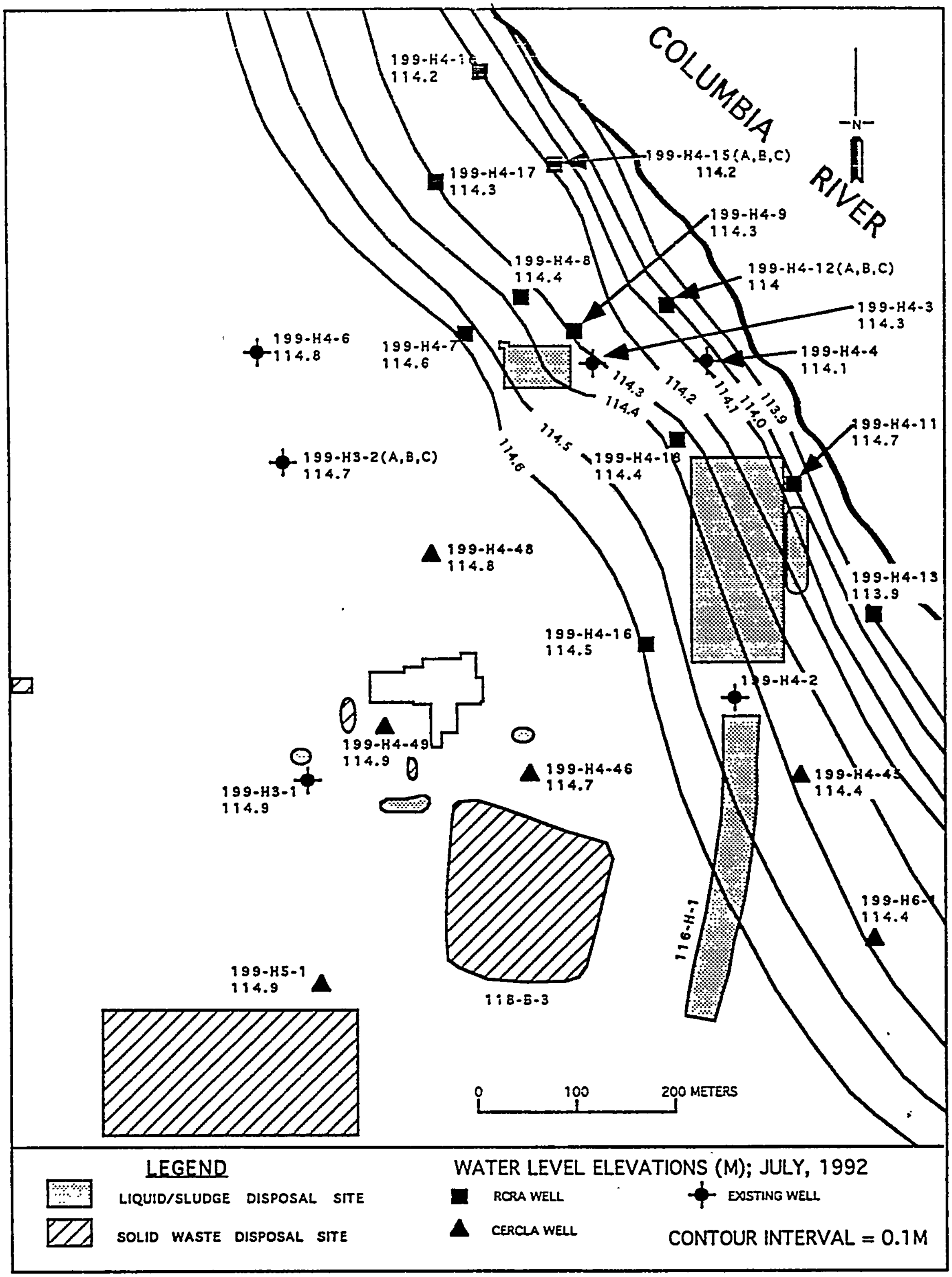

Figure 2.3. Water Table at the 100-H Area During Low Columbia River Stage (DOE-RL 1993)

3.0 Well Design and Construction

In February and March 1995, 16 wells were drilled and installed at the ISRM field test site. Locations of these wells is shown in Figure 1.2. These wells consisted of one injection/withdrawal well (199-H5-2), three upper piezometers, nine lower piezometers, and three downgradient monitoring wells. Details pertaining to the design and construction of these wells will be discussed in the following sections.

3.1 Drilling Method

All of the wells were drilled using the resonant sonic drilling method by Water Development Hanford Company. This drilling method was chosen because it was crucial that the wells and piezometers be installed without the use of drilling fluids or muds and minimally disturbed samples could be collected. This drilling method satisfies all of these criteria.

In the resonant sonic drilling method, an outer, threaded drill casing is used in conjunction with a smaller diameter inner casing. The outer casing serves to keep the borehole from collapsing and is advanced as the borehole is deepened. The inner casing is used as a drive barrel; it collects drill cuttings and is periodically removed and emptied. The energy that is used in this drilling method consists of a series of high-frequency, sinusoidal wave vibrations that cause a resonance condition on the drilling casing (Barrow 1994). The resonance state of the drill casing fluidizes the surrounding soil within a few millimeters of the casing wall, and significantly reduces the frictional forces that constrain the casing from advancing. Using the correct bit, this method can also quickly and cleanly core through solid boulders (Barrow 1994). An alternate variation on this drilling method called "sonic push" can also be used. In the sonic push method, a plug is placed at the end of the outer casing, and material is displaced similar to a pile driver.

During the installation of the 16 wells at the ISRM site, both the conventional resonant sonic drilling method and the sonic push method were used. The drill method and total depth drilled for each well is shown in Table 3.1. The 6 wells that were sampled were drilled exclusively with the conventional resonant sonic drilling method. The other 10 wells were generally drilled using a combination of the two methods. For these 10 wells, sonic push was generally used above a depth of 11.6 m (38 ft) and then conventional resonant sonic drilling was used from 11.6 m (38 ft) to total depth.

3.2 Sampling Method

Sediment samples were collected from six wells during resonant sonic drilling (Table 3.1). The other 10 wells were not sampled to be more cost effective. Samples were collected for three different types of analyses: 1) samples for sediment physical properties, 2) samples for sediment chemical characterization, and 3) samples for microbiologic characterization. Sample types and depth intervals are summarized in Table 3.2. Specific details on the sampling methods, sample intervals, and sample analyses results are discussed in Section 4.0.

Sediment samples were collected using a split-spoon sampler with lexan liners. The 1.5 m (5 ft) length split-spoon sampler was advanced using resonance sonic energy. The quality of samples recovered and the percentage of sample recovery versus nonrecovery was generally very good. Significant heat can sometimes be generated during sonic drilling as a result of the drilling process. Heating of the core during sampling was generally not observed; however, one core sample was hot to the touch. This core was not used for microbiologic characterization.

Table 3.1. Well Construction Information for Wells Installed in 1995 at the ISRM Site

Well Number	Well Diameter (cm)	Well Diameter (in.)	Approximate Radial Distance From Injection Well (m)	Approximate Radial Distance From Injection Well (ft)	Drill Depth (m)	Drill Depth (ft)	Screened Inverval (m)	Screened Inverval (ft)	Samples Collected?	Drill Method	Purpose
199-H5-2	20	8	--	--	16.5	54.0	13.87 - 15.37	45.52 - 50.44	Yes	Sonic	Injection Well
199-H5-3 (O)	5	2	6.1	20.0	13.9	45.7	12.52 - 13.27	41.09 - 43.56	No	Sonic/Sonic Push	Upper Piezometer
199-H5-3 (P)	5	2	6.1	20.0	16.8	55.0	14.11 - 14.87	46.29 - 48.79	Yes	Sonic	Lower Piezometer
199-H5-4 (O)	5	2	3.8	12.5	14.3	46.9	12.70 - 13.46	41.69 - 44.16	No	Sonic/Sonic Push	Upper Piezometer
199-H5-4 (P)	5	2	3.8	12.4	16.5	54.0	14.55 - 15.29	47.72 - 50.18	Yes	Sonic	Lower Piezometer
199-H5-5 (O)	5	2	1.5	5.1	13.7	45.0	12.69 - 13.45	41.62 - 44.12	No	Sonic/Sonic Push	Upper Piezometer
199-H5-5 (P)	5	2	1.5	5.0	16.5	54.0	14.76 - 15.51	48.44 - 50.90	Yes	Sonic	Lower Piezometer
199-H5-6	5	2	2.3	7.6	16.4	53.7	13.99 - 14.75	45.91 - 48.38	No	Sonic/Sonic Push	Lower Piezometer
199-H5-7	5	2	4.6	15.2	16.2	53.2	14.23 - 14.98	46.69 - 49.16	No	Sonic/Sonic Push	Lower Piezometer
199-H5-8	5	2	6.9	22.7	15.8	52.0	14.26 - 15.01	46.80 - 49.26	Yes	Sonic	Lower Piezometer
199-H5-9	5	2	3.0	10.1	15.9	52.1	14.39 - 15.14	47.20 - 49.66	No	Sonic/Sonic Push	Lower Piezometer
199-H5-10	5	2	5.3	17.3	16.1	52.7	14.24 - 15.00	46.74 - 49.21	No	Sonic Push	Lower Piezometer
199-H5-11	5	2	7.6	24.6	16.2	53.0	14.12 - 14.9	46.33 - 48.8	Yes	Sonic	Lower Piezometer
199-H5-12	5	2	18.3	60.0	16.0	52.5	12.82 - 15.8	42.05 - 52.0	No	Sonic Push	Downgradient Monitoring
199-H5-13	5	2	27.4	90.6	16.0	52.6	12.81 - 15.84	42.03 - 51.97	No	Sonic/Sonic Push	Downgradient Monitoring
199-H5-14	5	2	27.4	89.9	15.8	52.0	12.88 - 15.91	42.26 - 52.21	No	Sonic	Downgradient Monitoring

Table 3.2. Sediment Sampling Summary

Depth (meters)	Depth (feet)	H5-2	H5-3P	H5-4P	H5-5P	H5-8	H5-11
9.1 - 10.7	30 - 35						
11.0 - 11.3	36 - 37						
11.3 - 11.6	37 - 38						
11.6 - 11.9	38 - 39						
11.9 - 12.2	39 - 40						
12.2 - 12.3	40 - 40.5						
12.3 - 12.5	40.5 - 41						
12.5 - 12.6	41 - 41.5						
12.6 - 12.8	41.5 - 42						
12.8 - 13.0	42 - 42.5						
13.0 - 13.1	42.5 - 43						
13.1 - 13.3	43 - 43.5						
13.3 - 13.4	43.5 - 44						
13.4 - 13.6	44 - 44.5						
13.6 - 13.7	44.5 - 45						
13.7 - 13.9	45 - 45.5						
13.9 - 14.0	45.5 - 46						
14.0 - 14.2	46 - 46.5						
14.2 - 14.3	46.5 - 47						
14.3 - 14.5	47 - 47.5						
14.5 - 14.6	47.5 - 48						
14.6 - 14.8	48 - 48.5						
14.8 - 14.9	48.5 - 49						
14.9 - 15.1	49 - 49.5						
15.1 - 15.2	49.5 - 50						
15.2 - 15.4	50 - 50.5						
15.4 - 15.5	50.5 - 51						
15.5 - 15.7	51 - 51.5						
15.7 - 15.8	51.5 - 52						
15.8 - 16.0	52 - 52.5						
16.0 - 16.2	52.5 - 53						
16.2 - 16.3	53 - 53.5						
16.3 - 16.5	53.5 - 54						

Samples for Sediment Physical Property Analysis
Samples for Sediment Chemical Characterization
Samples for Microbiologic Characterization
No Samples Collected for Analysis

Notes:

- Well numbers prefixed by 199-
- Grab samples for sediment chemical characterization were also taken from:

H5-7	13.7-15.2 m (45-50 ft)
H5-9	13.7-15.2 m (45 - 50 ft)
H5-10	13.7-15.8 m (45 - 52 ft)

3.3 Well Completion

Table 3.1 shows well construction information for the 16 wells installed at the ISRM site in 1995 including well diameter, radial distance from injection well, drill depth, and screened interval. Figure 3.1 shows a schematic illustration of the construction of each of the 4 types of wells. All of the wells were constructed of polyvinyl chloride (PVC) casing and screen. The screen for the injection/withdrawal well was a 20-slot size, schedule 40, continuous wire-wrap type. This screen is placed within the lower 1.5 m (5 ft) of the aquifer. The screen for all of the other wells was a 10-slot size, and they were also a schedule 40 PVC, continuous wire-wrap type. The screens for the upper and lower piezometers were 0.76 m (2.5 ft) in length and were placed to monitor the upper and lower portions of the aquifer, respectively. The downgradient monitoring wells have fully penetrating 3-m- (10-ft-) long screens that are placed just below the water-table surface.

All of the wells have an artificial filter pack placed around the well screen appropriate for the slot size of the well screen. Annular seal materials were placed above the filter pack and consist of bentonite crumbles, bentonite hole plug, cement grout, and a concrete pad. All wells meet Washington Administrative Code (WAC) 173-160 specifications. Detailed as-built diagrams for each well are shown in Appendix A.

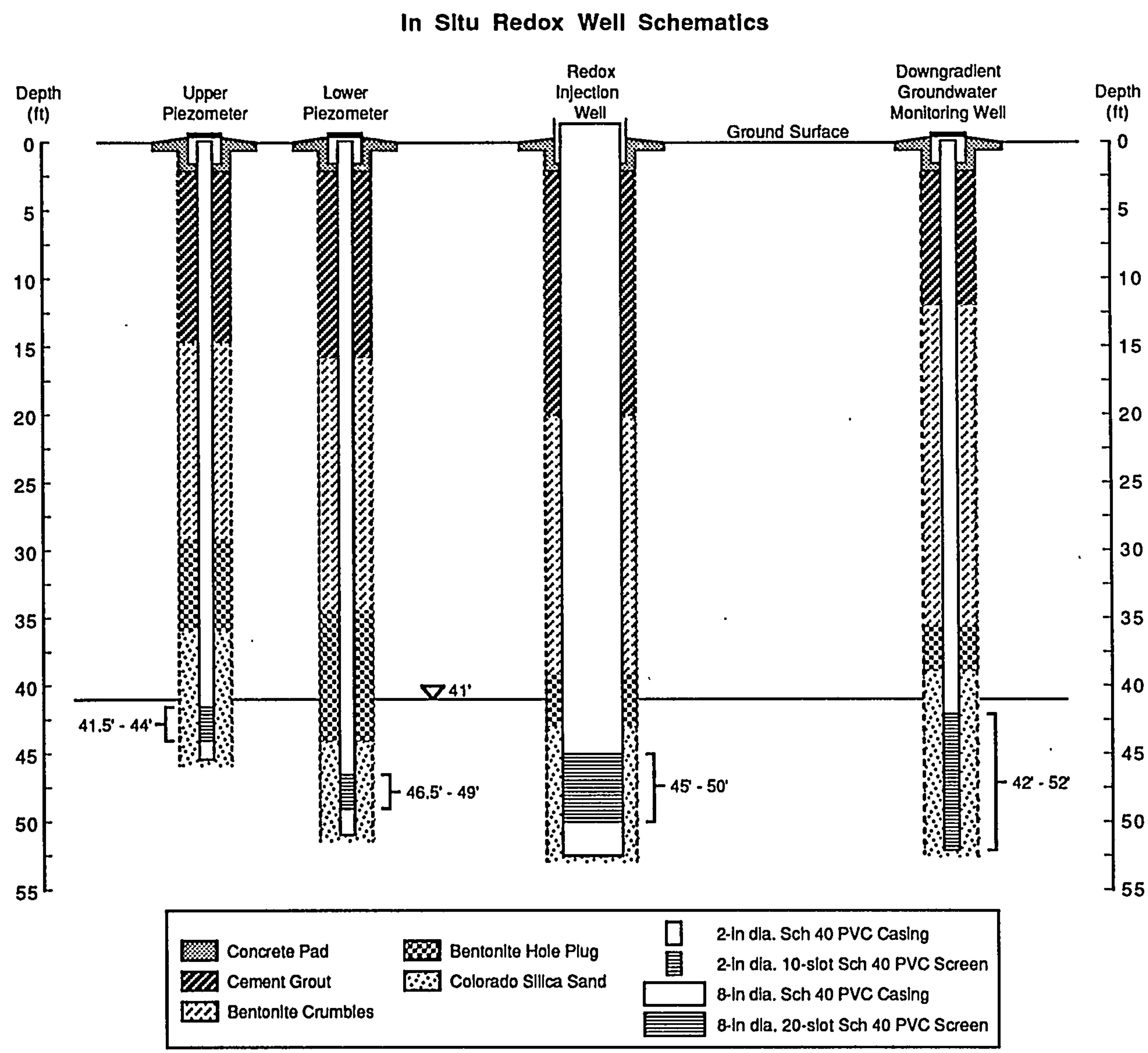

Figure 3.1. Schematic Well Construction Diagram for Wells Installed at the ISRM Site

4.0 Sediment Characterization

4.1 Sediment Physical Properties

Physical property analyses included: moisture content, sieve, particle density, bulk density, hydrometer, and porosity. Table 3.2 shows the core intervals that were collected for sediment physical property analysis. Table 4.1 shows the specific analyses that were performed.

Samples were analyzed consistent with the procedures by PNL (1992). Average values for selected sediment physical property analyses are shown in Table 4.2; complete analyses results are shown in Appendix B.

4.2 Lithologic Description

This section discusses in more detail the sediment lithologic descriptions made during well installation and also describes the procedures used in making these descriptions.

4.2.1 Field Description Procedure

Sediment samples were collected from six wells at the ISRM site during 1995 (see Tables 3.1 and 3.2). During drilling from the surface to approximately the 12.2-m (40-ft) depth, split-spoon samples were generally not collected, and therefore lithologic descriptions were not made for this interval (except for occasional observation of drill cuttings). Lithologic descriptions were primarily made within the interval sampled (>12.2-m [40-ft] depth).

The primary focus of the split-spoon sampling was collecting samples for physical property, chemical, and microbiologic characterization. Collection of these type of samples requires immediate capping and proper handling. Field lithologic description were of secondary importance and were based on brief visual observations of the core. However, in cases where core recovery was poor and thus not suitable for collection of the above sample types, or when sufficient excess sediment in the shoe of the split-spoon sampler was available, more detailed lithologic descriptions were made.

The field lithologic description was performed consistent with procedures in PNL (1992) and included, if possible: sample name (based on a texture), a visual estimate of the particle size distribution, sorting, gross mineralogy, roundness, color, and reaction to 10% HCl. Sample name was based on a classification from Tallman et al. (1979) (Figure 4.1). After the samples were described, they were contained along with the other spoils from drilling. Lithologic samples were not collected for archive. Lithologic descriptions were recorded on a borehole log by the geologist; these are shown in Appendix A.

Table 4.1. Sediment Physical Property Analyses

Sample No.	Depth	Moisture	Sieve Analysis	Particle Density	Hydrom. Analysis	Bulk Density	Porosity
H5-2	39 - 40.25	X	X	X		X	X
	46 - 46.5	X	X	X		X	X
	48.75 - 51	X	X	X		X	X
H5-5	42 - 42.5	X	X	X		X	X
	49 - 50	X	X	X		X	X
H5-3	40 - 41	X	X	X	X	X	X
	43 - 45	X	X	X	X	X	X
	47.5 - 48	X	X	X			
	48.7 - 50	X	X	X			
	50.5 - 51	X	X	X	X	X	X
	52 - 52.5	X	X	X	X	X	X
	53 - 53.5	X	X	X	X	X	X
H5-4	43 -44	X	X	X			
	45.5 - 46	X	X	X		X	X
H5-11	43.5 - 44	X	X	X		X	X
	42 - 42.5	X	X	X		X	X
	43 - 43.5	X	X				
	49.5 - 50	X	X	X			
H5-8	44 - 45	X	X	X		X	X
	48 - 49	X	X	X		X	X

Table 4.2. Average Results for Selected Sediment Physical Property Analyses

Parameter	Value
Hanford Formation (4 samples, 12 to 13.1 m depth) Sand-dominated Lithology	
Particle density	2.74 g/cm^3
Bulk density	1.83 g/cm^3
Porosity	33%
Hanford Formation (6 samples, 13.1 to 15.2 m depth) Gravel-dominated Lithology	
Particle density	2.73 g/cm^3
Bulk density	1.93 g/cm^3
Porosity	29%
Ringold Formation (3 samples)	
Particle density	2.55 g/cm^3
Bulk density	1.70 g/cm^3
Porosity	33%

4.2.2 Ringold Formation

The Lower Mud Unit was encountered at a depth of approximately 15.3 m (50.3 ft) below ground surface beneath the ISRM site. This unit is typically a moderately consolidated, light brownish gray to light yellowish brown and reddish brown (2.5Y6/3) to brown (10YR5/3), sandy clayey silt to clayey silt. Colors are from the Munsell soil color chart (Munsell 1988). Hydrometer analyses of this unit are summarized in Table 4.3 and show that it contains 12.7% to 27.5% sand, 46.8% to 67.9% silt, and 19.4% to 33.9% clay.

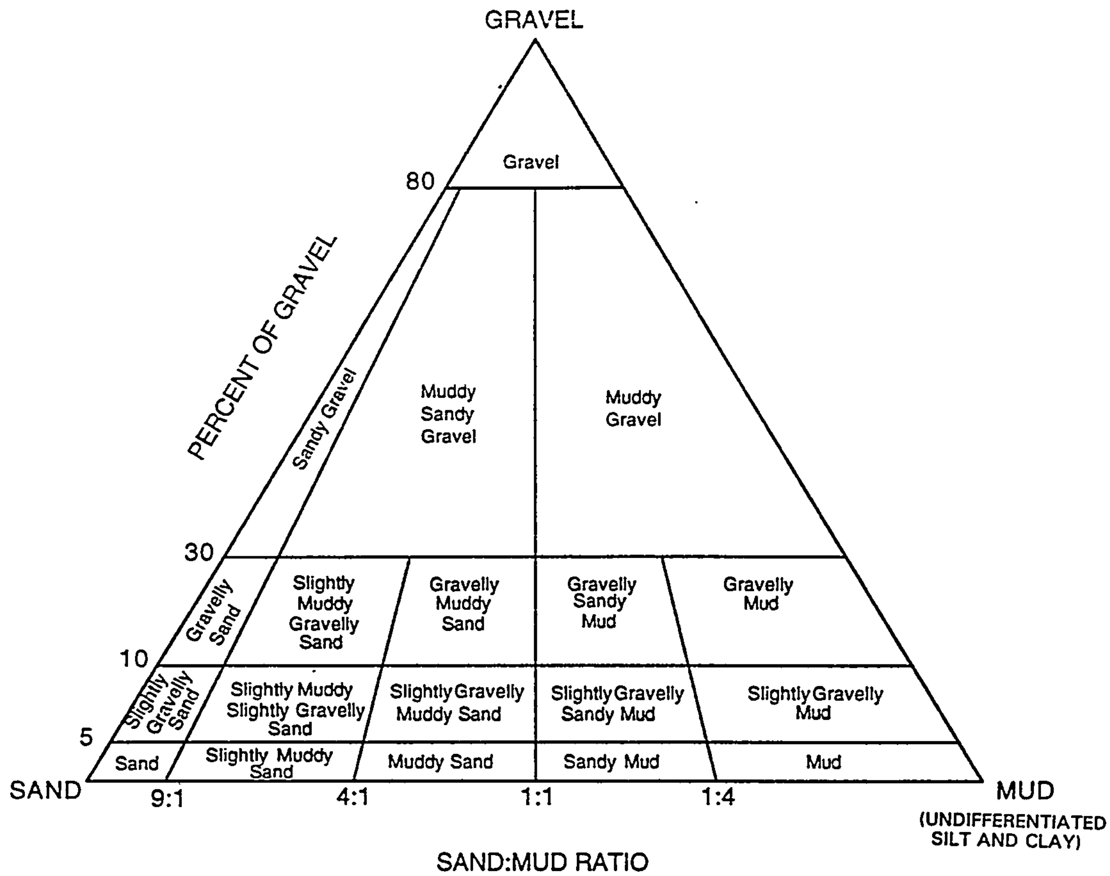

Figure 4.1. Ternary Diagram for Naming of Sediments (after Folk 1968; modified from Tallman et al. 1979)

Table 4.3. Hydrometer Analyses Results From the Ringold Formation

Well Number	Depth Interval m (ft)	% Sand	% Silt	% Clay
199-H5-3P	15.4-15.5 (50.5-51)	12.7	67.9	19.4
199-H5-3P	15.8-16 (52-52.5)	19.1	46.8	33.9
199-H5-3P	16.2-16.3 (53-53.5)	27.5	49.4	23.1

4.2.3 Hanford Formation

From the surface to a depth of approximately 11.9 m (39 ft), the Hanford formation consists of a light gray (10YR7/1) sandy gravel consisting of 50% to 65% gravel, 35% to 50% sand, and trace silt and clay. The gravel portion is typical of other Hanford formation deposits on the Hanford Site and is subangular to rounded, 60% felsic/40% mafic, and ranges from very fine pebble (2 to 4-mm diameter) to small cobble (64 to 128-mm diameter) size.

From approximately 11.9 to 13.1 m (39 to 43 ft) in all of the wells except 199-H5-2, the formation lithology changes from a sandy gravel facies to a sand-dominated facies. This sand facies ranges from very fine sand (0.06 to 0.12 mm) to medium sand (0.25 to 0.5 mm) size. This facies appears to become more silty in well 199-H5-5P, and well 199-H5-11 consists of a slightly gravelly, slightly muddy sand. From approximately 13.0 to 15.3 m (43 to 50.3 ft), the unit is dominated by a sandy gravel with some gravelly sand and muddy sandy gravel layers.

The contact with the underlying Ringold Formation (Lower Mud Unit) occurs at approximately 15.3 m (50.3 ft). Well locations are shown in Figure 1.2. The static water table is located at a depth of 12.5 m (41.1 ft) below ground surface.

4.2.4 Summary Hydrogeology of the Unconfined Aquifer

The primary focus of the sampling performed during 1995 well installation activities at the ISRM site was the characterization of the sediments within the unconfined aquifer. The unconfined aquifer is approximately 3-m (9-ft) thick beneath the ISRM test site and is contained within the sands and sandy gravels of the Hanford formation. The Lower Mud Unit of the Ringold Formation, represented by a sandy clayey silt to clayey silt, forms the base of the upper unconfined aquifer.

Figure 4.2 shows an west-to-east cross-section across the ISRM site illustrating the lithology of the unconfined aquifer. As shown on this cross-section, the lower 1.8 to 2.1 m (6 to 7 ft) of the aquifer is dominated by a sandy gravel. The upper 0.9 to 1.2 m (3 to 4 ft) of the aquifer is dominantly a sand lithology in most wells except 199-H5-2 and 199-H5-5P. In 199-H5-2, this sand lithology is present as only a thin layer. In well 199-H5-5P, this sandy interval contained noticeably more silt.

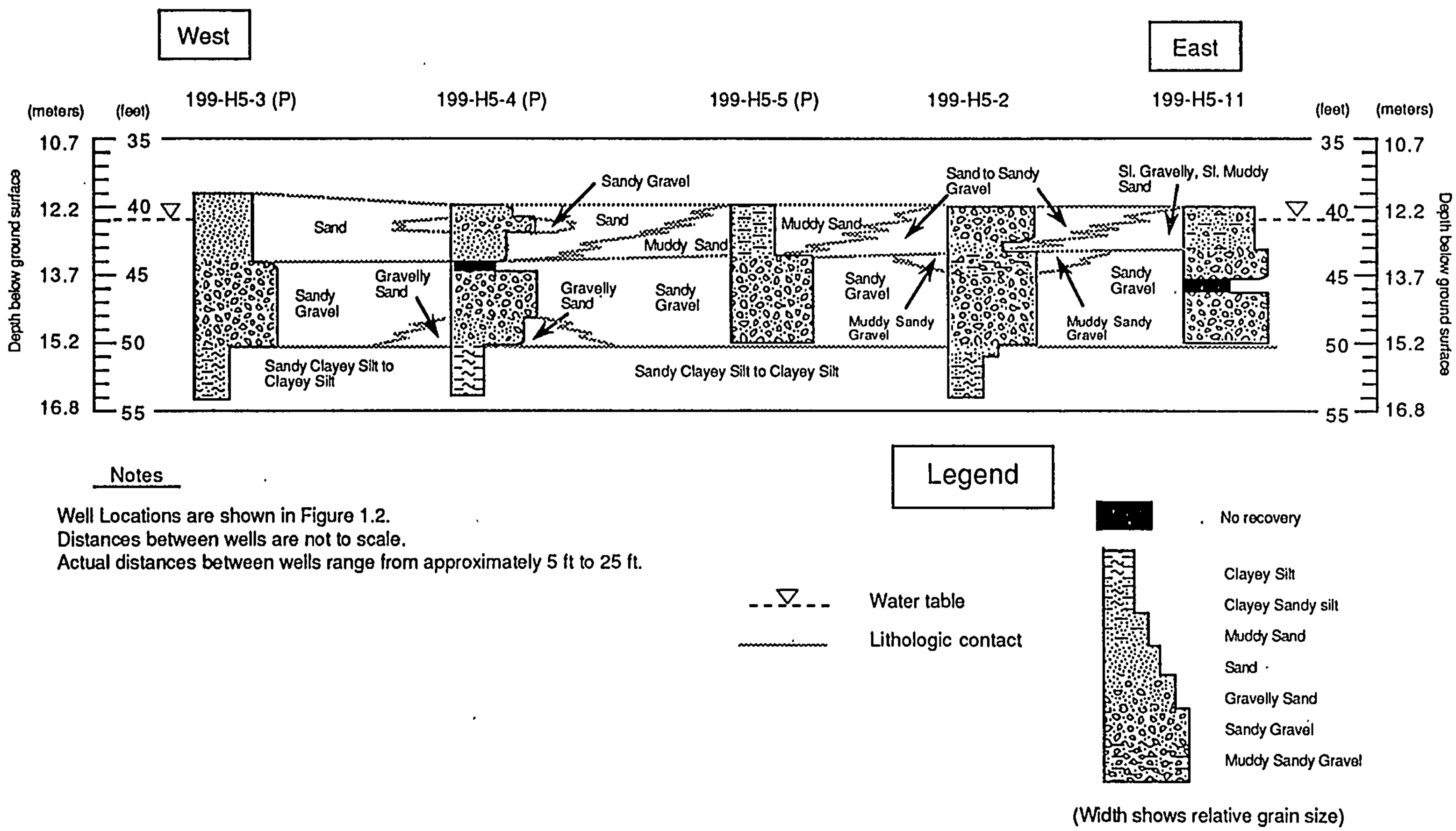

Figure 4.2. West-to-East Geologic Cross-Section of the Unconfined Aquifer

4.3 Sediment Chemistry

Samples for geochemical analysis for ferrous/ferric iron [Fe(II)/iron(III)], total metals, and bulk mineralogy were collected via split-spoon sampler from the intervals shown on Table 3.2. Preliminary analyses results for total iron, iron(II), iron(III), and "available" iron(III) were completed in time for inclusion in this report; analyses of additional samples are ongoing. Final results of available iron(III), total metals, and bulk mineralogy analyses shall be available at a later date upon request.

The redox status of the 100-H sediments is largely reflected in the redox state of the iron present in these sediments, but can also be inferred from the oxygen content of groundwater contacting the sediments. Measurements were made of the total iron, iron(II), and iron(III) contents of selected sediments. These total results, however, do not indicate how much of the iron is in contact with the groundwater and thus available to participate in the redox chemistry with dissolved species such as dithionite, oxygen, and contaminants. Methods used to determine available iron(III) are described below. Dissolved oxygen data from monitoring wells located in the 100 Areas and across the Hanford Site (Appendix C), in addition to available iron(III) data, suggest that the sediments and the aquifer beneath the ISRM test site are highly oxidized and that little of no iron(II) is available for reaction with the groundwater constituents before treatment with a reductant such as dithionite.

The iron(III) available for reduction to Fe(II) by dithionite (the reagent selected for the ISRM field experiment) in selected sediments was determined by either a colorimetric or a kinetic method. Both methods provided acceptable results. The kinetic method is advantageous because, in addition to measuring available, it also yields rate constants for decomposition of dithionite and the reduction of iron(III).

The colorimetric method measured the amount of Fe(II) in the silt- and clay-sized fractions of sediment samples before or after a 24-h treatment with dithionite (and removal of the excess reductants by washing with an inert salt solution). With this method, samples were dissolved in acid in the presence of phenanthroline [an Fe(II) colorimetric reagent]. The intensity of the color produced was used to calculate the amount of Fe(II) present. The difference in the Fe(II) measured for the samples before or after dithionite treatment was taken to be the amount of available iron(III).

The kinetic method measured the decrease in dithionite concentration during treatment of the sediment samples under anoxic conditions at 15°C. Loss of dithionite was assumed to be due to a combination of two independent first-order reactions: 1) reduction of iron(III), and 2) a surface-mediated decomposition reaction. Because the decomposition reaction occurred at the same rate throughout the treatment period, the loss of dithionite in the later portions of the treatment period (i.e., after ~24 hours) was assumed to stem entirely from this reaction. Extrapolation of the rate law for this reaction to the starting time of the experiment yielded an initial dithionite concentration. The difference between this extrapolated value and the actual starting concentration represented the amount of dithionite consumed by reduction of iron(III). Values for available iron(III), therefore, were calculated from this value by assuming two mols of iron(III) reduced for each mole of dithionite consumed. Two replicates were analyzed for each sediment sample.

Table 4.4 contains results from total iron, iron(II), iron(III), and available iron(III) analyses for sediment samples collected at the ISRM test site. Available iron(III) ranged from 0.038 (±0.011) to 0.212% by weight for Hanford Formation sediments and 0.73% by weight for Ringold Formation sediments.

Table 4.4. Total Iron, Iron(II), Iron(III), and Available Iron(III) Analyses Results

Well ID	Sample Interval (m)	(ft)	Total Iron (% by weight)	Iron(II) (% by weight)	Iron(III) (% by weight)	Available Iron(III) (% by weight)
199-H5-1A	13.7-14.0[c]	45.0-46.0	4.70	2.80	1.90	0.059 (±0.008)
	15.2-15.5[c]	50.0-51.0	5.74	3.36	2.38	0.038 (±0.011)
	15.8-16.2[c]	52.0-53.0	3.42	0.54	2.88	0.73[a][b]
	16.8-17.4[c]	55.0-57.0	3.80	1.25	2.55	0.73[a][b]
199-H5-2	13.1-13.4[d]	43.0-44.0	N/A	N/A	N/A	0.104 (±0.016)
	14.2-14.3[d]	46.5-47.0	N/A	N/A	N/A	0.098 (±0.025)
199-H5-3P	12.8-13.1[d]	42.0-43.0	N/A	N/A	N/A	0.212[b]

(a) Sample from lower confining layer (Ringold Formation).
(b) One replicate only.
(c) Colorimetric analysis method.
(d) Kinetic analysis method.

4.4 Sediment Microbiologic Characterization

Microbiologic samples were collected using split-spoons, lexan liners, and sample handling equipment that was sterilized. Care was taken not to contaminate the sampler and samples before or following sample recovery. After the split-spoon sampler was recovered, the lexan liners were immediately capped, placed in an argon-filled plastic bag, and placed in an ice-filled cooler until the samples could be transported to PNL.

Microbiologic analyses results are summarized in Table 4.5. Low microbiological populations are defined as having less than 10^4 colony forming units per gram (CFU/g) of sediment. Medium populations are between 10^4 to 10^7 CFU/g, and high populations are above 10^7 CFU/g. Most of the sediment samples analyzed from the ISRM test site have low (or no) microbiological populations. Although these populations are low, they are consistent with the results of other microbiological sampling on the Hanford Site. At the Yakima Barricade deep borehole (Hanford well 699-48-96) microbiologic populations from 10^1 to 10^2 CFU/g in the unsaturated zone and 10^2 to 10^4 CFU/g in the saturated zone were found. Population counts could be higher if the samples were cultured in additional types of media.

Table 4.5. Microbiological Characterization Summary (after 28 days incubation)

Well ID	Sample Interval (m)	(ft)	Lithology	CFU/g sediment	# of Colony Types
199-H5-2	13.4	44.0	Silty sandy gravel	7.4×10^3	4
199-H5-2	14.3	47.0	Sandy gravel	6.1×10^3	4
199-H5-2	14.5	47.5	Sandy gravel	1×10^2	1
199-H5-2	15.5	51.0	Slightly clayey sandy silt	0	0
199-H5-2	15.8	52.0	Slightly clayey sandy silt	1×10^1	1
199-H5-2	16.1	53.0	Slightly clayey sandy silt	0	0
199-H5-3	14.0-14.2	46.0-46.5	Sandy gravel	1.5×10^5	4
199-H5-4	12.8-13.1	42.0-43.0	Sand	1.3×10^4	6
199-H5-4	14.0-14.3	46.0-47.0	Sandy gravel	2.2×10^4	2
199-H5-5	13.4-13.7	44.0-45.0	Sandy gravel	1.6×10^4	3
199-H5-5	14.3-14.6	47.0-48.0	Sandy gravel	Suspect contamination	Suspect contamination
199-H5-8	13.1-13.4	43.0-44.0	Gravelly sand	5.0×10^1	1
199-H5-8	14.9-15.2	49.0-50.0	Sandy gravel	0	0
199-H5-8	16.0-16.1	52.5-53.0	Silt/clay	0	0
199-H5-11	14,5-14.8	47.5-48.5	Sandy gravel	9.0×10^1	1

CFU = colony forming unit

5.0 Hydrologic Characterization

During FY 1995, hydrologic characterization activities were initiated at the ISRM field test site. Hydraulic tests conducted at the site were designed to improve the conceptual understanding of the geohydrology beneath the ISRM test site and provide detailed, site specific hydraulic parameter estimates. The hydraulic tests included several single-well slug displacement tests conducted during well installation and a constant-rate discharge test that included pressure response monitoring at 15 locations across the site. Geohydrologic information obtained from these tests will be incorporated into a numerical model developed to simulate the physical and chemical processes associated with the field experiment and aid in experiment design and interpretation.

5.1 Hydrologic Characterization During Well Installation

Single well slug tests were conducted during well installation to assess the vertical distribution of horizontal hydraulic conductivity. Tests were conducted as the borehole was advanced, generally the upper 1.5 m (5 ft) and the lower 1.5 m (5 ft) of the aquifer was tested. Test intervals were screened by drilling and driving temporary casing to the desired depth, installing a temporary telescoping screen, and pulling back the temporary casing to expose the desired test interval. The slug stress was applied by instantaneously withdrawing a slug of known volume from the test interval. The resulting pressure response was monitored using Keller Series 173 pressure transducers. Early-time test response was monitored with a sampling interval of 0.5 sec to adequately describe the instantaneous pressure change initiated at the beginning of the test.

Slug tests were conducted at two discrete depth intervals during installation of the injection/withdrawal well (199-H5-2) and two monitoring wells (199-H5-3P and 199-H5-4P). Table 5.1 contains a summary of results from the slug displacement tests conducted at the ISRM test site.

Note that transmissivity estimates obtained from the analysis of single-well slug test data should be considered qualitative estimates. Ferris et al. (1962) state that:

> The duration of a slug test is very short, hence the estimated transmissibility determined from the test will be representative only of the water-bearing material close to the well. Serious errors will be introduced unless the ... well is fully developed and completely penetrates the aquifer.

Although the analytical methods discussed previously have been formulated to account for partial penetration effects, the stipulation that the well be "fully developed" was not met. Fines generated and/or mobilized during drilling, which were observed during geologic sample collection and during well development activities following well installation (see Section 5.2), likely affected the permeability of the "near well" formation materials. Because well development was not conducted at any of the test locations before the slug displacement testing and data from the single-well slug tests do not correlate well with results from the full-field constant-rate discharge test, slug displacement testing results are considered suspect.

Table 5.1. Summary of Single-Well Slug Test Analysis

Well ID	Test Interval (m)	(ft)	Hydraulic Conductivity (m/d)	(ft/d)
199-H5-2	12.5 - 13.6	41.1 - 44.5	36	120
199-H5-2	13.7 - 15.2	45.0 - 50.0	38	120
199-H5-3P	12.8 - 14.3	42.0 - 46.9	39	130
199-H5-3P	13.7 - 15.3	45.0 - 50.2	18	59
199-H5-4P	12.8 - 14.5	42.0 - 47.7	50	160
199-H5-4P	13.7 - 15.2	45.0 - 49.8	11	36

5.2 Well Development

During March 1995, wells installed at the ISRM test site were developed by a combination of bailing, pumping, surged pumping, and surge block development. During the initial stages of well development, which involved bailing the well to assess the amount of sediment present and remove as much of the sediment as possible, many of the wells contained significant quantities of sediment and had a lower production rate than expected. Most likely, fines generated and/or mobilized during drilling, which were also observed during geologic sample collection, had plugged the screen and/or sandpack.

The initial production rates, where available, for wells at the ISRM test site are contained in Table 5.2; this value represents the production rate before any surge block development. As the data indicate, the initial production rate of several of the monitoring wells was significantly less than the 0.3 L/s (5 gal/min) they were designed to produce. In two of the monitoring wells (H5-5'O' and H5-10), the wellbore contained such a thick slurry and the screen was so plugged with fine-grained materials that it could be bailed dry. The "pumped dry" designation indicates the wellbore was pumped dry (using a submersible pump) before water reached the ground surface and the flow rate could be measured. Because of the time required to determine the initial production rate, scheduling constraints, and the consistently low initial production rates of the first several wells, initial production rate was not measured at every well (N/A designation).

Following the initial bailing of the wellbore, a three-step procedure was utilized to work the fine-grained sediments out of the sandpack and into the wellbore through the screen. The steps included: 1) develop screen using a surge block development tool; the surge block, when worked up and down in the wellbore, forces water into and out of the well screen loosening fine grained materials in the sandpack and moving them into the wellbore, 2) bail sediments from the well, and 3) pump the well to remove any remaining fine-grained materials and determine the maximum production rate. This procedure was repeated as required until an adequate production rate was obtained or no further improvement was realized.

The final production rates obtained from the injection/withdrawal well and monitoring wells are contained in Table 5.2. The final production rate represents the maximum flow rate that could be maintained without dewatering the screen. As the data indicate, site monitoring wells were sufficiently developed to assure hydraulic contact with the aquifer and provide representative groundwater samples. The injection/withdrawal well was capable of producing approximately 1.8 L/s (29 gal/min).

Table 5.2. Summary of Injection/Withdrawal and Monitoring Well Production Rates

Well ID	Initial Production Rate (gal/min)	Final Production Rate (L/s)	(gal/min)
199-H5-2	26	1.8	29
199-H5-3P	pumped dry	0.13	2.0
199-H5-3'O'	2.4	0.15	2.4
199-H5-4P	0.6	0.17	2.7
199-H5-4'O'	2.3	0.25	4.0
199-H5-5P	N/A	0.25	4.0
199-H5-5'O'	bailed dry	0.16	2.6
199-H5-6	< 1.9	0.25	4.0
199-H5-7	N/A	0.25	4.0
199-H5-8	N/A	0.31	5.0
199-H5-9	N/A	0.30	4.8
199-H5-10	bailed dry	0.13	2.0
199-H5-11	N/A	0.25	4.0
199-H5-12	N/A	0.25	4.0
199-H5-13	N/A	0.16	2.5
199-H5-14	N/A	0.09	1.5

5.3 Hydrologic Characterization Following Well Completion

Following installation, completion and development of the injection/withdrawal well and all test site monitoring wells, a 24-h constant-rate discharge test was conducted to assess the horizontal hydraulic conductivity and its spatial variability, storativity and specific yield, and formation anisotropy. The test was conducted between March 27 and 28, 1995. The average discharge rate during the test was 1.32 L/s (20.9 gal/min). Pressure response was continuously monitored with pressure transducers at the stress well and 10 of the 15 available monitoring wells (Figure 1.2). The remaining five monitoring wells were periodically measured for pressure response using a calibrated steel electric water-level indicator; monitoring wells equipped with pressure transducers were also periodically measured with a calibrated steel electric water-level indicator to verify the transducer calibration.

Analysis of the constant-rate pumping test data for the ISRM test site, included two approaches: 1) individual analyses for each of the observation well sites, and 2) simultaneous composite analysis of selected groups of observation well test data. In both instances, the type-curve matching technique was applied, which was based on a homogeneous porous media continuum approach. For the individual test well analyses, the degree of correspondence between the hydrologic property estimates obtained for the various test sites indicates whether a homogeneous model approach is valid for the test site area. Individual analytical results also provide information concerning the spatial distribution of hydraulic properties within the test site region. In contrast, the simultaneous composite analysis approach provides information as to which overall aquifer test conditions best match observed test response characteristics over the monitored area. This analysis approach provides the best average, area-weighted estimates for aquifer properties, again assuming that the test aquifer can be represented by a homogeneous porous media model. A summary of results obtained from both analysis approaches follows; for a detailed description of analytical techniques and a complete description of individual and composite test analyses see Appendix C.

Results of individual observation well analyses are listed in Table 5.3. The results listed represent the best combined type-curve and derivative matches for individual recovery water-level responses recorded at each ISRM test site observation well. Recovery water-level data were analyzed instead of drawdown data because of adverse effects caused by discharge fluctuations that occurred during the initial minutes of the pumping test. Drawdown data, however, were compared with recovery data to corroborate the similarity of intermediate and late-time test response for both phases of the pumping test. For all observation wells, intermediate and late-time data provided nearly identical drawdown and recovery test responses. Because the recovery data provides a complete analysis record of the test response (including the early-time, elastic response phase of the test), recovery rather than drawdown data was the focus of the individual test well analysis effort.

Of the hydraulic properties determined, only transmissivity exhibited any spatial dependence. A general dependence between transmissivity and well screen/aquifer depth was indicated. Locations having two closely spaced observation well installations (i.e., H5-3'O' -3P, and H5-4'O' -4P), exhibited significantly lower transmissivities for wells completed at greater depths within the aquifer. A possible decreasing transmissivity with increasing depth relationship is consistent with geologic descriptions of well logs available for the ISRM test site. In addition, a general relationship of increasing transmissivity with increased distance from pumping well H5-2 was evident. This general association was exhibited irrespective of azimuth direction for observation wells at the ISRM test site. The cause for this distance correspondence is not known. This distance dependence may be associated with changes in aquifer characteristics (e.g., increasing aquifer thickness or hydraulic conductivity with distance) or inherent deficiencies in the analytical solution for analyzing tests conducted in shallow thin unconfined aquifers.

Table 5.3. Results of Constant-Rate Discharge Test Recovery Analysis for Individual ISRM Test Site Observation Well Locations

Well ID	Transmissivity (m^2/d)	(ft^2/d)	Storativity	Specific Yield[(a)]	Vertical Anisotropy
H5-3'O'	300	3200	0.008	0.057	0.07
H5-3P	240	2600	0.0055	0.037	0.07
H5-4'O'	250	2700	0.0055	0.018	0.07
H5-4P	200	2200	0.0055	0.028	0.07
H5-5P	160	1700	0.006	0.086	0.09
H5-6	200	2200	0.009	0.036	0.09
H5-8	300	3200	0.005	0.025	0.08
H5-9	190	2100	0.004	0.026	0.06
H5-11	280	3000	0.004	0.027	0.06

(a) Because of the short test duration (i.e., 1440 min), estimates for specific yield are expected to be highly qualitative and may significantly underestimate actual in situ conditions.

To examine areal average characteristics of the test aquifer, three composite analyses of observation well recovery data were completed. Two of the composite analyses were for locations where two wells were completed at different depths in the aquifer (well sites H5-3'O' -3P, and H5-4'O' -4P) and a third composite analysis for selected observation wells located at distances greater than 3.7 m (12 ft) from the pumping well. Because the third composite analysis included data for observation wells located at different distances from the pumping well, the recovery data for each well were normalized (as is standard practice) by dividing time by the square of their radial distance. Summary results of the composite analysis are presented in Table 5.4.

The composite analysis results generally support findings previously obtained from the individual observation well analyses, specifically that average aquifer transmissivity exhibits a distance dependence with lower transmissivity values indicated for wells located closer to the pumping well (as noted by comparing the composite analysis for wells H5-4'O' -4P to results obtained for wells H5-3'O' -3P). As discussed earlier, whether or not this distance dependence is associated with changes in aquifer characteristics (e.g., increasing aquifer thickness or hydraulic conductivity with distance), or inherent deficiencies in the analytical solution for analyzing tests conducted in shallow thin unconfined aquifers is not known. Of particular interest is the third composite analysis for selected wells located at distances greater than 3.7 m (12 ft) from the pumping well. The normalized observation well recovery responses converge and become asymptotic with the Theis curve in late test times. This suggests that the values estimated for transmissivity (250 m^2/d [2700 ft^2/d]) and specific yield (0.037) are probably close to the actual large-scale aquifer characteristics in the vicinity of the ISRM test site.

Table 5.4. Results of Constant-Rate Discharge Test Composite Analysis for ISRM Test Site Observation Well Locations

Well Grouping	Transmissivity (m^2/d)	Transmissivity (ft^2/d)	Storativity	Specific Yield[(a)]	Vertical Anisotropy
H5-3'O' & 3P	260	2800	0.0055	0.055	0.05
H5-4'O' & 4P	210	2300	0.006	0.03	0.07
H5-3P, 4P, 8, & 11	250	2700	0.0055	0.037	0.06

(a) Because of the short test duration (i.e., 1440 min), estimates for specific yield are expected to be highly qualitative and may significantly underestimate actual in situ conditions.

6.0 Groundwater Chemistry

Analyses for groundwater chemistry characterization were not performed as part of site characterization activities in FY 1995. Existing groundwater data from well 199-H5-1A was sufficient to establish baseline conditions. Extensive groundwater sampling is planned associated with the actual ISRM field experiment, to be conducted in the fourth quarter of FY 1995. The purpose of this section is to briefly discuss the existing groundwater data from the 100-H Area and specifically well 199-H5-1A.

As part of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process, a Limited Field Investigation was undertaken in the 100-HR-3 Operable Unit (DOE-RL 1993). This investigation evaluated the groundwater chemistry of the 100-H Area and identified constituents of primary concern. These constituents were then evaluated further in a qualitative risk assessment (DOE-RL 1993). Based on the qualitative risk assessment, the constituents of primary concern for human health risk in the groundwater beneath the 100-H Area are tritium, carbon-14, strontium-90, technetium-99, uranium-238, chromium, and nitrate. The constituents of primary concern for ecological risk (contamination near the river) in the 100-H Area are chromium, iron, and lead. The human health risks for the occasional- and frequent-use scenarios are low to very low. The constituents identified for ecological risk exceed the chronic lowest observable effect level. DOE-RL (1993) concluded that an interim remedial measure may be necessary based on the chromium and iron concentrations in the near river wells, springs, and/or the Columbia River.

Well 199-H5-1A is outside of the main contamination plume for all of the above-mentioned constituents of primary concern. Existing groundwater data for well 199-H5-1A is shown in Appendix C.

7.0 Conclusions

The uppermost unconfined aquifer is approximately 3 m (9 ft) thick beneath the ISRM test site and is contained within the sands and sandy gravels of the Hanford formation. The static water table is located at a depth of 12.5 m (41.1 ft) below ground surface. From approximately 11.9 to 13.0 m (39 to 43 ft) in all of the wells expect 199-H5-2, the formation lithology is dominated by a sand facies. The sand facies ranges from very fine sand (0.06 to 0.12 mm) to medium sand (0.25 to 0.5 mm) size. The facies appears to become more silty in well 199-H5-5P, and well 199-H5-11 consists of a slightly gravelly, slightly muddy sand. From approximately 13.0 to 15.3 m (43 to 50.3 ft), the unit is dominated by a sandy gravel with some gravelly sand and muddy sandy gravel layers. Subsequently, the uppermost unconfined aquifer can be described as containing two hydrofacies: 1) a lower unit dominated by a sandy gravel (the lower 1.8 to 2.1 m [6 to 7 ft] of the aquifer), and 2) an upper unit dominated by sand (the upper 0.9 to 1.2 m [3 to 4 ft] of the aquifer).

The contact with the underlying Ringold Formation (Lower Mud Unit) occurs at approximately 15.3 m (50.3 ft). The spatial continuity of this uppermost, fine-grained Ringold Unit was observed during hydrogeologic characterization activities at the ISRM test site and is supported by hydrochemical data from across the 100-HR-3 Operable Unit that indicates contamination does not extend beyond the uppermost part of the unconfined aquifer.

Sediment samples were collected from the uppermost unconfined aquifer during installation of six ISRM test site wells to obtain samples for physical property analyses, chemical analyses, and characterization of microbiological populations. On average, sediment samples collected from the sand-dominated facies of the Hanford formation had a particle density of 2.74 g/cm^3, a bulk density of 1.83 g/cm^3, and a porosity of 33%. Sediment samples collected from the gravel-dominated facies of the Hanford formation had a particle density of 2.73 g/cm^3, a bulk density of 1.93 g/cm^3, and a porosity of 29%. Sediment samples collected from the Ringold Formation had a particle density of 2.55 g/cm^3, a bulk density of 1.70 g/cm^3, and a porosity of 33%. Preliminary geochemical analyses indicate available iron(III) ranged from 0.038 (±0.011) to 0.212% by weight for Hanford formation sediments and 0.73% by weight for Ringold Formation sediments. Sediment samples collected for microbiological analysis indicate low (or no) microbiological populations. This microbiological information is consistent with the results of other microbiological analyses on the Hanford Site.

Single-well slug displacement tests were conducted during well installation to assess the vertical distribution of horizontal hydraulic conductivity. Tests were conducted as the borehole was advanced; generally the upper 1.5 m (5 ft) and the lower 1.5 m (5 ft) of the aquifer was tested. Hydraulic conductivity estimates obtained from the slug tests ranged from 36 to 50 m/d (120 to 160 ft/d) for the upper zone and 11 to 38 m/d (36 to 120 ft/d) for the lower zone. These estimates are not consistent with the field site-scale hydraulic conductivity estimate of 90 m/d (300 ft/d) obtained from the constant-rate discharge test analysis. However, fines generated and/or mobilized during drilling, which were observed during geologic sample collection and during well development activities following well installation, likely affected the permeability of the "near well" formation materials. Because well development was not conducted at any of the test locations before the slug displacement testing and data from the single-well slug tests do not correlate well with results from the constant-rate discharge test, slug displacement testing results are considered suspect.

Analysis of the constant-rate discharge test data for the ISRM test site included two approaches: 1) individual analyses for each of the observation well sites, and 2) simultaneous composite analysis of selected groups of observation well test data. Individual and simultaneous analysis provided comparable results and indicate the following "best estimate" for test site-scale hydraulic properties: transmissivity = 250 m^2/d (2700 ft^2/d), effective hydraulic conductivity = 90 m/d (300 ft/d), storativity = 0.0055, specific yield = 0.037, and vertical anisotropy ($K_D = K_v/K_h$) = 0.06.

Of the hydraulic properties determined, only transmissivity exhibited any spatial dependence. A general dependence between transmissivity and well screen/aquifer depth was indicated. A possible decreasing transmissivity with increasing depth relationship is consistent with geologic descriptions of well logs available for the ISRM test site. In addition, a general relationship of increasing transmissivity with increased distance from pumping well H5-2 was indicated. This general association was exhibited irrespective of azimuth direction for observation wells at the ISRM test site. The cause for this distance correspondence is not known. This distance dependence may be associated with changes in aquifer characteristics (e.g., increasing aquifer thickness or hydraulic conductivity with distance) or inherent deficiencies in the analytical solution for analyzing tests conducted in shallow thin unconfined aquifers.

8.0 References

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Appendix A

As-Built Diagrams

and Borehole Logs

Appendix A

As-Built Diagrams and Borehole Logs

This appendix contains as-built diagrams for all 16 wells installed during FY 1995 at the In Situ Redox Manipulation Test Site. Information contained on these diagrams include well construction details, sampling intervals, and lithology.

Also contained in this appendix are the borehole logs for the six wells that were sampled. These logs contain the geologist's field lithologic descriptions and a description of sample intervals.

AS-BUILT DIAGRAM

Boring or Well Number 199-H5-2 — Sheet 1 of 1

Location Hanford Site, 100-H Area — Project Redox Manipulation

Logged by SS Teel — Date Well Started 1-25-95

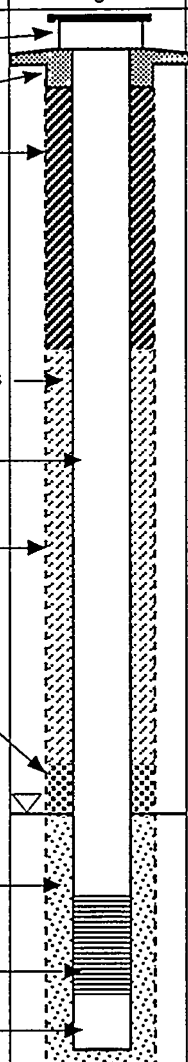
Reviewed by ______ Date ______ — Date Well Completed 3-3-95

Well Construction Data

Drill Bit: Sonic (0–55 ft)

Depth (ft)	Description
	Protective casing
0.0 - 2.0	Concrete pad
2.0 - 15.8	Cement grout
15.8 - 38	Bentonite crumbles
+2.7 - 45.42	8-in dia. sch 40 PVC casing
0 - 54	12-in. dia. borehole
38 - 41.2	Bentonite pellets
44.06	Depth to water (from top of casing, 3/27/95)
41.2 - 53.6	10-20 mesh Colo. Silica Sand
45.42 - 50.44	8-in dia. Sch 40 PVC Screen
50.44 - 53.45	8-in dia. Sch 40 PVC sump with end cap

Construction Diagram



TD = 54 feet

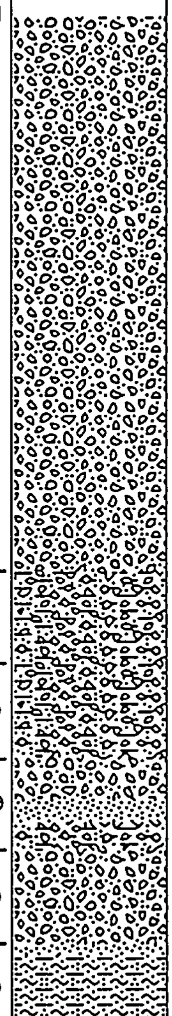
All depths are feet below land surface except where noted. Depth to water is measured in feet below top of casing.

Depth in Feet: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55

Geologic / Hydrologic Data

Sample Method: Sonic (0–30 ft); Split-Barrel samples at approx. 33, 38, 43, 48, 53 ft

Lithologic Diagram



Depth (ft)	Lithologic Description
0.0 - 30	Sandy Gravel
30 - 40	Silty Sandy Gravel
40 - 42.5	Sandy Gravel
42.5 - 43.5	Sand
43.5 - 45	Silty Sandy Gravel
45 - 50	Sandy Gravel
50 - 50.3	Sand
50.3 - 54	Slightly Clayey, Sandy Silt

Lithologic description based on geologist's field notes.

Drill Bit / Sample Method Used:
☐ Sonic ☒ Air Rotary ■ Mud Rotary ▲ Air Percussion △ Back Hoe ◇ Auger ○ Drive Barrel ● Hard Tool ⊕ Split-Barrel

A-1800-186 (12-91)

AS-BUILT DIAGRAM

Boring or Well Number 199-H5-3 (O) Sheet 1 of 1

Location Hanford Site, 100-H Area Project Redox Manipulation

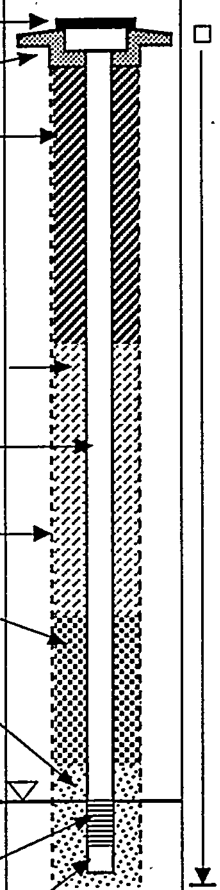
Logged by SS Teel

Reviewed by ______ Date ______

Date Well Started 2-18-95

Date Well Completed 3-3-95

Well Construction Data			Depth in Feet	Geologic / Hydrologic Data		
Description	Construction Diagram	Drill Bit		Sample Method	Lithologic Diagram	Lithologic Description
Manhole cover		☐	0			
0.0 - 2.0 Concrete pad						0.0 - 45.7 No samples collected
2.0 - 16.3 Cement grout			5			
			10			
			15			
16.3 - 30.9 Bentonite crumbles			20			
0 - 41.09 2-in dia. sch 40 PVC casing			25			
0 - 45.7 7.25-in. dia. borehole			30			
30.9 - 39.2 Bentonite hole plug			35			
39.2 - 45.7 20-40 mesh Colo. Silica Sand			40			
40.62 Depth to water (from top of casing, 3/27/95)						
41.09 - 43.56 2-in dia. 10-slot Sch 40 PVC Screen			45			
43.56 - 44.9 2-in dia. Sch 40 PVC sump with end cap	TD = 45.7 feet		50			
			55			



All depths are feet below land surface except where noted. Depth to water is measured in feet below top of casing.

Drill Bit / Sample Method Used:

☐ Sonic ☒ Air Rotary ■ Mud Rotary ▲ Air Percussion △ Back Hoe ◇ Auger ○ Drive Barrel ● Hard Tool ⊕ Split-Barrel

A-1800-186 (12-91)

AS-BUILT DIAGRAM

Boring or Well Number 199-H5-3 (P) Sheet 1 of 1

Location Hanford Site, 100-H Area Project Redox Manipulation

Logged by SS Teel

Reviewed by ______ Date ______

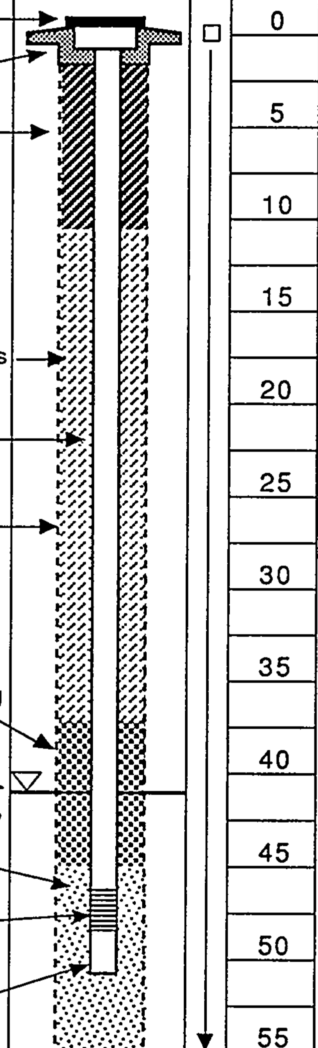
Date Well Started 2-6-95

Date Well Completed 3-3-95

Well Construction Data

Drill Bit: □ Sonic (0 - 55 feet)

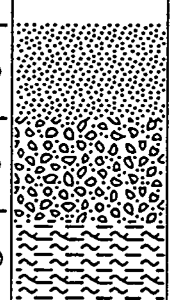
Description	
	Manhole cover
0.0 - 2.0	Concrete pad
2.0 - 11	Cement grout
11 - 37.2	Bentonite crumbles
0 - 46.29	2-in dia. sch 40 PVC casing
0 - 55	7.25-in. dia. borehole
37.2 - 45.5	Bentonite hole plug
40.60	Depth to water (from top of casing, 3/27/95)
45.5 - 55.5	20-40 mesh Colo. Silica Sand
46.29 - 48.79	2-in dia. 10-slot Sch 40 PVC Screen
48.79 - 51.64	2-in dia. Sch 40 PVC sump with end cap



All depths are feet below land surface except where noted. Depth to water is measured in feet below top of casing.

Geologic / Hydrologic Data

Sample Method: □ Sonic (0 - 39); ⊕ Split-Barrel (39 - 55)



Lithologic Description	
0.0 - 39	No samples collected. Cuttings appeared similar to adjacent well 199-H5-2.
39 - 44	Sand
44 - 50.2	Sandy Gravel
50.2 - 54	Clayey Silt
54 - 55	No samples collected

Lithologic description based on geologist's field notes.

Drill Bit / Sample Method Used:
□ Sonic ⊠ Air Rotary ■ Mud Rotary ▲ Air Percussion △ Back Hoe ◇ Auger ○ Drive Barrel ● Hard Tool ⊕ Split-Barrel

A-1800-186 (12-91)

AS-BUILT DIAGRAM

Boring or Well Number 199-H5-4 (O) Sheet 1 of 1

Location Hanford Site, 100-H Area Project Redox Manipulation

Logged by SS Teel

Reviewed by ______ Date ______

Date Well Started 2-17-95

Date Well Completed 3-3-95

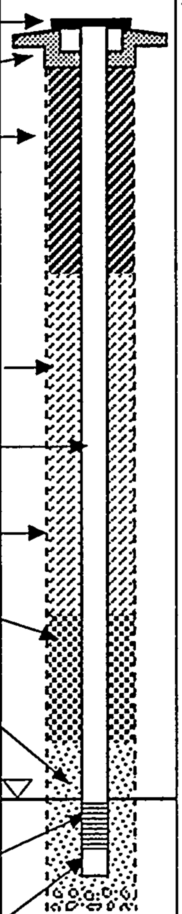
Well Construction Data | Depth in Feet | Geologic / Hydrologic Data

Drill Bit: ☐ (Sonic) | Sample Method:

Depth	Description
	Manhole cover
0.0 - 2.0	Concrete pad
2.0 - 12.5	Cement grout
12.5 - 30.8	Bentonite crumbles
0 - 41.69	2-in dia. sch 40 PVC casing
0 - 46.9	7.25-in. dia. borehole
30.8 - 38.2	Bentonite hole plug
38.2 - 45.5	20-40 mesh Colo. Silica Sand
40.62	Depth to water (from top of casing, 3/27/95)
41.69 - 44.16	2-in dia. 10-slot Sch 40 PVC Screen
44.16 - 45.5	2-in dia. Sch 40 PVC sump with end cap
45.5 - 46.9	Slough

All depths are feet below land surface except where noted. Depth to water is measured in feet below top of casing.

Construction Diagram:



TD = 46.9 feet

Depth in Feet: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55

Lithologic Diagram | Lithologic Description

0 - 46.9 No samples collected

Drill Bit / Sample Method Used:

☐ Sonic ☒ Air Rotary ■ Mud Rotary ▲ Air Percussion △ Back Hoe ◇ Auger ○ Drive Barrel ● Hard Tool ⊕ Split-Barrel

A-1800-186 (12-91)

AS-BUILT DIAGRAM

Boring or Well Number 199-H5-4 (P) Sheet 1 of 1

Location Hanford Site, 100-H Area Project Redox Manipulation

Logged by SS Teel

Reviewed by ______ Date ______

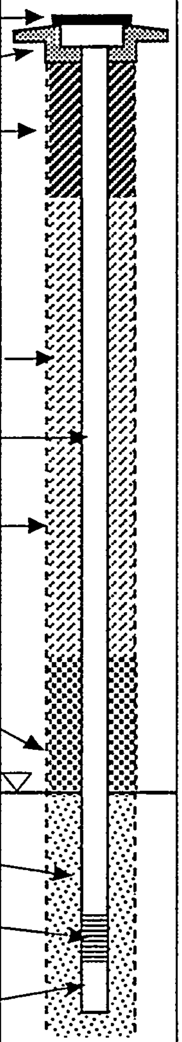
Date Well Started 2-8-95

Date Well Completed 3-3-95

Well Construction Data

Drill Bit: ☐ Sonic (0 - 54)

Depth	Description
	Manhole cover
0.0 - 2.0	Concrete pad
2.0 - 8.7	Cement grout
8.7 - 33.9	Bentonite crumbles
0 - 47.72	2-in dia. sch 40 PVC casing
0 - 54	7.25-in. dia. borehole
33.9 - 41.5	Bentonite hole plug
40.55	Depth to water (from top of casing, 3/27/95)
41.5 - 54	20-40 mesh Colo. Silica Sand
47.72 - 50.18	2-in dia. 10-slot Sch 40 PVC Screen
50.18 - 53.03	2-in dia. Sch 40 PVC sump with end cap

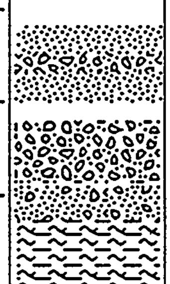


All depths are feet below land surface except where noted. Depth to water is measured in feet below top of casing.

Geologic / Hydrologic Data

Sample Method: ☐ Sonic (0 - 40); ⊕ Split-Barrel (40 - 55)

Depth in Feet: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55



Depth	Lithologic Description
0.0 - 39	No samples collected. Cuttings appeared similar to nearby well 199-H5-2.
39 - 40	No Recovery
40 - 41	Sand
41 - 42	Sandy Gravel
42 - 44	Sand
44 - 45	No recovery
45 - 48.5	Sandy Gravel
48.5 - 50.2	Gravelly Sand
50.2 - 54	Silt to Clayey Silt

Lithologic description based on geologist's field notes.

Drill Bit / Sample Method Used:

☐ Sonic ☒ Air Rotary ■ Mud Rotary ▲ Air Percussion △ Back Hoe ◇ Auger ○ Drive Barrel ● Hard Tool ⊕ Split-Barrel

A-1800-186 (12-91)

AS-BUILT DIAGRAM

Boring or Well Number 199-H5-5 (O) Sheet 1 of 1

Location Hanford Site, 100-H Area Project Redox Manipulation

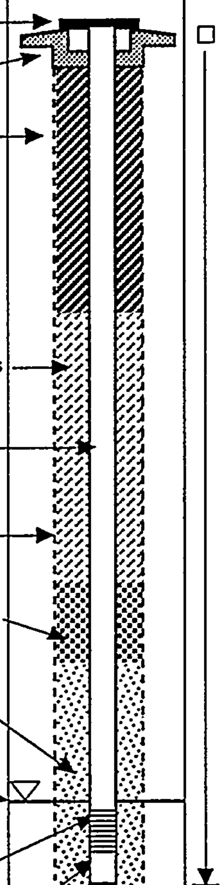
Logged by SS Teel

Reviewed by ______ Date ______

Date Well Started 2-16-95

Date Well Completed 3-3-95

Well Construction Data		Depth in Feet	Geologic / Hydrologic Data
Description	Construction Diagram / Drill Bit		Sample Method / Lithologic Diagram / Lithologic Description
Manhole cover		0	0 - 45.5 No samples collected
0.0 - 2.0 Concrete pad			
2.0 - 14.6 Cement grout		5	
		10	
		15	
14.6 - 29.0 Bentonite crumbles		20	
.0 - 41.62 2-in dia. sch 40 PVC casing		25	
0 - 45.5 7.25-in. dia. borehole			
29.0 - 33.5 Bentonite hole plug		30	
33.5 - 45.5 20-40 mesh Colo. Silica Sand		35	
40.65 Depth to water (from top of casing, 3/27/95)		40	
41.62 - 44.12 2-in dia. 10-slot Sch 40 PVC Screen		45	
44.12 - 45.46 2-in dia. Sch 40 PVC sump with end cap	TD = 45.5 feet	50	
		55	



All depths are feet below land surface except where noted. Depth to water is measured in feet below top of casing.

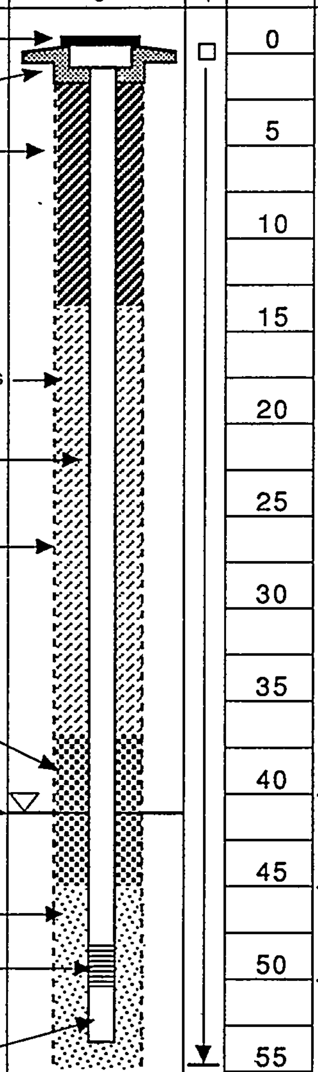
Drill Bit / Sample Method Used:
☐ Sonic ☒ Air Rotary ■ Mud Rotary ▲ Air Percussion △ Back Hoe ◇ Auger ○ Drive Barrel ● Hard Tool ⊕ Split-Barrel

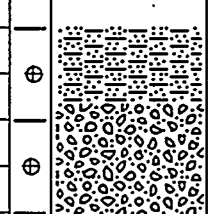
A-1800-186 (12-91)

AS-BUILT DIAGRAM	Boring or Well Number 199-H5-5 (P)	Sheet 1 of 1
	Location Hanford Site, 100-H Area	Project Redox Manipulation
Logged by SS Teel		Date Well Started 2-13-95
Reviewed by	Date	Date Well Completed 3-3-95

Well Construction Data | Drill Bit | Depth in Feet | Sample Method | **Geologic / Hydrologic Data**

Description		Lithologic Description	
	Manhole cover	0.0 - 40	No samples collected. Cuttings appeared similar to nearby well 199-H5-2.
0.0 - 2.0	Concrete pad	40 - 43.75	Silty Sand
2.0 - 13.4	Cement grout	43.75 - 50	Sandy Gravel
13.4 - 37.1	Bentonite crumbles	50 - 54	No samples collected. Driller reported silt layer starting at about 50.5.
0 - 48.44	2-in dia. sch 40 PVC casing		
0 - 54	7.25-in. dia. borehole		
37.1 - 44.8	Bentonite hole plug		
40.61	Depth to water (from top of casing, 3/27/95)		
44.8 - 54	20-40 mesh Colo. Silica Sand		
48.44 - 50.90	2-in dia. 10-slot Sch 40 PVC Screen		
50.90 - 53.75	2-in dia. Sch 40 PVC sump with end cap		





All depths are feet below land surface except where noted. Depth to water is measured in feet below top of casing.

Lithologic description based on geologist's field notes.

Drill Bit / Sample Method Used:
☐ Sonic ☒ Air Rotary ■ Mud Rotary ▲ Air Percussion △ Back Hoe ◇ Auger ○ Drive Barrel ● Hard Tool ⊕ Split-Barrel

A-1800-186 (12-91)

AS-BUILT DIAGRAM

Boring or Well Number 199-H5-6 Sheet 1 of 1

Location Hanford Site, 100-H Area Project Redox Manipulation

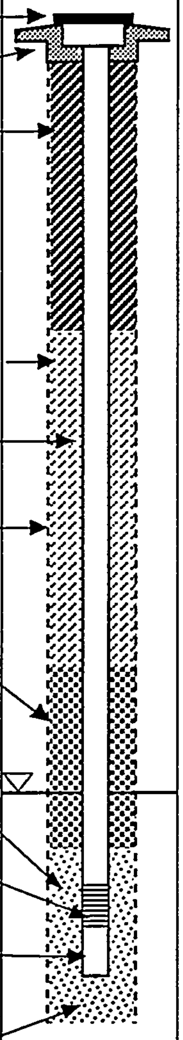
Logged by SS Teel

Reviewed by ____________ Date ____________

Date Well Started 2-20-95

Date Well Completed 3-3-95

Well Construction Data			Depth in Feet	Geologic / Hydrologic Data		
Description	Construction Diagram	Drill Bit		Sample Method	Lithologic Diagram	Lithologic Description
Manhole cover		☐	0			0.0 - 53.7 No samples collected
0.0 - 2.0 Concrete pad			5			
2.0 - 15.8 Cement grout			10			
15.8 - 34.3 Bentonite crumbles			15			
0 - 45.91 2-in dia. sch 40 PVC casing			20			
0 - 53.7 7.25-in. dia. borehole			25			
34.3 - 43.95 Bentonite hole plug			30			
40.68 Depth to water (from top of casing, 3/27/95)			35			
43.95 - 51.6 20-40 mesh Colo. Silica Sand			40			
45.91 - 48.38 2-in dia. 10-slot Sch 40 PVC Screen			45			
48.38 - 51.22 2-in dia. Sch 40 PVC sump with end cap			50			
51.6 - 53.7 4-8 mesh Colo. Silica Sand	TD = 53.7 feet		55			



All depths are feet below land surface except where noted. Depth to water is measured in feet below top of casing.

Drill Bit / Sample Method Used:
☐ Sonic ☒ Air Rotary ■ Mud Rotary ▲ Air Percussion △ Back Hoe ◇ Auger ○ Drive Barrel ● Hard Tool ⊕ Split-Barrel

A-1800-186 (12-91)

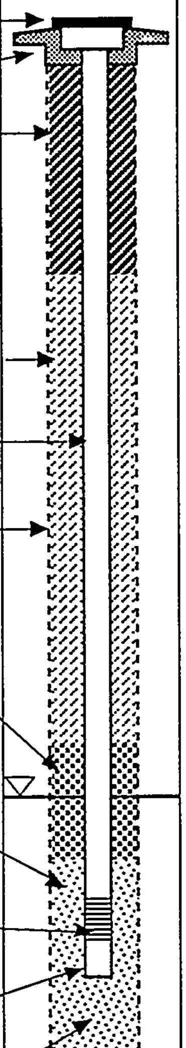
AS-BUILT DIAGRAM

Boring or Well Number 199-H5-7 Sheet 1 of 1

Location Hanford Site, 100-H Area Project Redox Manipulation

Logged by SS Teel Date Well Started 2-21-95

Reviewed by ______ Date ______ Date Well Completed 3-3-95

Well Construction Data			Depth in Feet	Geologic / Hydrologic Data		
Description	Construction Diagram	Drill Bit		Sample Method	Lithologic Diagram	Lithologic Description
Manhole cover 0.0 - 2.0 Concrete pad 2.0 - 12.7 Cement grout 12.7 - 38.2 Bentonite crumbles 0 - 46.69 2-in dia. sch 40 PVC casing 0 - 53.2 7.25-in. dia. borehole 38.2 - 44.25 Bentonite hole plug 40.61 Depth to water (from top of casing, 3/27/95) 44.25 - 51.8 20-40 mesh Colo. Silica Sand 46.69 - 49.16 2-in dia. 10-slot Sch 40 PVC Screen 49.16 - 52 2-in dia. Sch 40 PVC sump with end cap 51.8 - 53.2 10 - 20 mesh Colo. Silica Sand	 TD = 53.2 feet	☐	0 5 10 15 20 25 30 35 40 45 50 55			0.0 - 53.2 No samples collected Driller reported silt layer starts at about 50.5 ft. All depths are feet below land surface except where noted. Depth to water is measured in feet below top of casing.

Drill Bit / Sample Method Used:

☐ Sonic ☒ Air Rotary ■ Mud Rotary ▲ Air Percussion △ Back Hoe ◇ Auger ○ Drive Barrel ● Hard Tool ⊕ Split-Barrel

A-1800-186 (12-91)

AS-BUILT DIAGRAM

Boring or Well Number 199-H5-8 Sheet 1 of 1

Location Hanford Site, 100-H Area Project Redox Manipulation

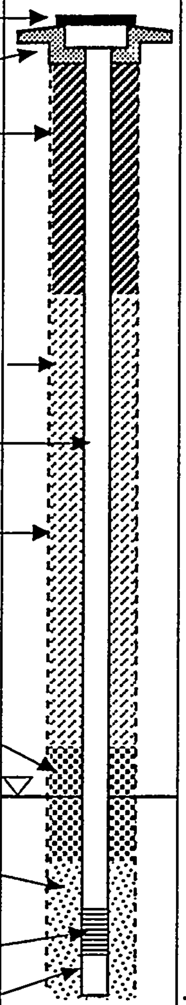
Logged by AW Pearson Date Well Started 3-1-95

Reviewed by ______ Date ______ Date Well Completed 3-3-95

Well Construction Data

Drill Bit: □ (Sonic), 0 to 52 ft

Depth	Description
	Manhole cover
0.0 - 2.0	Concrete pad
2.0 - 13.8	Cement grout
13.8 - 38.4	Bentonite crumbles
0 - 46.80	2-in dia. sch 40 PVC casing
0 - 52	7.25-in. dia. borehole
38.4 - 44.3	Bentonite hole plug
40.68	Depth to water (from top of casing, 3/27/95)
44.3 - 52	20-40 mesh Colo. Silica Sand
46.80 - 49.26	2-in dia. 10-slot Sch 40 PVC Screen
49.26 - 52	2-in dia. Sch 40 PVC sump with end cap



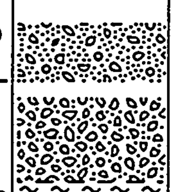
TD = 52 feet

All depths are feet below land surface except where noted. Depth to water is measured in feet below top of casing.

Depth in Feet: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55

Geologic / Hydrologic Data

Sample Method: ⊕ (Split-Barrel), 40-45 and 45-51



Depth	Lithologic Description
0.0 - 40	No samples collected
40 - 42	Poor recovery
42 - 45	Gravelly Sand (sample may have slid down during removal - may actually be from 40 - 43)
45 - 46	No recovery
46 - 50.7	Sandy Gravel
50.7 - 51	Silt/Clay
51 - 52	No sample collected

Lithologic description based on geologist's field notes.

Drill Bit / Sample Method Used:

□ Sonic ☒ Air Rotary ■ Mud Rotary ▲ Air Percussion △ Back Hoe ◇ Auger ○ Drive Barrel ● Hard Tool ⊕ Split-Barrel

A-1800-186 (12-91)

AS-BUILT DIAGRAM

Boring or Well Number 199-H5-9 Sheet 1 of 1

Location Hanford Site, 100-H Area Project Redox Manipulation

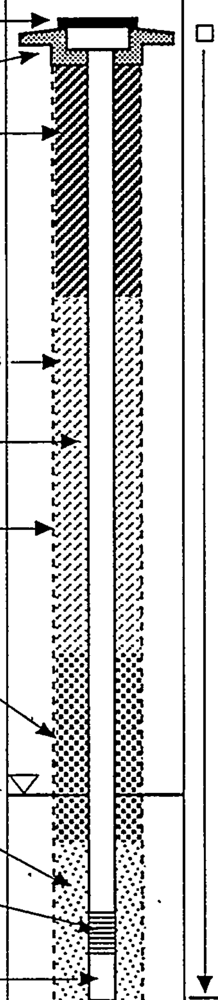
Logged by SS Teel

Reviewed by ______ Date ______

Date Well Started 2-21-95

Date Well Completed 3-3-95

Well Construction Data				Geologic / Hydrologic Data		
Description	Construction Diagram	Drill Bit	Depth in Feet	Sample Method	Lithologic Diagram	Lithologic Description
Manhole cover		☐	0			
0.0 - 2.0 Concrete pad						0.0 - 52.1 No samples collected Driller reported silt layer starts at about 50.5 ft.
2.0 - 14.8 Cement grout			5			
			10			
			15			
14.8 - 33.2 Bentonite crumbles			20			
0 - 47.20 2-in dia. sch 40 PVC casing						
0 - 52.1 7.25-in. dia. borehole			25			
			30			
33.2 - 43.7 Bentonite hole plug			35			
40.65 Depth to water (from top of casing, 3/27/95)			40			
43.7- 51.7 20-40 mesh Colo. Silica Sand			45			
47.20 - 49.66 2-in dia. 10-slot Sch 40 PVC Screen			50			
49.66 - 52 2-in dia. Sch 40 PVC sump with end cap						
51.7 - 52.1 Slough	TD = 52.1 feet		55			



All depths are feet below land surface except where noted. Depth to water is measured in feet below top of casing.

Drill Bit / Sample Method Used:

☐ Sonic ☒ Air Rotary ■ Mud Rotary ▲ Air Percussion △ Back Hoe ◇ Auger ○ Drive Barrel ● Hard Tool ⊕ Split-Barrel

A-1800-186 (12-91)

AS-BUILT DIAGRAM

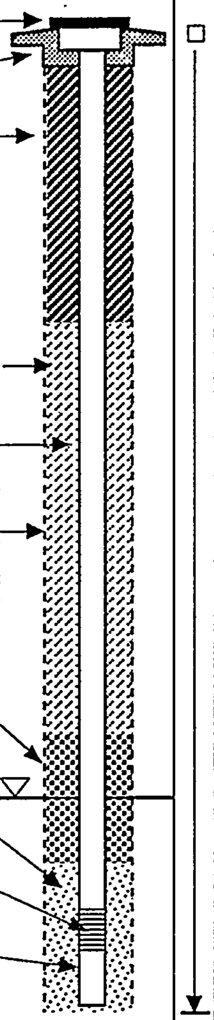
Boring or Well Number 199-H5-10 — Sheet 1 of 1

Location Hanford Site, 100-H Area — Project Redox Manipulation

Logged by SS Teel — Date Well Started 2-22-95

Reviewed by ______ Date ______ — Date Well Completed 3-3-95

Well Construction Data				Geologic / Hydrologic Data		
Description	Construction Diagram	Drill Bit	Depth in Feet	Sample Method	Lithologic Diagram	Lithologic Description



Description

- Manhole cover
- 0.0 - 2.0 Concrete pad
- 2.0 - 15.2 Cement grout
- 15.2 - 37.7 Bentonite crumbles
- 0 - 46.74 2-in dia. sch 40 PVC casing
- 0 - 52.7 7.25-in. dia. borehole
- 37.7 - 44.3 Bentonite hole plug
- 40.65 Depth to water (from top of casing, 3/27/95)
- 44.3- 52.7 20-40 mesh Colo. Silica Sand
- 46.74 - 49.21 2-in dia. 10-slot Sch 40 PVC Screen
- 49.21 - 52.05 2-in dia. Sch 40 PVC sump with end cap

TD = 52.7 feet

Depth in Feet: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55

All depths are feet below land surface except where noted. Depth to water is measured in feet below top of casing.

Lithologic Description

0.0 - 52.7 No samples collected. Driller reported silt layer starts at about 50.5 ft.

Drill Bit / Sample Method Used:

☐ Sonic ☒ Air Rotary ■ Mud Rotary ▲ Air Percussion △ Back Hoe ◇ Auger ○ Drive Barrel ● Hard Tool ⊕ Split-Barrel

A-1800-186 (12-91)

AS-BUILT DIAGRAM

Boring or Well Number 199-H5-11 Sheet 1 of 1

Location Hanford Site, 100-H Area Project Redox Manipulation

Logged by SS Teel Date Well Started 2-28-95

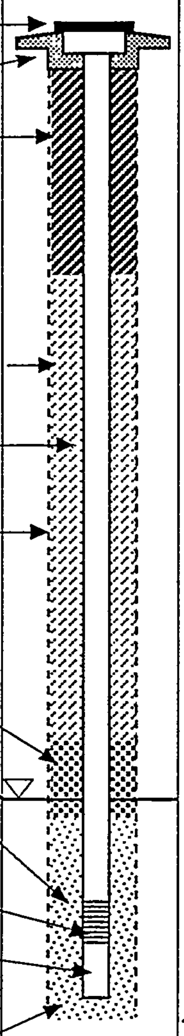
Reviewed by ______ Date ______ Date Well Completed 3-3-95

Well Construction Data

Drill Bit: ☐ (Sonic), 0 – 53 ft

Depth	Description
	Manhole cover
0.0 - 2.0	Concrete pad
2.0 - 12.7	Cement grout
12.7 - 38.2	Bentonite crumbles
0 - 46.33	2-in dia. sch 40 PVC casing
0 - 53	7.25-in. dia. borehole
38.2 - 42.2	Bentonite hole plug
40.78	Depth to water (from top of casing, 3/27/95)
42.2 - 52.1	20-40 mesh Colo. Silica Sand
46.33 - 48.8	2-in dia. 10-slot Sch 40 PVC Screen
48.8 - 51.64	2-in dia. Sch 40 PVC sump with end cap
52.1 - 53	10 - 20 mesh Colo. Silica Sand

Construction Diagram



TD = 53 feet

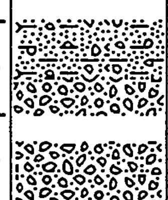
All depths are feet below land surface except where noted. Depth to water is measured in feet below top of casing.

Depth in Feet: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55

Geologic / Hydrologic Data

Sample Method: ⊕ (Split-Barrel), 40 – 45 ft and 45 – 50 ft

Lithologic Diagram



Depth	Lithologic Description
0.0 - 40	No samples collected
40 - 43.25	Slightly Gravelly, Slightly Muddy Sand
43.25 - 45	Sandy Gravel
45 - 46.5	No recovery
46.5 - 50	Sandy Gravel
50 - 53	No samples collected. Driller reported silt layer starts at about 50.5 ft.

Lithologic description based on geologist's field notes.

Drill Bit / Sample Method Used:

☐ Sonic ☒ Air Rotary ■ Mud Rotary ▲ Air Percussion △ Back Hoe ◇ Auger ○ Drive Barrel ● Hard Tool ⊕ Split-Barrel

A-1800-186 (12-91)

AS-BUILT DIAGRAM

Boring or Well Number 199-H5-12 | Sheet 1 of 1

Location Hanford Site, 100-H Area | Project Redox Manipulation

Logged by SS Teel, AW Pearson | Date Well Started 3-4-95

Reviewed by ____ Date ____ | Date Well Completed 3-7-95

Well Construction Data		Depth in Feet	Geologic / Hydrologic Data	
Description	Construction Diagram / Drill Bit		Sample Method / Lithologic Diagram	Lithologic Description

Manhole cover

0.0 - 2.0 Concrete pad

2.0 - 12.4 Cement grout

12.4 - 33.9 Bentonite crumbles

0 - 42.05 2-in dia. sch 40 PVC casing

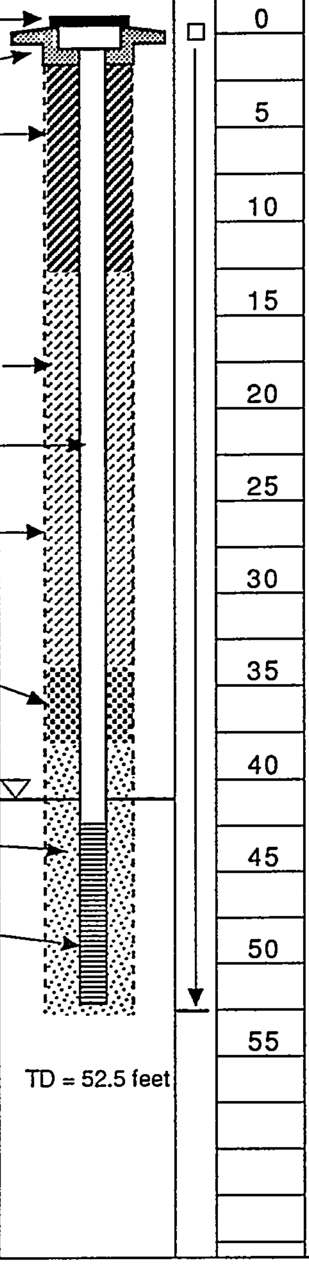
0 - 52.5 7.25-in. dia. borehole

33.9 - 38.2 Bentonite hole plug

41.00 Depth to water (from top of casing, 3/27/95)

38.2- 52.5 20-40 mesh Colo. Silica Sand

42.05 - 52.34 2-in dia. 10-slot Sch 40 PVC screen w/ end cap



TD = 52.5 feet

All depths are feet below land surface except where noted. Depth to water is measured in feet below top of casing.

Lithologic Description:

0.0 - 52.5 No samples collected. Driller reported silt layer starts at about 50.5 ft.

Drill Bit / Sample Method Used:

☐ Sonic ☒ Air Rotary ■ Mud Rotary ▲ Air Percussion △ Back Hoe ◇ Auger ○ Drive Barrel ● Hard Tool ⊕ Split-Barrel

A-1800-186 (12-91)

AS-BUILT DIAGRAM

Boring or Well Number 199-H5-13 Sheet 1 of 1

Location Hanford Site, 100-H Area Project Redox Manipulation

Logged by AW Pearson

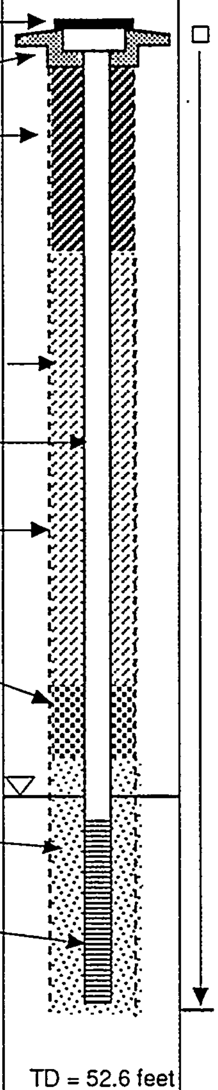
Reviewed by ______ Date ______

Date Well Started 3-6-95

Date Well Completed 3-7-95

Well Construction Data | Drill Bit | Depth in Feet | **Geologic / Hydrologic Data** | Sample Method | Lithologic Diagram | Lithologic Description

Depth	Description
	Manhole cover
0.0 - 2.0	Concrete pad
2.0 - 11.8	Cement grout
11.8 - 35.4	Bentonite crumbles
0 - 42.03	2-in dia. sch 40 PVC casing
0 - 52.6	7.25-in. dia. borehole
35.4 - 39.2	Bentonite hole plug
41.80	Depth to water (from top of casing, 3/27/95)
39.2- 52.6	20-40 mesh Colo. Silica Sand
42.03 - 52.27	2-in dia. 10-slot Sch 40 PVC screen w/ end cap



Depth in Feet: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55

Lithologic Description: 0.0 - 52.6 No samples collected

All depths are feet below land surface except where noted. Depth to water is measured in feet below top of casing.

Drill Bit / Sample Method Used:
☐ Sonic ☒ Air Rotary ■ Mud Rotary ▲ Air Percussion △ Back Hoe ◇ Auger ○ Drive Barrel ● Hard Tool ⊕ Split-Barrel

A-1800-186 (12-91)

AS-BUILT DIAGRAM

Boring or Well Number 199-H5-14 Sheet 1 of 1

Location Hanford Site, 100-H Area Project Redox Manipulation

Logged by AW Pearson Date Well Started 3-6-95

Reviewed by ______ Date ______ Date Well Completed 3-7-95

Well Construction Data			Depth in Feet	Geologic / Hydrologic Data		
Description	Construction Diagram	Drill Bit		Sample Method	Lithologic Diagram	Lithologic Description

Manhole cover

0.0 - 2.0 Concrete pad

2.0 - 13.2 Cement grout

13.2 - 35.7 Bentonite crumbles

0 - 42.26 2-in dia. sch 40 PVC casing

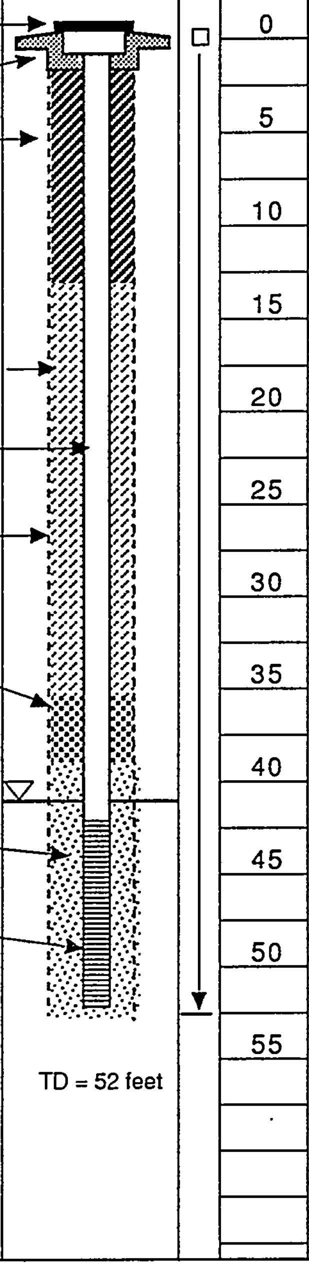
0 - 52.0 7.25-in. dia. borehole

35.7 - 39.0 Bentonite hole plug

41.66 Depth to water (from top of casing, 3/27/95)

39.0- 52.0 20-40 mesh Colo. Silica Sand

42.26 - 52.51 2-in dia. 10-slot Sch 40 PVC screen w/ end cap



TD = 52 feet

0.0 - 52.0 No samples collected

All depths are feet below land surface except where noted. Depth to water is measured in feet below top of casing.

Drill Bit / Sample Method Used:

☐ Sonic ☒ Air Rotary ■ Mud Rotary ▲ Air Percussion △ Back Hoe ◇ Auger ○ Drive Barrel ● Hard Tool ⊕ Split-Barrel

A-1800-186 (12-91)

BOREHOLE LOG

Boring or Well No. 199-H5-2

Sheet 1 of 2

Location: 100-HR-3 ~~"p"~~ SST 2/1/95 — Project: Redox

Prepared By: SS Teel (Sign/Print Name) — Date: 2/1/95 — Reviewed By: (Sign/Print Name) — Date:

Depth ( )	Sample: Type and No.	Sample: Blows or Recovery	Graphic Log	Sample Description: Group Name, Group Symbol, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Rate, Casing Size & Type, Bit Size, Water Level
(0-14)	Grab	N/A		1/25/95 (0-14') Sandy Gravel (55% gravel, 45% sand, trace silt/clay)! 20% SC, 20% VCP, 10% CP, 5% VFP-MP, 5% VCS, 15% CS, 15% MS, 5% FS, 5% VFS, trace silt. Also has 6" layer of dom VFS – not sure what interval this layer is from. Sandy Gravel is dry – VFS layer is moist. Unconsolidated (Gravel). VFS layer is slightly consol. Color of gravel fines is 10YR 7/1 (lt gray). VFS (moist color) is 10YR 4/4 (dk yellowish brown). Gravel fines - strong HCL reaction. VFS layer – slight HCL reaction	Sample taken from 6" sonic core barrel. 1/25/95 0810 hrs. No casing. (Disturbed sample). No archive or chem. samples taken
5					
10					
15 ~~(10-17)~~ SST 1/31/95	Grab	N/A		(10-17') Sandy Gravel – similar to previous except max size of cobbles is larger (~~medium~~ cobble size) SST 1/25/95 large. Don't see the VFS layer previously noted	6" core barrel sample 1305 hrs 1/25/95. casing @ 10'. (Disturbed Sample). No archive or chem. samples taken.
20 ~~(30-35)~~ SST 1/31/95	Grab Micro. ~~20% rec~~ JBT 1/31/95 rad release sample	20% rec. (1' rec.)		Silty Sand Gravel (30-35') 15% silt, 25% sand, 60% gravels w/ trace of mica. Sand → Angular; 60% felsic 40% mafic 5% VFS, 5% FS, 10% MS, 5% CS. Gravel → Subangular; 30% felsic, 70% mafic 5% VFP, 10% FP, 10% CP, 25% VCP, 10% SC. Wet → 10YR 3/1 Dry → 5Y 5/1	5' split spoon taken. 1' recovery. 1' microbial liner collected. grab sample/rad release collected. Customer ID → 199H52-1. Lab ID → N4565
25					
30–35	↑ split spoon ↓	sonic			

A-6000-382 (01/93)

BOREHOLE LOG

Boring or Well No. 199-H5-2

Sheet 2 of 2

Location: 100-HR-3 ~~"pu~~ SST 2/1/95

Project: Redox Manipulation Experiment

Prepared By: SS Teel (Sign/Print Name) Date: 2/1/95

Reviewed By: ______ (Sign/Print Name) Date: ______

Depth (35)	Sample: Type and No.	Sample: Blows or Recovery	Graphic Log	Sample Description (Group Name, Group Symbol, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl)	Comments (Depth of Casing, Drilling Rate, Casing Size & Type, Bit Size, Water Level)
	split spoon	sonic		Silty Sandy Gravel (35-40')	(4.5' recovery)
				same as previous sample	~~#~~ 6" recovery 39-40'
40				Sandy Gravel (40-42.5)(43.5-45')	(Gravel - 60% Si-rich - 40% basalt)
	split spoon	sonic		65% gravel, 35% sand, tr. silt/cl. (15% SC, 10% VCP ?, 15% CP, 10% MP	
				10% FP, 5% VFP, 5% VCS, 5% CS, 10% MS, 10% FS, 5% VFS, tr. silt	
				Sand (42.5-43.5) - basalt rich -	(3.7' recovery)
				dom med. sand size	(3" recover 44.5-45')
45					(40-41.3 no recovery)
	split spoon	sonic		Sandy Gravel (45-50')	
				Includes 2-3 thin sand layers (1-2" thick) ~~(3-4" thick)~~ SST 1/31/95	
				Appears to become sandy at 50' also.	
				Gravel layers are same as prev. Sand layers	~~(4' recovery)~~ SST 2/1/95
50				are dom VCS - CS and are 30% basalt,	(4.5' recovery)
	split spoon	sonic		70% qtz, qtzite, + Si-rich.	(49-50 - 0.5' recover)
				~~Sandy Gravel (50-50.3') VCS-CS~~ SST 2/1/95	
				Sand (50-50.3) VCS-CS.	
55					
				Slightly Clayey, Sandy Silt. (50.3-54')	(Full recovery)
				(Sandy Mud) ~~so~~ 30% sand, 50% silt,	
				20% clay. Mod. consol., 2.5Y 6/3	
				lt brownish gray to lt. yellowish brown.	
				Strong reaction to 10% HCL.	

A-6000-382 (01/93)

BOREHOLE LOG

Boring or Well No.	199-HS-3
Sheet	1 of 1
Location	S of 100-H Reactor (100HR-3)
Project	Redox Manipulation Experiment
Prepared By (Sign/Print Name)	SS Teel SS Teel
Date	2/8/95
Reviewed By (Sign/Print Name)	
Date	

Depth (39')	Sample: Type and No.	Sample: Blows or Recovery	Graphic Log	Sample Description (Group Name, Group Symbol, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl)	Comments (Depth of Casing, Drilling Rate, Casing Size & Type, Bit Size, Water Level)
40	↓			No samples collected from 0-39'.	/Shoe was flamed prior to use.
41	split	sonic		Cuttings ~~appeared~~ SST 2/7/95 appeared similar	Split-spoon sampler was
42	spoon			to adjacent well 199-HS-2.	de-conned prior to use.)
43	↑				(4.5' recovery)
44				Sand (39-44') ~~60%~~ SST 2/7/95	(6" recover 39-40')
45	↓			Trace MS, 60% FS, 40% VFS, trace	
46	split			silt. Wet color 5YR 3/1 (very dark gray)	
47	spoon	sonic		Unconsolidated to Sl. Consol.	Note: casing was not advanced
48					for 44'-49" sample. Therefore
49	↑			Sandy Gravel (44-49') Similar to	there is some possibility for
50	↑			same interval in HS-2. Gravels up to	slough in the sample.
51	split			small cobble size. Wet color is 5YR 3/2	However, the sampler was
52	spoon			(dark olive gray). Sands are dominantly	driven the full 5'.
53	↓			CS-MS, trace silt. Sample was very	(48.5-49' 0.2' recovery)
54				"loose" (unconsolidated").	
				Sandy Gravel (49-50.2') same as	(Full recovery)
				above.	
				Clayey Silt (50.2-54')	
				20% clay, 80% silt, trace sand.	
				Seems to increase clay w/ depth	
				(dom silt @ 50' - up to 30%	
				clay @ 54'? Wet ~~ct~~ color is 10YR 5/3	
				(brown). Moderately consolidated.	

A-6000-382 (01/93)

BOREHOLE LOG

Boring or Well No. 199-H5-4 "p"

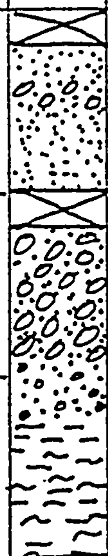
Sheet 1 of 1

Location 199-H5-4 'p'

Project Redox Manipulation

Prepared By SS Teel (Sign/Print Name) Date 2/16/95

Reviewed By ______ (Sign/Print Name) Date ______



Depth (39')	Sample: Type and No.	Sample: Blows or Recovery	Sample Description (Group Name, Group Symbol, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl)	Comments (Depth of Casing, Drilling Rate, Casing Size & Type, Bit Size, Water Level)
	6" recover		No samples collected from 0-39'	39-40' No recovery
40	No samples taken		Cuttings appeared similar to adj.	40-41' - 6" recovery -
41	Chem	Sonic	wells.	not representative
42	Bio			
43	Phys		No recovery (39-40')	
44	X		Sand? ('40-41') Poor recovery -	44-45' No recovery
45	Chem / Phys		may not be representative.	
46	Bio / Bio	Sonic	Sandy Gravel (41-42')	
47	Chem		Sand (42-43') (43-44')	
48	Chem / Chem / Bio		No Recovery (44-45')	
49			Sandy Gravel (45-48.5)	
50			Gravelly Sand (48.5-50.2')	
51			Silt to Clayey Silt (50.2-54')	
52				
53				
54				
55				

A-6000-382 (01/93)

BOREHOLE LOG

Boring or Well No. 199-HS-5 "P"

Sheet 1 of 1

Location: 199-HS-5 "P"

Project: Redox Manipulation

Prepared By: SS Teel (Sign/Print Name) Date: 2/15/95

Reviewed By: ______ (Sign/Print Name) Date: ______

Depth (40)	Sample: Type and No.	Sample: Blows or Recovery	Sample Description (Group Name, Group Symbol, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl)	Comments (Depth of Casing, Drilling Rate, Casing Size & Type, Bit Size, Water Level)
		Sonic (40–45)	(No samples collected prior to 40')	40-41' No recovery
40.5			Silty Sand (40 - 43.75')	41-41.5' 2" recovery
			(60% sand, 40% silt) Tr CS, 5% MS	44.5-45' 2" recovery
41			15% FS, 40% VFS, 40% silt.	40-45' sample collected
			Dry color 10YR 6/2 lt brownish gray.	@ 1020 hrs 2/14/95
41.5	Visual		Mod. consol (?) to unconsol.	(metal "sand catcher"
	Chem		Slight reaction to 10% HCL. No	was used).
42			evidence of moisture.	Temp tape < 160°
	Phys.			(100°F tape was ~~to~~ rubbed
			Sandy Gravel (43.75 - 50')	off).
	Bio		Similar to described in other boreholes.	Sample did not feel warm.
43			Cobble - pebble gravels and med - coarse	
	Bio		sand. ~10-~~15~~ % mud. Saturated. (<5% 2/14/95)	
	Chem			
44	Bio			
	Chem 2" recovery			
45	Visual Description (2" recovery)	Sonic (45–50)		45-50 sample @ 1125 2/14/95
				Sand catcher not used.
				Sample did not feel warm
46				saturated
	Chem			
47				
	Bio			
48				
	Chem			
49				
	4" recovery Phys			No samples collected after 50'
50				

A-6000-382 (01/93)

BOREHOLE LOG

Boring or Well No. 199-H5-8

Sheet 1 of 1

Location 100-HR-3 Project 100 H Redox

Prepared By AW Pearson / [signature] Date 3/2/95 (Sign/Print Name)

Reviewed By ______ (Sign/Print Name) Date ______

Depth (40)	Sample Type and No.	Blows or Recovery	Graphic Log	Sample Description (Group Name, Group Symbol, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl)	Comments (Depth of Casing, Drilling Rate, Casing Size & Type, Bit Size, Water Level)
40	Visual	Sonic		(No Samples collected above 40')	40-42' Poor Recovery
				40'-45' Gravelly Sand	Visual only
				Samples collect @ 0840	
41	Visual			Samples Saturated	
				Samples slightly warm	
				Heat tape was used but	
				was "rubbed off".	
42	Chem			Sample may have slid down	
				in liners while removing	44.8-45.0' No Recovery
				sampler from borehole ∆	
				bottom of sand may be	
43	Bio			44-43 ft bls.	
44	Phys.				
45	X	Sonic	No Recovery	46-50.7' Sandy Gravel	Driller drove SS
				Samples collected @ 0930	Sampler to 51'
				Samples Saturated	into clay to hold
				Samples not warm	sample in liners
46	Chem				∆ 45'-46 ft => No
					recovery
47	Chem				
48	Phys.				
49	Bio				
50	Chem			50.7-51.0' Silt/Clay	

A-6000-382 (01/93)

BOREHOLE LOG

Boring or Well No. 199-45-11

Sheet 1 of 1

Location 199-H5-11

Project Redox Manipulation

Prepared By SSTeel SSteel (Sign/Print Name) Date

Reviewed By (Sign/Print Name) Date

Depth (40)	Sample: Type and No.	Sample: Blows or Recovery	Graphic Log	Sample Description: Group Name, Group Symbol, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Rate, Casing Size & Type, Bit Size, Water Level
	1" Recovery		Sonic	Sl. Gravelly, Sl. Muddy Sand (40'-43.25)	Note: Sampler was very hot! Therefore samples were not collected for micrbial analysis
	2" Recovery				
41	Chem			Sandy Gravel (43.25-45')	Sample collected @ 1615 hrs 2/28/95
	Chem				
42	Phys				
	Chem				
43	Phys			Sl	
	Phys				
44	Chem				
	Visual				
45		No Recovery		No Recovery 45-46.5	Sample collected @ 0900 hrs 3/1/95
46				Sandy Gravel (46.5-50')	
47	Chem		Sonic		
48	Bio				
	Chem				
49	Bio				
50	Phys				

A-6000-382 (01/93)

Appendix B

Sediment Physical Property Results

Appendix B

Sediment Physical Property Results

This appendix contains the results of the sediment physical property analyses. These analyses include moisture content, sieve, particle density, bulk density, hydrometer, and porosity. Samples were analyzed consistent with the procedures in Procedures for Ground-Water Investigations (PNL-6894. Rev.1) written by Pacific Northwest Laboratory in 1992.

Sample No.	Depth	Geologist Comment	Lab Comment	Moisture	Sieve Analysis	Particle Density	Hydrom. Analysis	Bulk Density	Porosity
H5-2	39 - 40.25	Intact - nearly full	repack core	X	X	X		X	X
	46 - 46.5	Intact		X	X	X		X	X
	48.75 - 51	may be disturbed	repack ends, rock in center	X	X	X		X	X
H5-5	42 - 42.5			X	X	X		X	X
	49 - 50	partially full		X	X	X		X	X
H5-3	40 - 41		repack core	X	X	X	X	X	X
	43 - 45		43.75-45' on core	X	X	X	X	X	X
	47.5 - 48		core disturbed - no BD	X	X	X			
	48.7 - 50		Large rocks - no BD	X	X	X			
	50.5 - 51		Large rocks in core	X	X	X	X	X	X
	52 - 52.5		Large rocks in core	X	X	X	X	X	X
	53 - 53.5		Large rocks in core	X	X	X	X	X	X
H5-4	43 -44	mason jar	no BD	X	X	X			
	45.5 - 46			X	X	X		X	X
H5-11	43.5 - 44			X	X	X		X	X
	42 - 42.5			X	X	X		X	X
	43 - 43.5		no BD - too rocky	X	X				
	49.5 - 50		Large rock in core	X	X	X			
H5-8	44 - 45			X	X	X		X	X
	48 - 49		Large rocks in core	X	X	X		X	X

WATER CONTENT

Sample No.	Beaker No.	Beaker Weight	Soil/Beaker Wet Weight	Soil/Beaker Dry Weight	% Water	Comments
H5-3	PAN	54.08	871.90	801.00	0.094923151	
43.75-45.0						
H5-3	75	50.37	82.22	79.20	0.104751994	
43.75-45.0	74	48.54	81.08	78.21	0.096730704	
	66	49.54	85.14	81.96	0.0980876	0.099856766
H5-3	78	48.86	95.89	94.32	0.034535856	
47.5-48.0	94	51.20	82.46	80.94	0.051109617	
	86	47.84	83.09	81.82	0.037374926	0.0410068
H5-3	73	50.68	84.73	82.66	0.064727955	
48.7-50.0	83	50.93	87.88	85.95	0.055111365	
	79	48.19	83.07	81.46	0.048391945	0.056077088
H5-3	PAN	56.66	1286.76	1101.82	0.176948984	
50.5-51.0	PAN	120.42	853.82	747.66	0.16924941	
						0.173099197
H5-3	92	48.21	69.80	66.67	0.169555796	
50.5-51.0	90	51.51	82.30	77.97	0.163643235	
						0.166599516
H5-3	PAN	104.31	830.74	699.56	0.220377992	
52.0-52.5						
H5-3	69	49.36	79.97	74.43	0.220981252	
52.0-52.5	85	49.85	80.93	75.40	0.216438356	
	76	48.81	84.13	77.87	0.21541638	0.217611996
H5-3	PAN	142.83	901.44	778.03	0.194285264	
53.0-53.5						
H5-3	61	49.99	83.26	77.77	0.19762419	
53.0-53.5	97	49.34	80.21	75.05	0.200700117	
	2	50.56	85.35	79.54	0.200483092	0.199602466
H5-4	95	49.20	81.28	75.58	0.216072782	
43.0-44.0	81	51.52	83.89	78.17	0.214634146	
	57	50.11	82.37	76.09	0.241724403	0.224143777

Analyst: ____________ Scale/Serial Number: ____________

Date: ____________ Calibration Date: ____________

Procedure Number	Revision Number	Effective Date
SA 7	1	Aug-90

WATER CONTENT

Sample No.	Beaker No.	Beaker Weight	Soil/Beaker Wet Weight	Soil/Beaker Dry Weight	% Water	Comments
H5-4	PAN	119.60	2301.20	2126.40	0.087103847	
45.5-46.0						
H5-5	PAN	58.70	1862.80	1847.65	0.008468655	
42.0-42.5						
H5-5	PAN	61.30	850.70	819.40	0.041287429	
49.0-50.0						
H5-2	99	51.95	87.55	87.23	0.009070295	
39.0-40.25	55	50.37	81.40	81.12	0.009105691	
	60	50.75	86.17	85.89	0.007968127	0.008714704
H5-2	PAN	57.80	1164.30	1155.25	0.008242715	
39.0-40.25						
H5-2	PAN	118.44	991.88	941.42	0.061313762	
46.0-46.5						
H5-2	PAN	52.84	1762.40	1688.85	0.044956938	
48.75-51.0						
H5-2	51	49.68	82.85	81.25	0.050681026	
48.75-51.0	34	50.30	85.49	83.94	0.0460761	
	98	49.60	85.67	84.03	0.047632878	0.048130001
H5-3	PAN	54.55	714.42	693.59	0.032595769	
40.0-41.0						
H5-3	68	48.01	82.87	82.04	0.024390244	
40.0-41.0	70	51.74	82.99	82.22	0.025262467	
	13	48.71	81.87	81.05	0.025355597	0.025002769

Analyst: ____________________ Scale/Serial Number: ____________________

Date: ____________________ Calibration Date: ____________________

Procedure Number	Revision Number	Effective Date
SA 7	1	Aug-90

WATER CONTENT

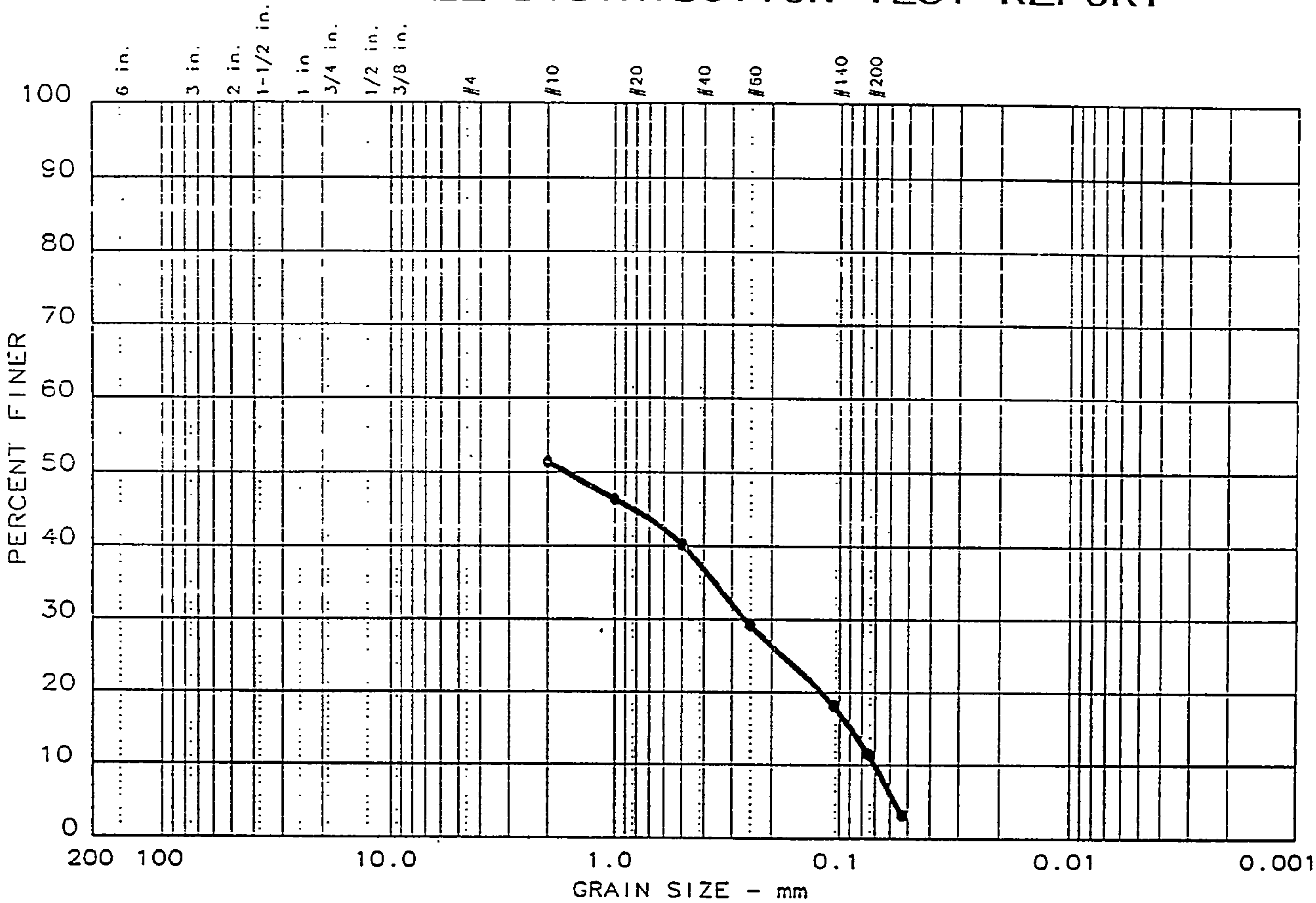
Sample No.	Beaker No.	Beaker Weight	Soil/Beaker Wet Weight	Soil/Beaker Dry Weight	% Water	Comments
H5-11	PAN	118.66	1199.10	1170.30	0.027385797	
43-43.5						
H5-11	51	49.71	84.25	82.74	0.045716016	
43-43.5	57	50.09	87.66	86.19	0.040720222	
	T4	51.64	98.96	97.16	0.039543058	0.041993098
H5-11	52	49.27	100.34	96.65	0.077880962	
42-42.5	55	50.36	86.55	83.93	0.078045874	
	43	50.59	89.33	86.31	0.084546473	0.08015777
H5-11	58	50.04	94.25	92.54	0.040235294	
43.5-44	81	51.52	98.41	96.67	0.038538206	
	68	47.99	88.10	86.79	0.033762887	0.037512129
H5-11	T5	49.63	96.90	95.10	0.039586541	
49.5-50	74	48.54	88.49	86.52	0.051869405	
	37	50.62	98.53	96.38	0.046984266	0.046146737
H5-8	90	51.50	113.95	109.95	0.068434559	
48-49	76	48.79	123.79	119.25	0.064433721	
	35	49.63	106.22	102.99	0.060532234	0.064466838
H5-8	71	48.82	87.20	84.89	0.06404214	
44-45	70	51.71	89.36	86.73	0.075099943	
	83	50.92	83.39	81.35	0.067039106	0.068727063

Analyst: ____________________ Scale/Serial Number: ____________________

Date: ____________________ Calibration Date: ____________________

Procedure Number	Revision Number	Effective Date
SA 7	1	Aug-90

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	5	0.0	48.6	48.2	3.2		SP-SM		

SIEVE inches size	PERCENT FINER ●		
GRAIN SIZE			
D_{60}	2.00		
D_{30}	0.26		
D_{10}	0.07		
COEFFICIENTS			
C_c	0.49		
C_u	28.6		

SIEVE number size	PERCENT FINER ●		
10	51.4		
18	46.3		
35	40.2		
60	29.3		
140	18.2		
200	11.5		
270	3.2		

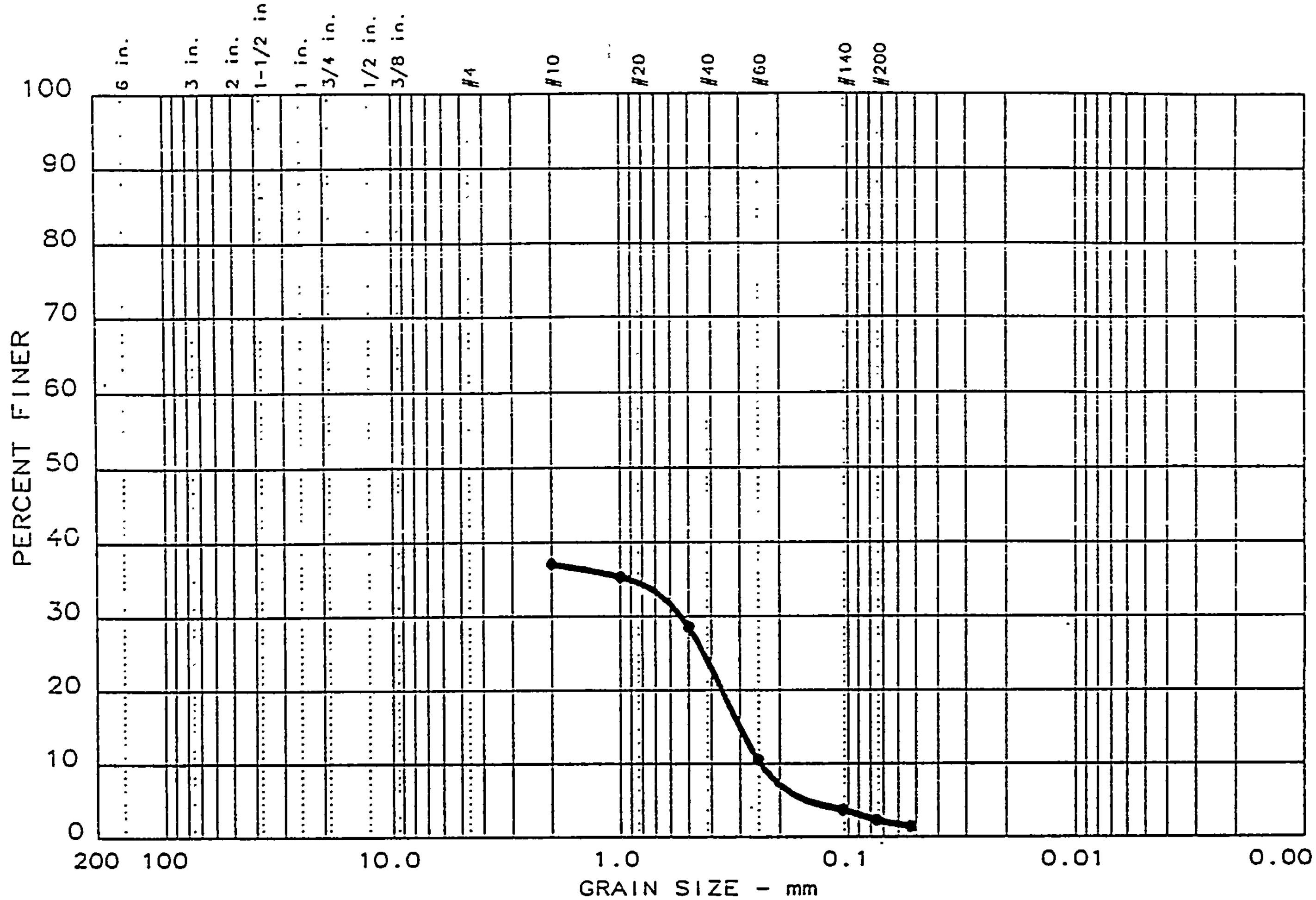
Sample information:
● H5-2
39.0 - 40.25
ASTM - SP-SM

Remarks:
a: gs5.sdt

Pacific Northwest Laboratory

Project No.: 100H
Project: 100H Remediation
Date: 4/17/95
Data Sheet No. 5

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	7	0.0	62.9	35.7	1.4		SP		

SIEVE inches size	PERCENT FINER ●		

	GRAIN SIZE		
D_{60}	2.00		
D_{30}	0.54		
D_{10}	0.24		

	COEFFICIENTS		
C_c	0.60		
C_u	8.3		

SIEVE number size	PERCENT FINER ●		
10	37.1		
18	35.3		
35	28.6		
60	10.6		
140	3.7		
200	2.3		
270	1.4		

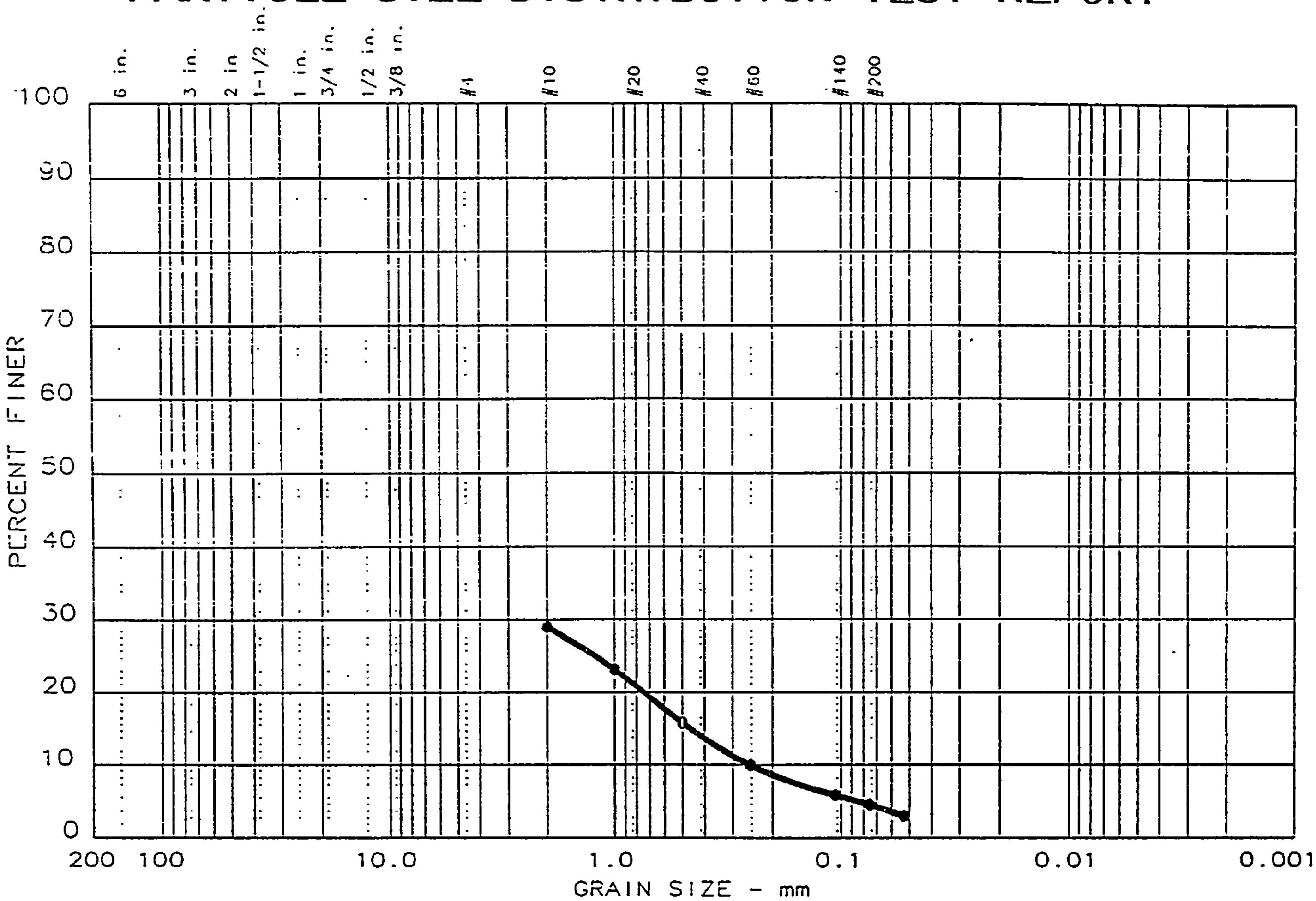
Sample information:
● H5-2
46.0 - 46.5
ASTM - SP

Remarks:
a: gs7.sdt

Pacific Northwest Laboratory

Project No.: 100H
Project: 100H Remediation
Date: 4/17/95 Data Sheet No. 7

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	8	0.0	71.0	26.0	3.0		SP		

SIEVE inches size	PERCENT FINER ●		

GRAIN SIZE			
D_{60}	2.00		
D_{30}	2.00		
D_{10}	0.24		

COEFFICIENTS			
C_c	8.04		
C_u	8.0		

SIEVE number size	PERCENT FINER ●		
10	29.0		
18	23.1		
35	15.8		
60	10.0		
140	5.9		
200	4.6		
270	3.0		

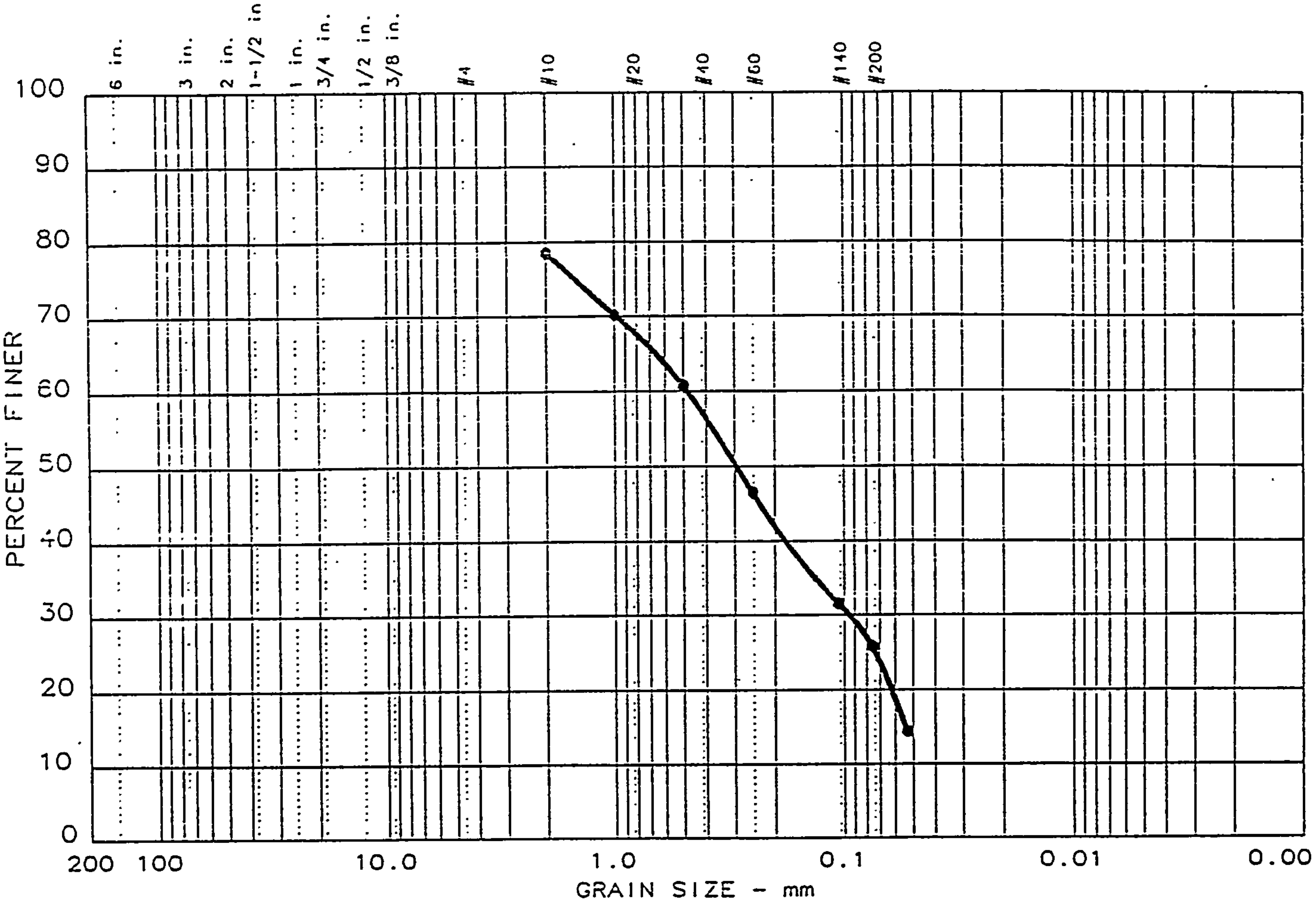
Sample information:
● H5-2
48.75 - 51.0
ASTM - SP

Remarks:
a: gs8.sdt

Pacific Northwest Laboratory

Project No.: 100H
Project: 100H Remediation
Date: 4/17/95
Data Sheet No. 8

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	14	0.0	21.5	64.0	14.5		SM		

SIEVE inches size	PERCENT FINER ●		

	GRAIN SIZE		
D_{60}	0.47		
D_{30}	0.09		
D_{10}			

	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ●		
10	78.5		
18	70.2		
35	60.8		
60	46.4		
140	31.6		
200	25.8		
270	14.5		

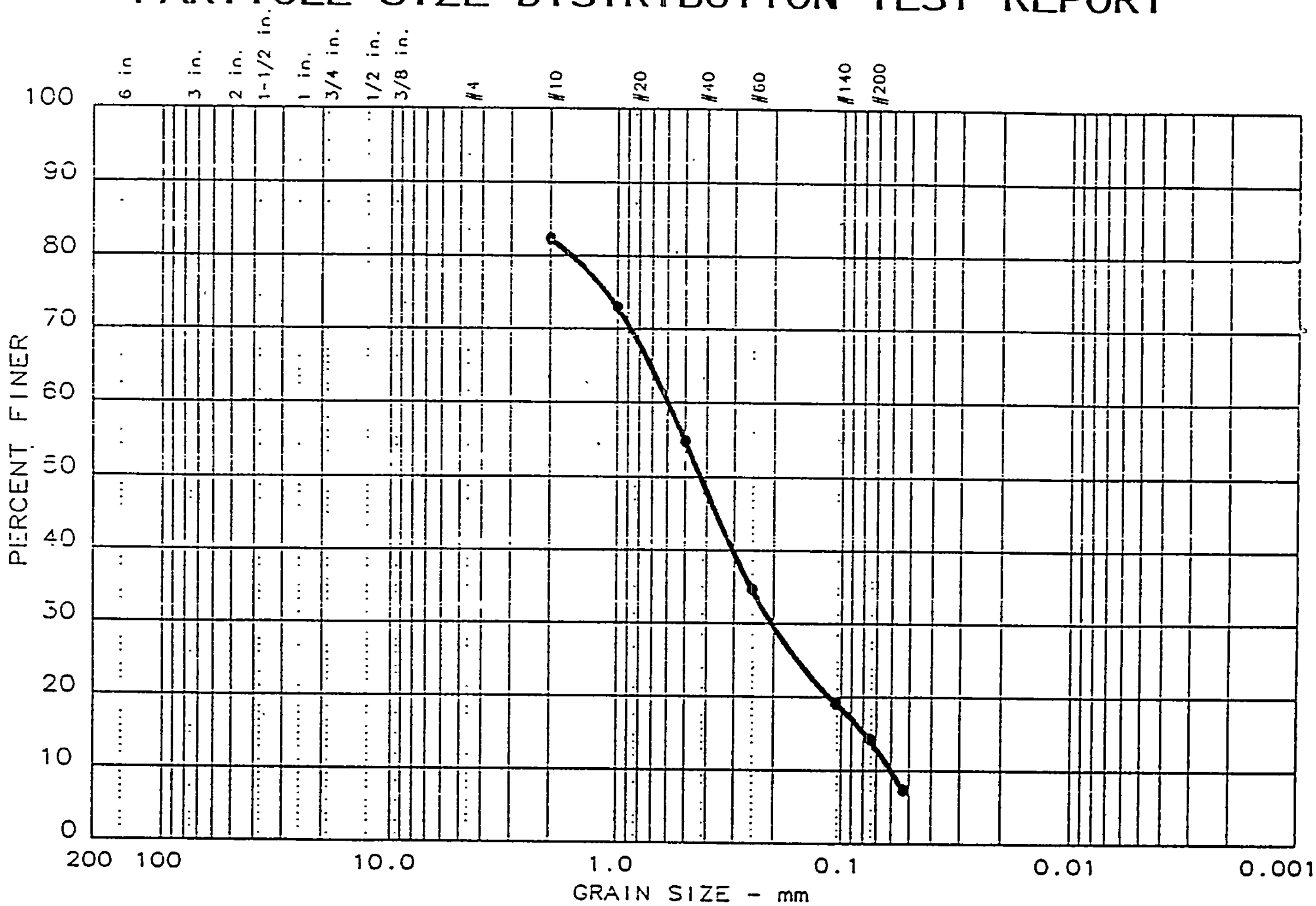
Sample information:
● H5-3
40.0 - 41.0 FEET
ASTM Class. SM

Remarks:
a: gs14sdt
Run Hydrometer
Hydrometer data =
a: data2 gs1.sdt

Pacific Northwest Laboratory

Project No.: 100H
Project: 100H Remediation
Date: 4/14/95
Data Sheet No. 14

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	1	0.0	17.7	75.0	7.3		SM		

SIEVE inches size	PERCENT FINER ●		
	GRAIN SIZE		
D_{60}	0.59		
D_{30}	0.20		
D_{10}	0.05		
	COEFFICIENTS		
C_c	1.17		
C_u	10.0		

SIEVE number size	PERCENT FINER ●		
10	82.3		
18	73.0		
35	54.8		
60	34.7		
140	19.2		
200	14.4		
270	7.4		

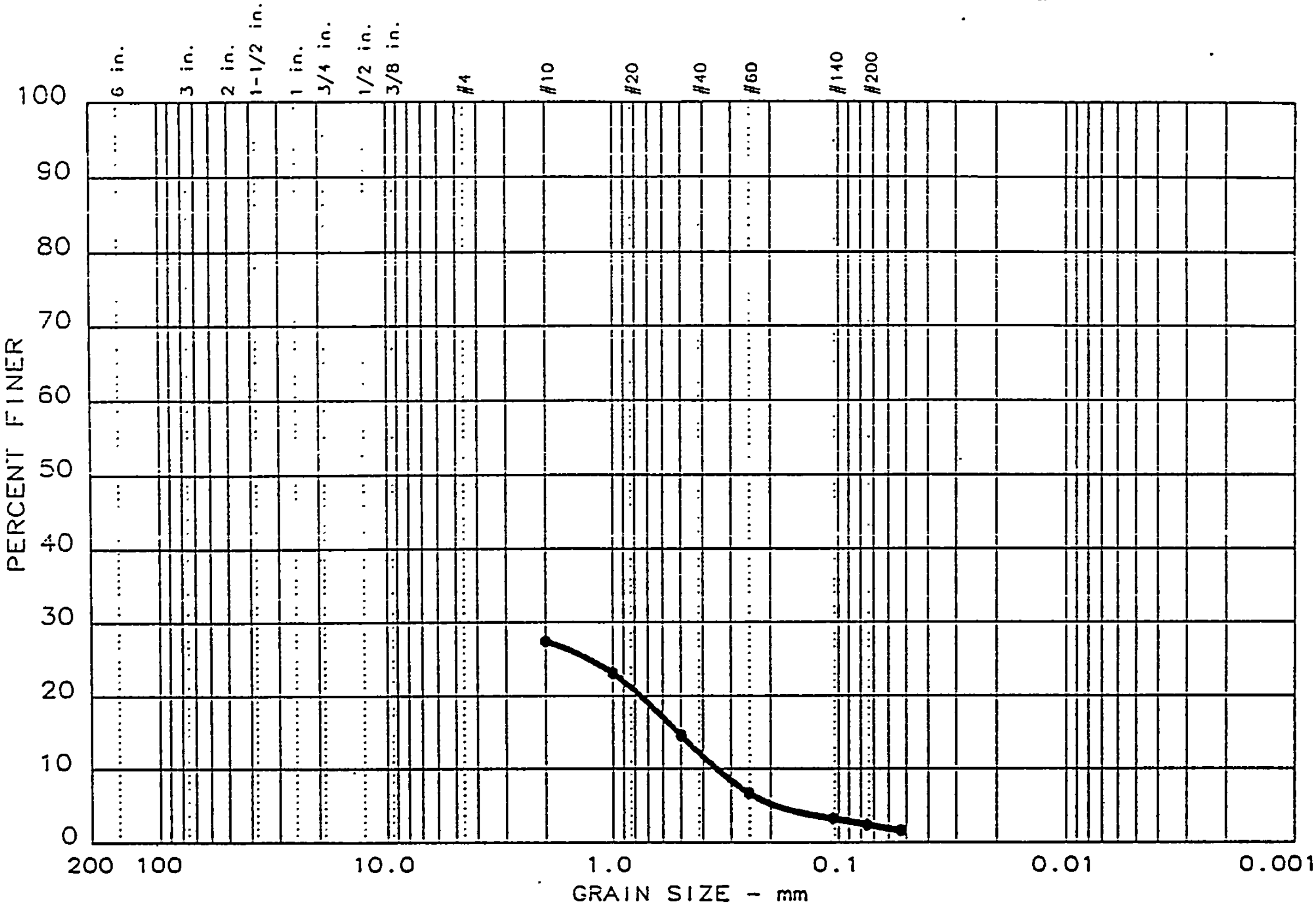
Sample information:
● H5-3
43.75 - 45.0
ASTM - SM

Remarks:
a: gs1.sdt
Run Hydrometer
Hydrometer data =
a: datc2 gs2.sdt

Pacific Northwest Laboratory

Project No.: 100H
Project: 100H Remediation
Date: 4/17/95
Data Sheet No. 1

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	6	0.0	72.6	25.8	1.6		SP		

SIEVE inches size	PERCENT FINER ●		
	GRAIN SIZE		
D_{60}	2.00		
D_{30}	2.00		
D_{10}	0.34		
	COEFFICIENTS		
C_c	5.75		
C_u	5.8		

SIEVE number size	PERCENT FINER ●		
10	27.4		
18	23.0		
35	14.6		
60	6.7		
140	3.2		
200	2.4		
270	1.6		

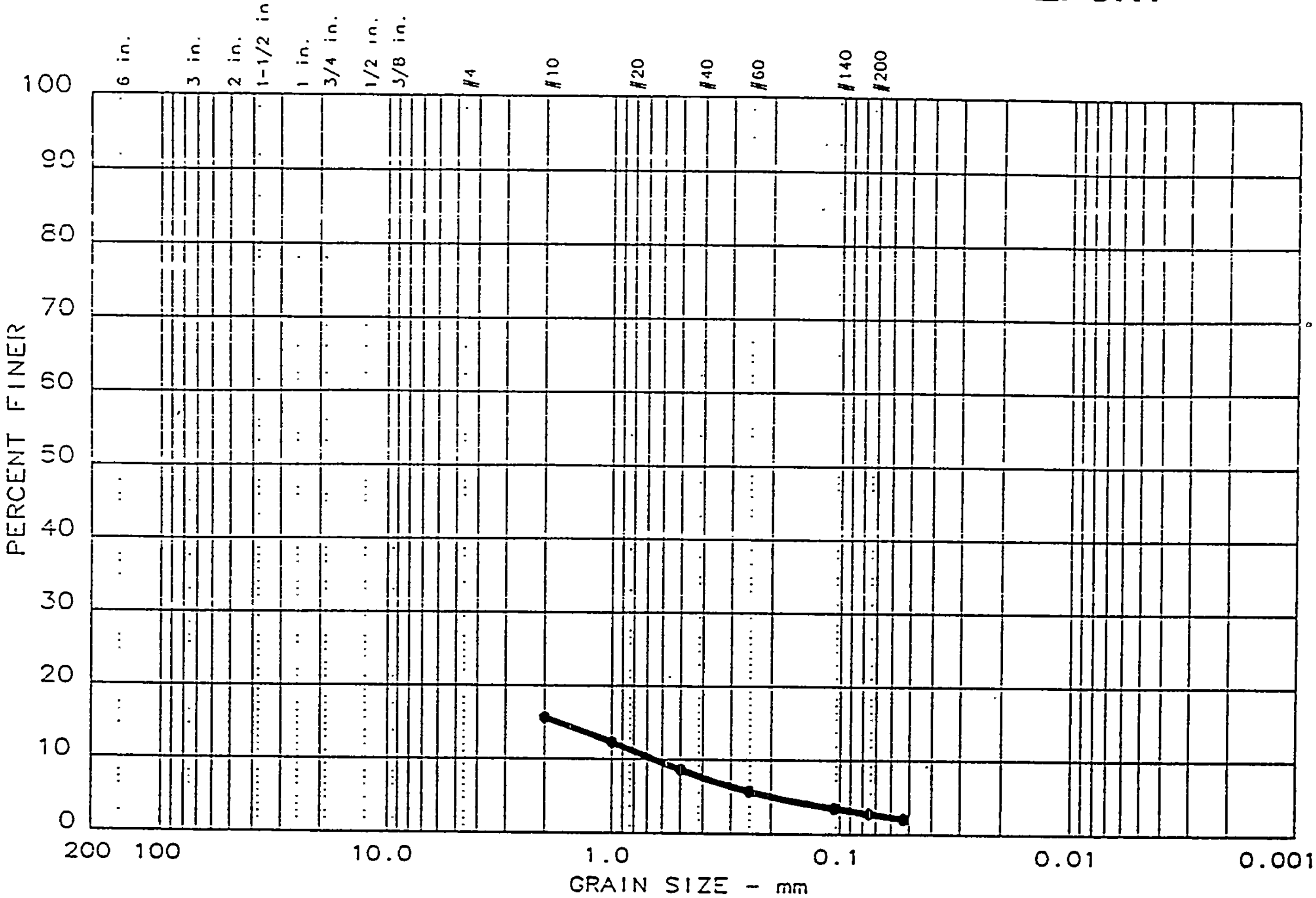
Sample information:
● H5-3
47.5 - 48.0
ASTM - SP

Remarks:
a: gs6.sdt

Pacific Northwest Laboratory

Project No.: 100H
Project: 100H Remediation
Date: 4/17/95 Data Sheet No. 6

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	4	0.0	84.3	13.6	2.1		SP		

SIEVE inches size	PERCENT FINER ●		
	GRAIN SIZE		
D_{60}	2.00		
D_{30}	2.00		
D_{10}	0.64		
	COEFFICIENTS		
C_c	3.09		
C_u	3.1		

SIEVE number size	PERCENT FINER ●		
10	15.7		
18	12.3		
35	8.6		
60	5.7		
140	3.5		
200	2.8		
270	2.0		

Sample information:
● H5-3
48.7 - 50.0
ASTM - SP

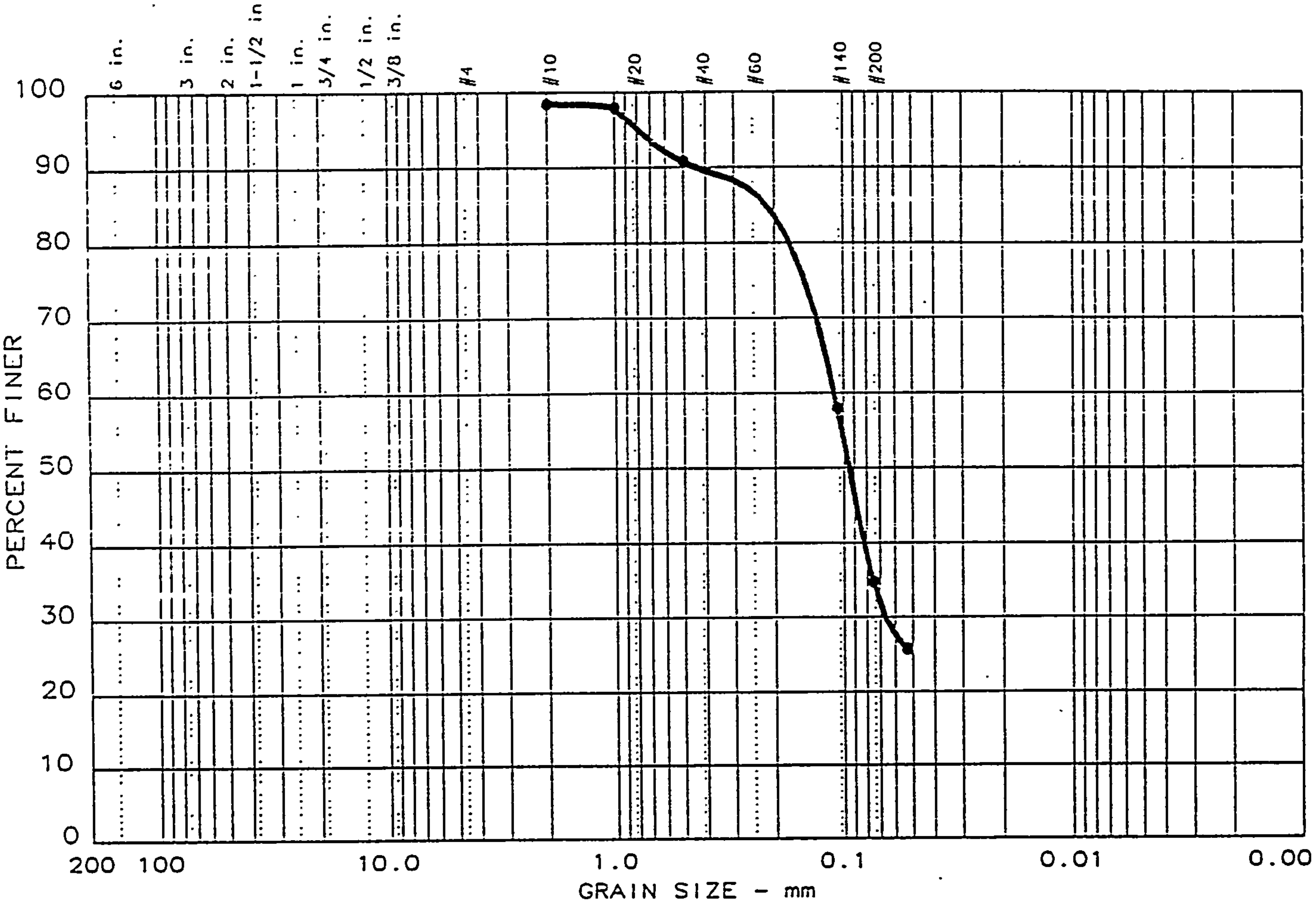
Remarks:
o: gs4.sdt

Pacific Northwest Laboratory

Project No.: 100H
Project: 100H Remediation

Date: 4/17/95 Data Sheet No. 4

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	12	0.0	1.6	72.7	25.7		SM		

SIEVE inches size	PERCENT FINER ●		

	GRAIN SIZE		
D_{60}	0.11		
D_{30}	0.07		
D_{10}			

	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ●		
10	98.4		
18	97.9		
35	90.7		
140	58.0		
200	34.7		
270	25.7		

Sample information:
● H5-3
50.5 - 51.0 feet
ASTM Class. SM

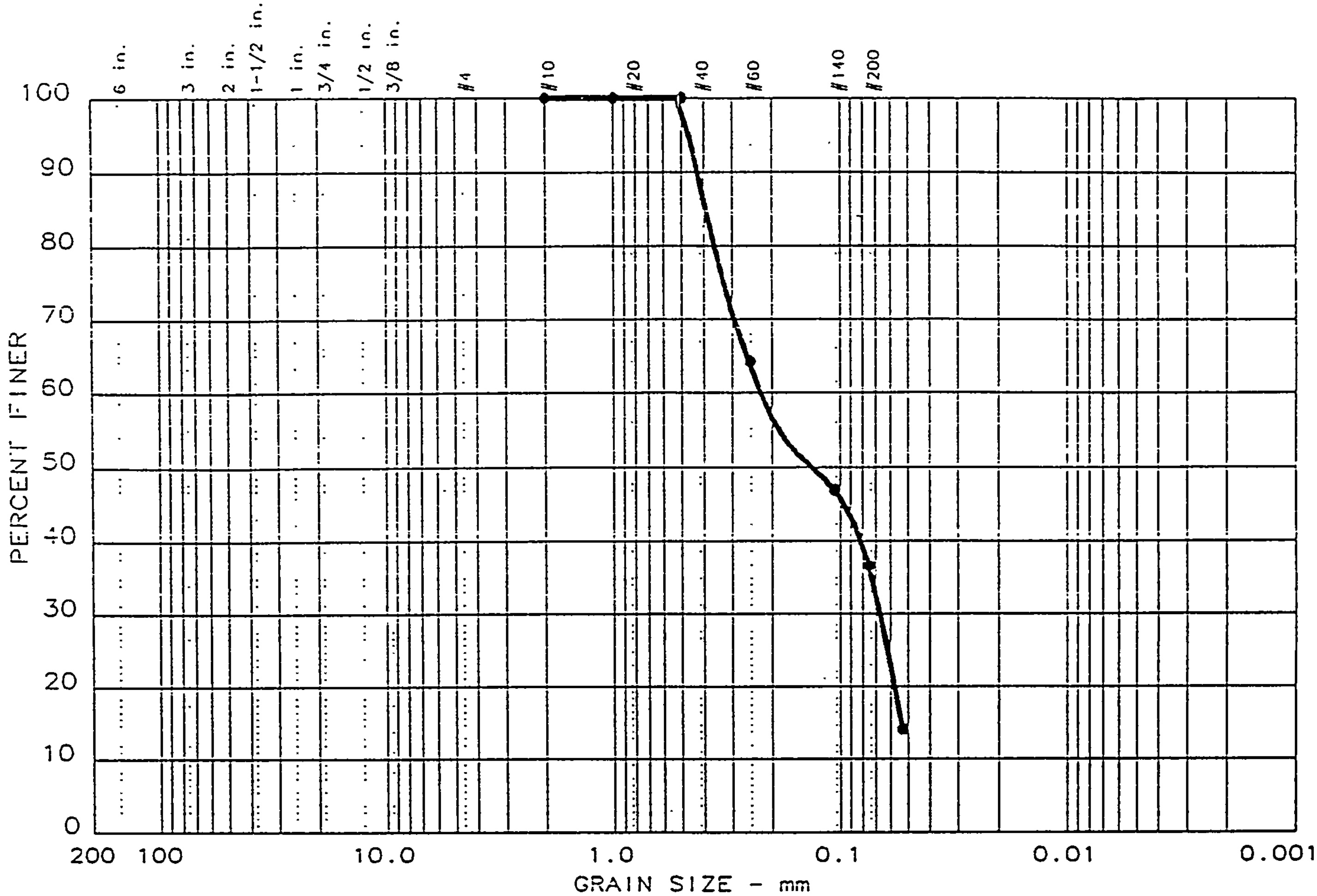
Remarks:
a: gs12.sdt
Run Hydrometer
Hydrometer data =
a: data2 gs3.sdt

Pacific Northwest Laboratory

Project No.: 100H
Project: 100H Remediation

Date: 4/12/95 Data Sheet No. 12

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	13	0.0	0.0	85.8	14.2		SM		

SIEVE inches size	PERCENT FINER ●		
	GRAIN SIZE		
D_{60}	0.22		
D_{30}	0.07		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ●		
10	100.0		
18	100.0		
35	100.0		
60	64.2		
140	46.9		
200	36.6		
270	14.2		

Sample information:
● H5-3
52.0 - 52.5 feet
ASTM Class. SM

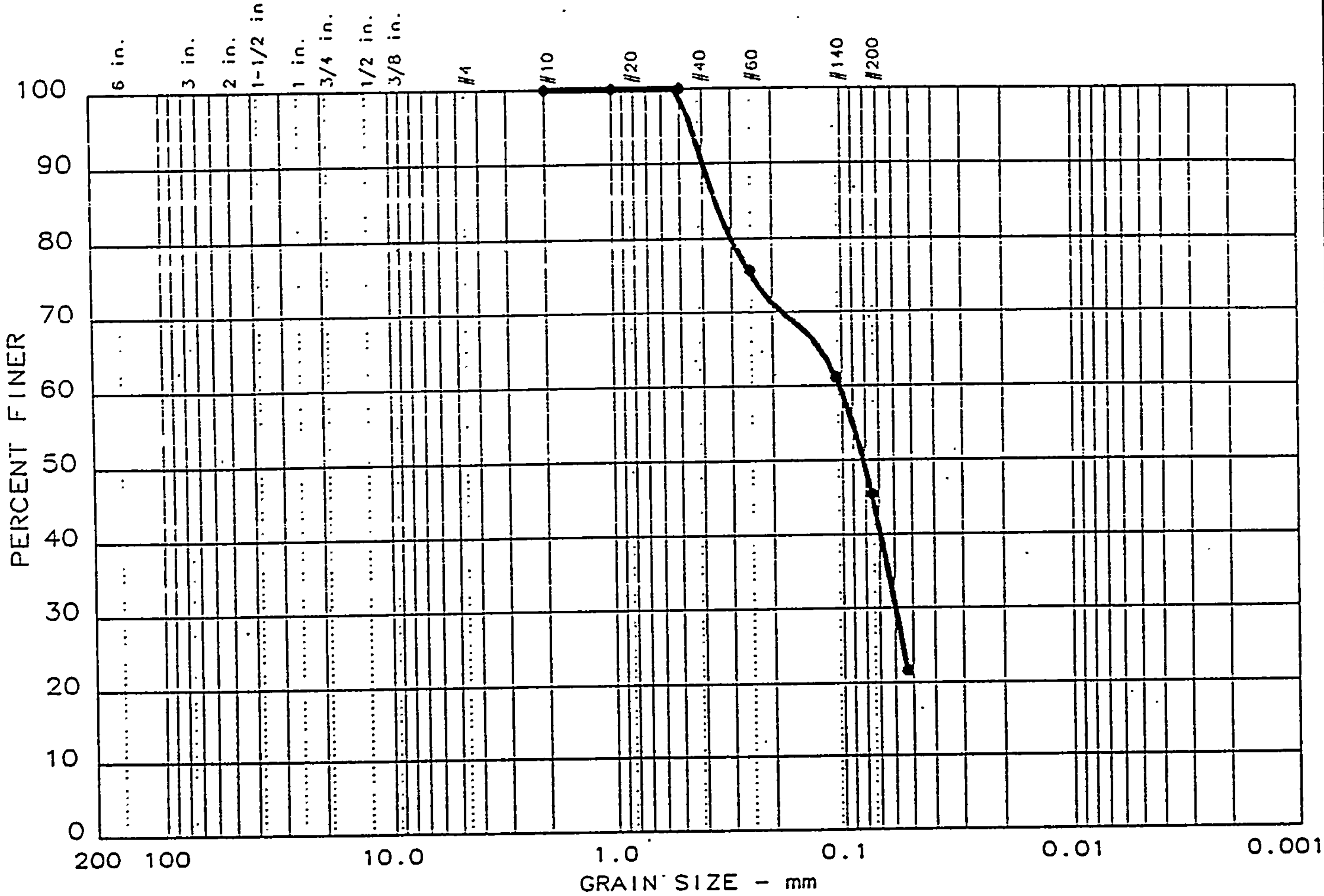
Remarks:
a: gs13.sdt
Run Hydrometer
Hydrometer data =
a: data2 gs4.sdt

Pacific Northwest Laboratory

Project No.: 100H
Project: 100H Remediation

Date: 4/12/95 Data Sheet No. 13

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	11	0.0	0.0	78.3	21.7		SM		

SIEVE inches size	PERCENT FINER ●		

	GRAIN SIZE		
D_{60}	0.10		
D_{30}	0.06		
D_{10}			

	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ●		
10	100.0		
18	100.0		
35	100.0		
60	75.7		
140	61.2		
200	45.4		
270	21.7		

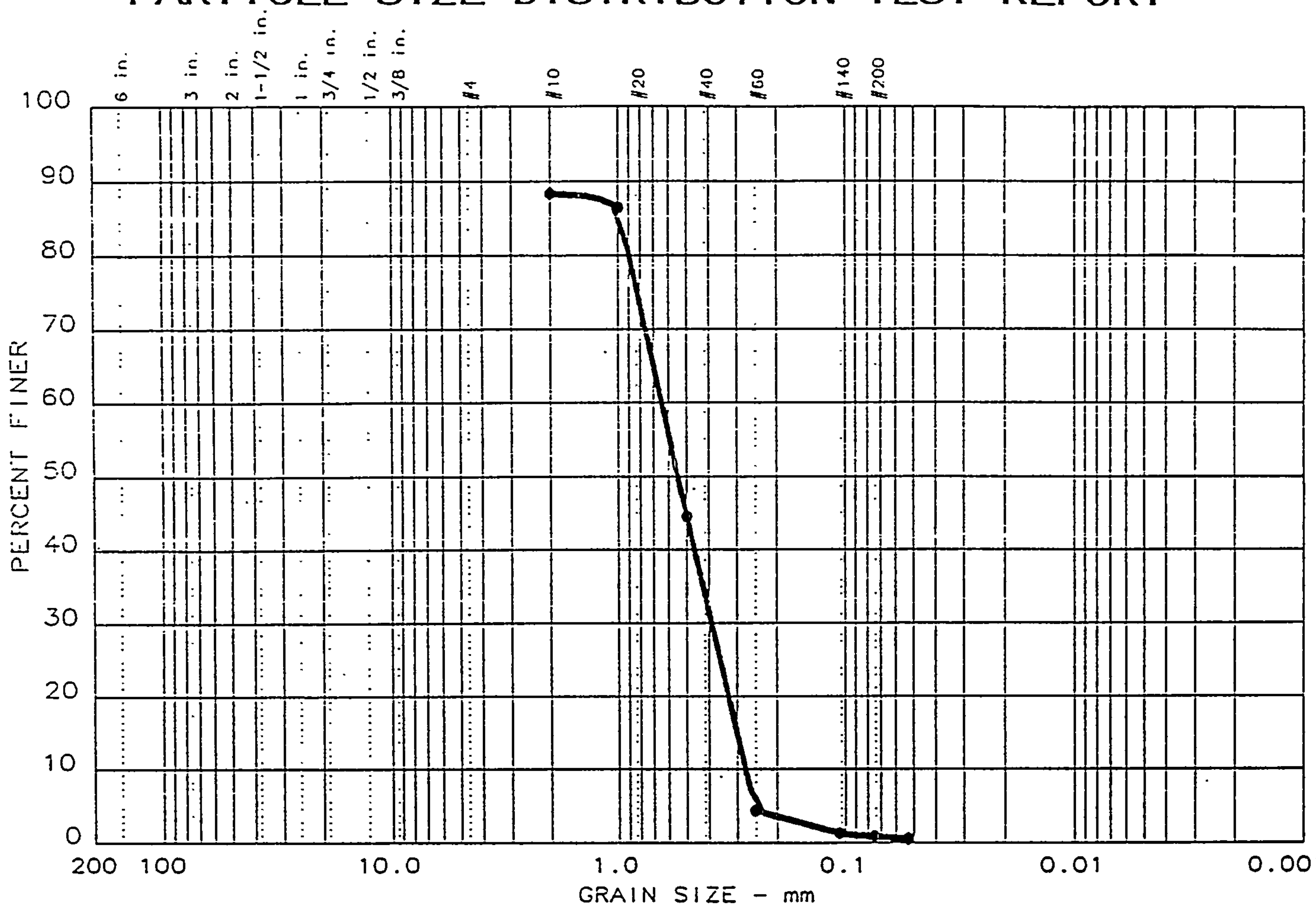
Sample information:
● H5-3
53.0 - 53.5 feet
ASTM Class. SM

Remarks:
a: gs11.sdt
Run Hydrometer
Hydrometer data =
a: data2 gs5.sdt

Pacific Northwest Laboratory

Project No.: 100H
Project: 100H Remediation
Date: 4/12/95
Data Sheet No. 11

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	10	0.0	11.6	87.8	0.6		SP		

SIEVE inches size	PERCENT FINER ●		
	GRAIN SIZE		
D_{60}	0.64		
D_{30}	0.39		
D_{10}	0.27		
	COEFFICIENTS		
C_c	0.86		
C_u	2.3		

SIEVE number size	PERCENT FINER ●		
10	88.4		
18	86.5		
35	44.5		
60	4.3		
140	1.3		
200	0.9		
270	0.5		

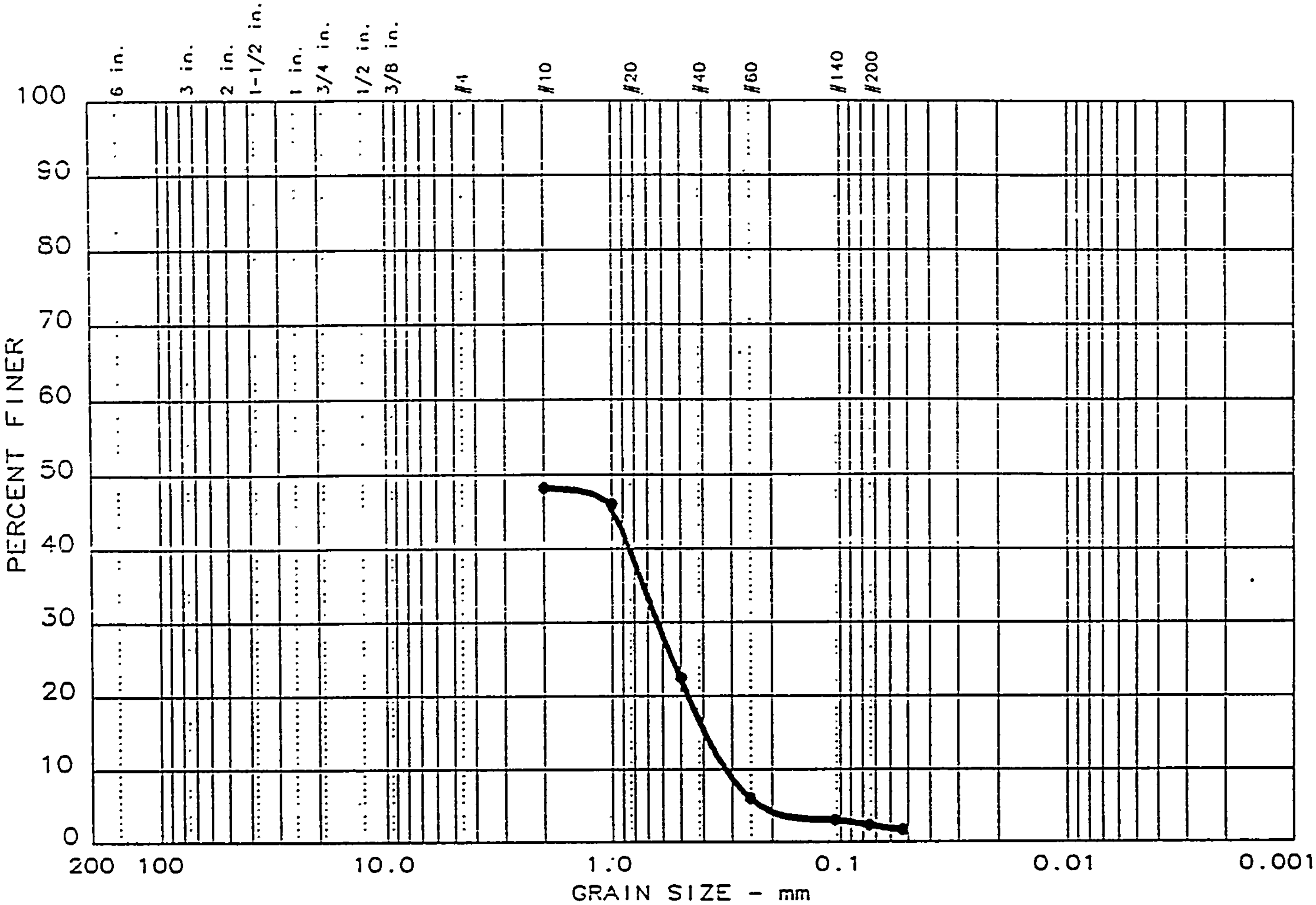
Sample information:
● H5-4
43.0 - 44.0 feet
ASTM Class. SP

Remarks:
a: gs10.sdt

Pacific Northwest Laboratory

Project No.: 100H
Project: 100H Remediation
Date: 4/12/95
Data Sheet No. 10

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	2	0.0	51.8	46.6	1.6		SP		

SIEVE inches size	PERCENT FINER ●		

	GRAIN SIZE		
D_{60}	2.00		
D_{30}	0.63		
D_{10}	0.31		

	COEFFICIENTS		
C_c	0.63		
C_u	6.3		

SIEVE number size	PERCENT FINER ●		
10	48.2		
18	46.0		
35	22.5		
60	6.0		
140	3.0		
200	2.3		
270	1.6		

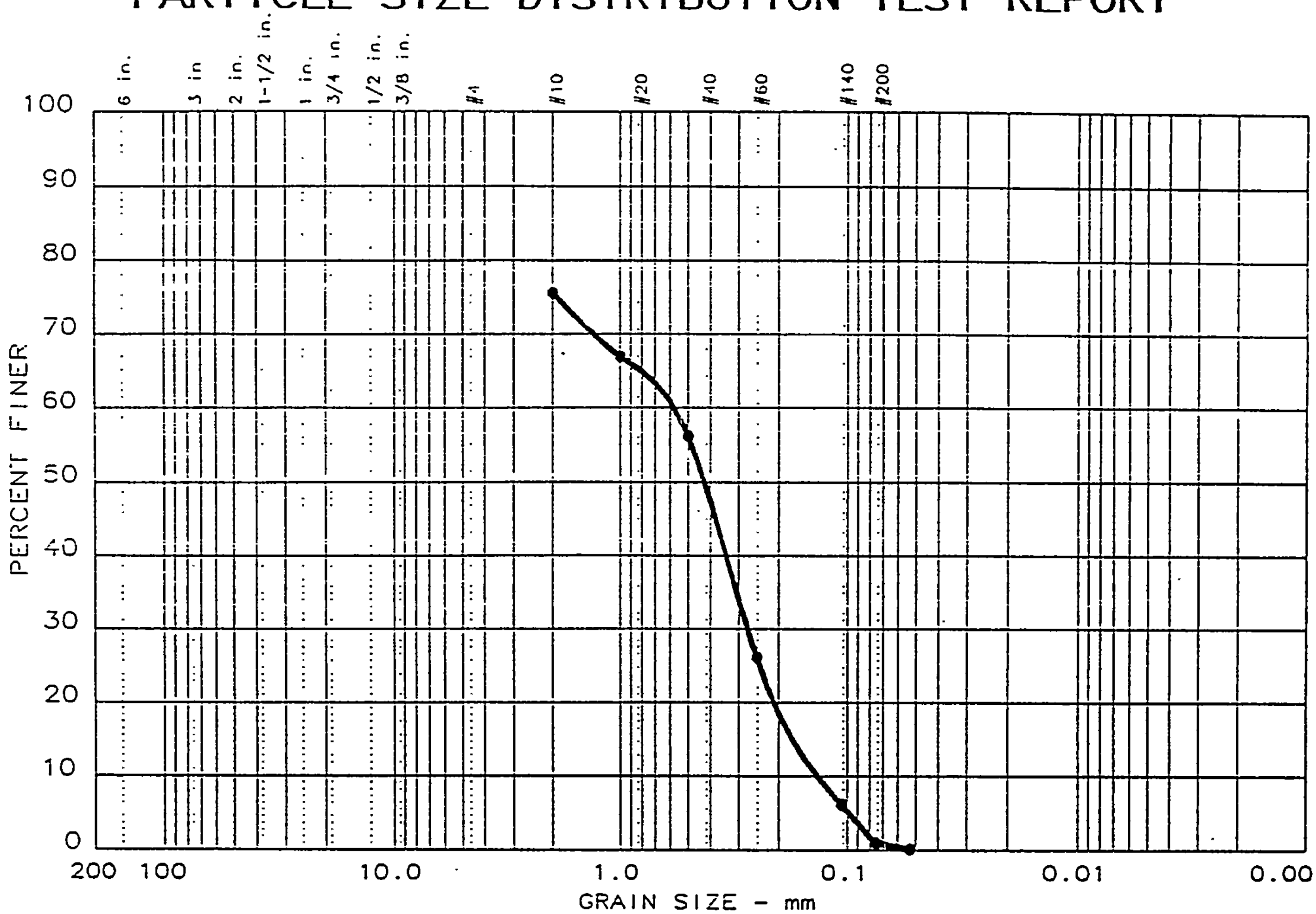
Sample information:
● H5-4
45.5 - 46.0
ASTM - SP

Remarks:
a: gs2.sdt

Pacific Northwest Laboratory

Project No.: 100H
Project: 100H Remediation
Date: 4/17/95 Data Sheet No. 2

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	9	0.0	24.3	75.5	0.2		SP		

SIEVE inches size	PERCENT FINER ●		

	GRAIN SIZE		
D_{60}	0.57		
D_{30}	0.27		
D_{10}	0.13		

	COEFFICIENTS		
C_c	0.99		
C_u	4.3		

SIEVE number size	PERCENT FINER ●		
10	75.7		
18	67.0		
35	56.2		
60	26.1		
140	6.2		
200	0.9		
270	0.1		

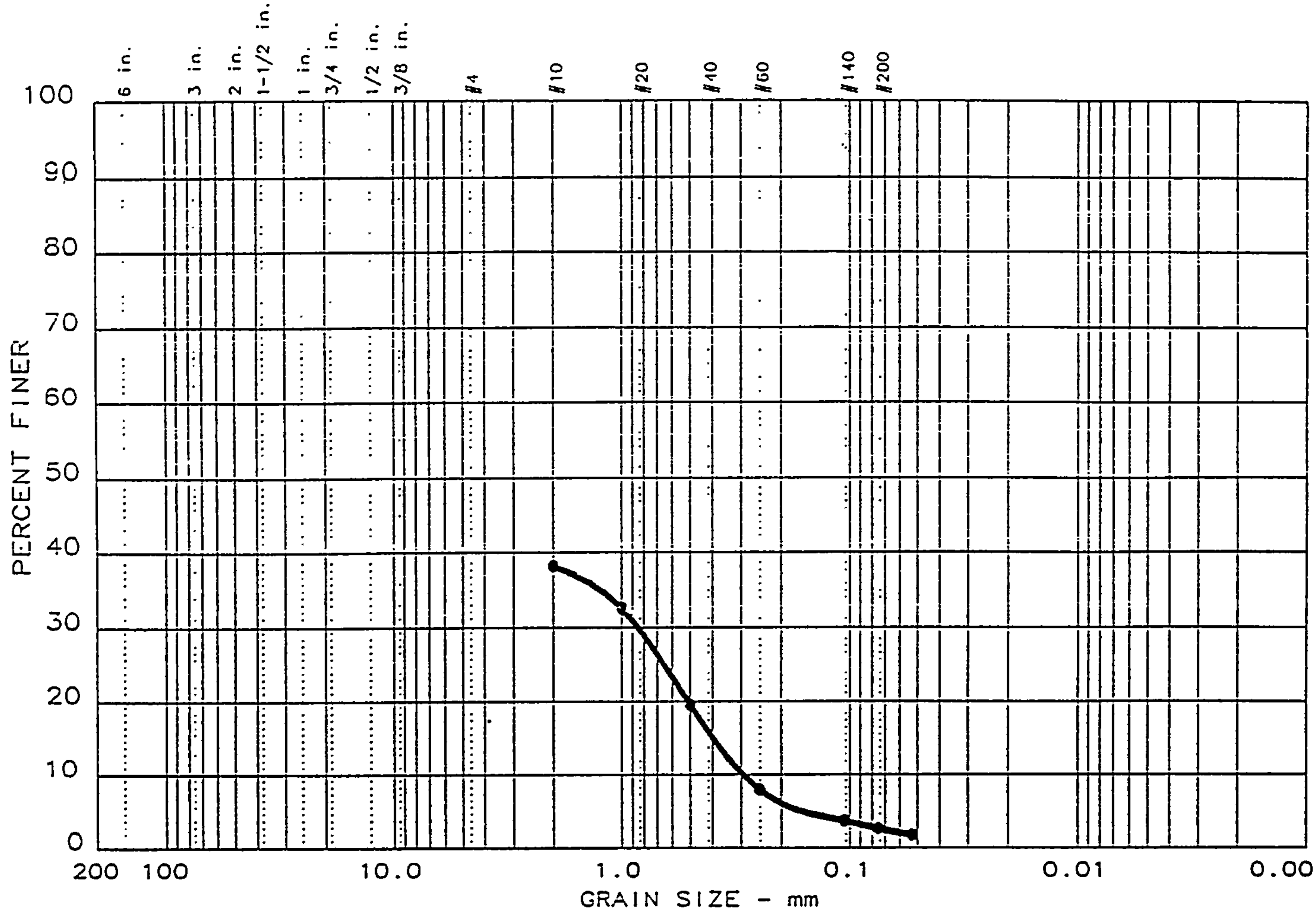
Sample information:
● H5-5
42.0 - 42.5 feet
ASTM Class. SP

Remarks:
a: gs9.sdt

Pacific Northwest Laboratory

Project No.: 100H
Project: 100H Remediation
Date: 4/12/95 Data Sheet No. 9

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	3	0.0	61.9	36.4	1.7		SW		

SIEVE inches size	PERCENT FINER ●		
GRAIN SIZE			
D_{60}	2.00		
D_{30}	0.84		
D_{10}	0.29		
COEFFICIENTS			
C_c	1.22		
C_u	6.8		

SIEVE number size	PERCENT FINER ●		
10	38.1		
18	32.6		
35	19.6		
60	8.0		
140	3.7		
200	2.6		
270	1.7		

Sample information:

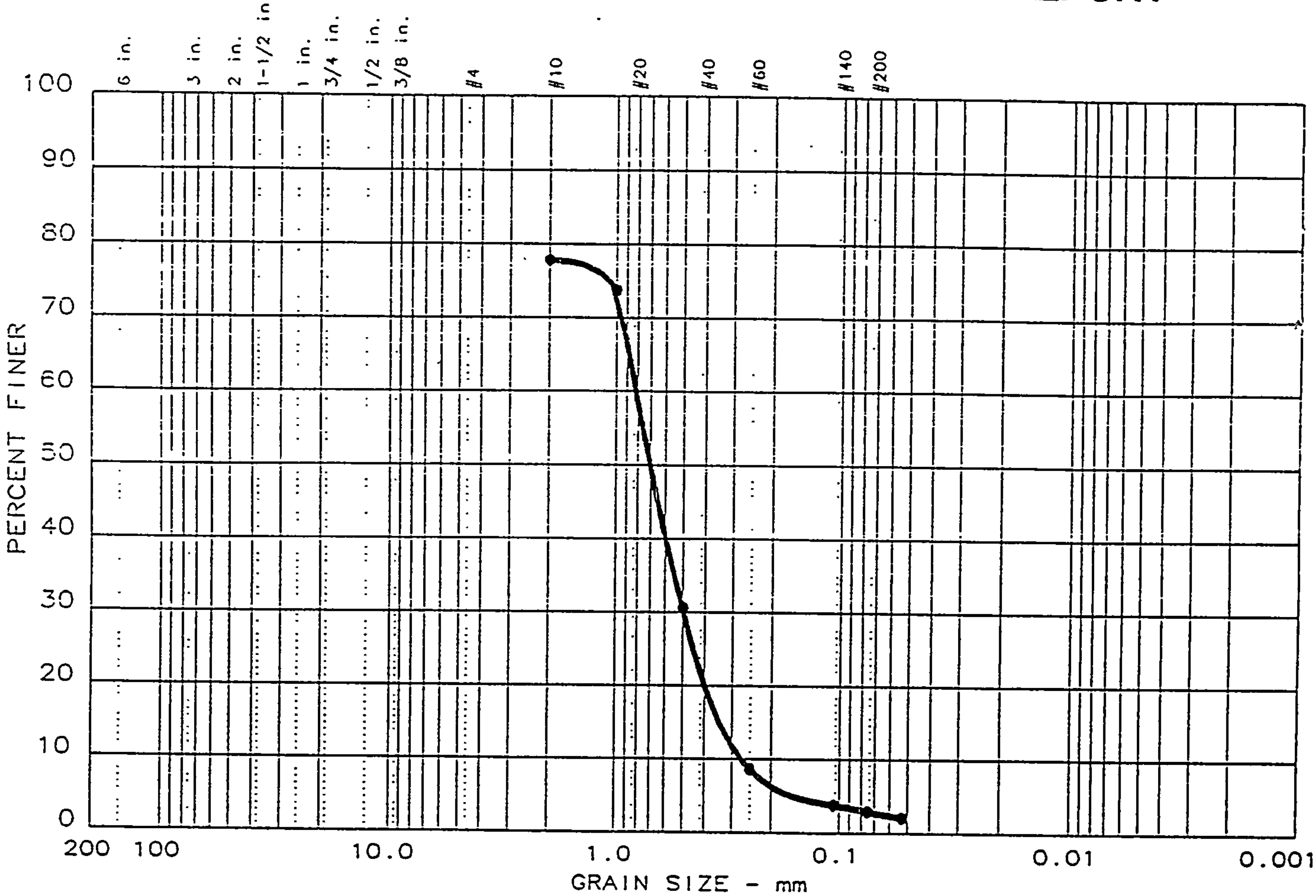
● H5-5
49.0 - 50.0
ASTM - SW

Remarks:
a: gs3.sdt

Pacific Northwest Laboratory

Project No.: 100H
Project: 100H Remediation
Date: 4/17/95 Data Sheet No. 3

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	15	0.0	22.2	75.7	2.1		SP		

SIEVE inches size	PERCENT FINER ●		

	GRAIN SIZE		
D_{60}	0.81		
D_{30}	0.49		
D_{10}	0.27		

	COEFFICIENTS		
C_c	1.10		
C_u	3.0		

SIEVE number size	PERCENT FINER ●		
10	77.8		
18	73.8		
35	30.6		
60	8.7		
140	3.8		
200	2.9		
270	2.1		

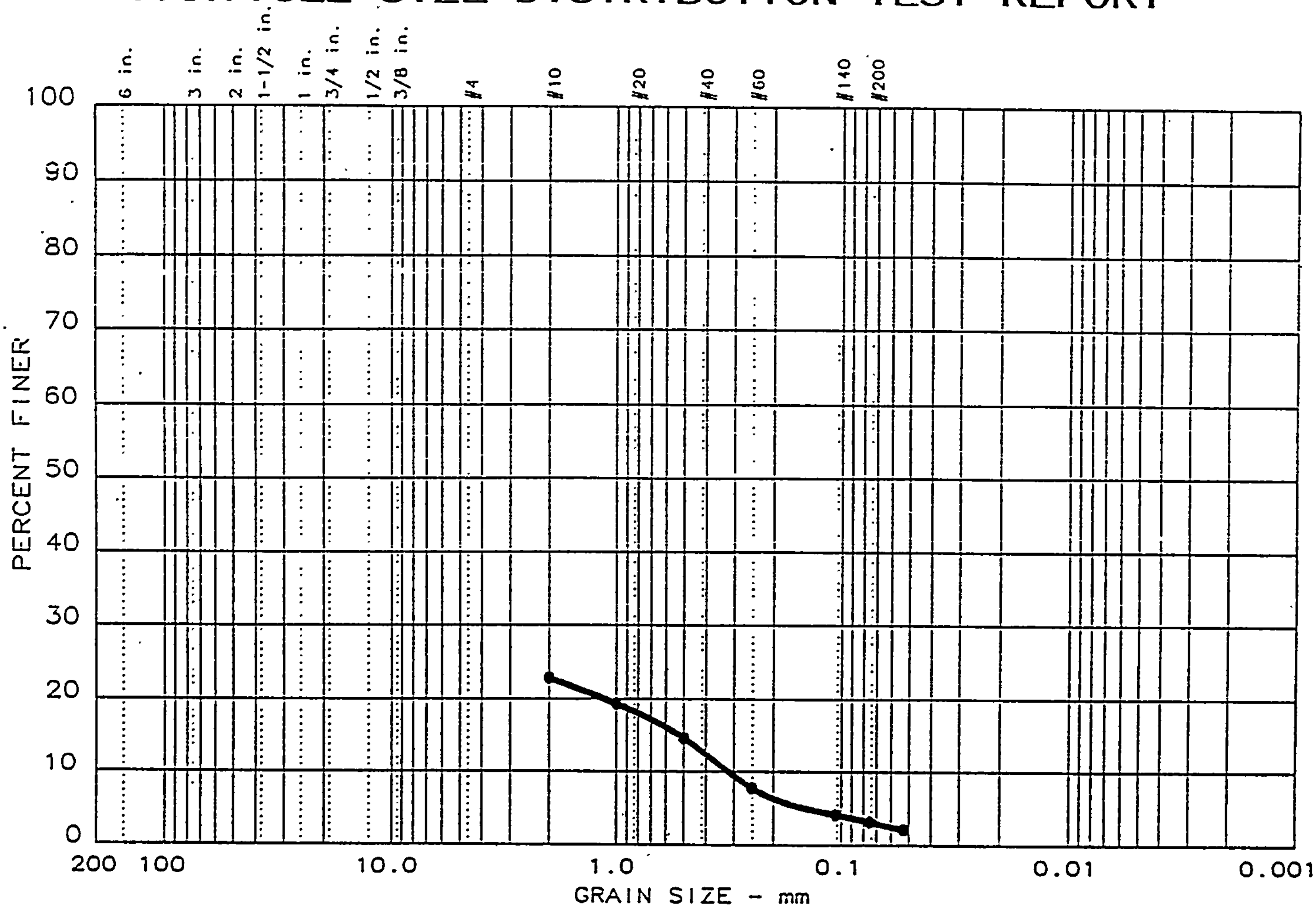
Sample information:
● H5-8
44.0 - 45.0 FEET
ASTM Class. SP

Remarks:
c: gs15sdt

Pacific Northwest Laboratory

Project No.: 100H
Project: 100H Remediation
Date: 4/14/95
Data Sheet No. 15

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	16	0.0	77.2	20.7	2.1		SP		

SIEVE inches size	PERCENT FINER ●		

	GRAIN SIZE		
D_{60}	2.00		
D_{30}	2.00		
D_{10}	0.31		

	COEFFICIENTS		
C_c	6.38		
C_u	6.4		

SIEVE number size	PERCENT FINER ●		
10	22.8		
18	19.4		
35	14.7		
60	7.8		
140	4.2		
200	3.2		
270	2.1		

Sample information:

● H5-8
48.0 - 49.0 FEET
ASTM Class. SP

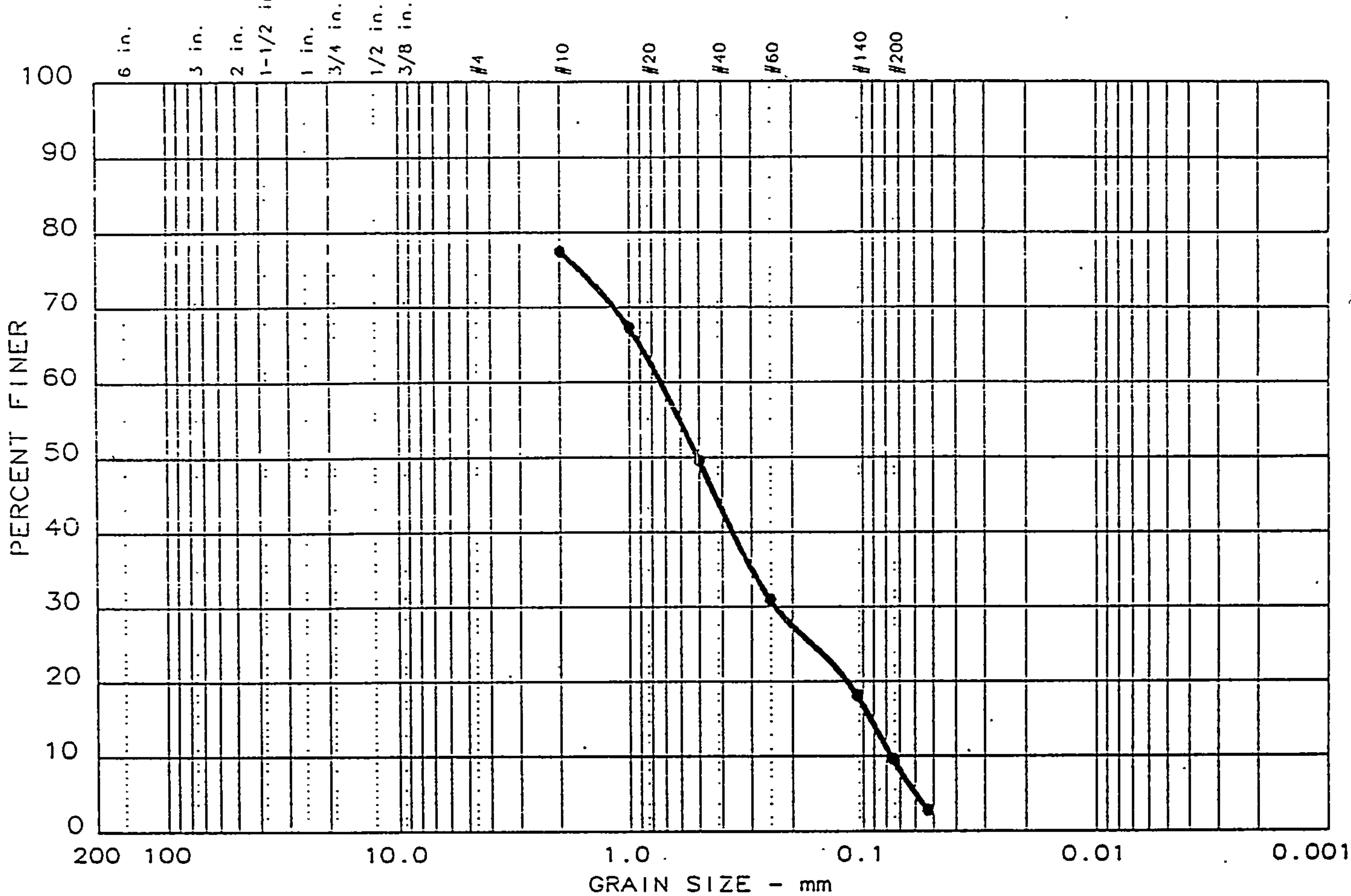
Remarks:
a: gs16sdt

Pacific Northwest Laboratory

Project No.: 100H
Project: 100H Remediation

Date: 4/14/95 Data Sheet No. 16

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	20	0.0	22.5	74.7	2.8		SW-SM		

SIEVE inches size	PERCENT FINER ●		
GRAIN SIZE			
D_{60}	0.73		
D_{30}	0.24		
D_{10}	0.07		
COEFFICIENTS			
C_c	1.02		
C_u	9.6		

SIEVE number size	PERCENT FINER ●		
10	77.5		
18	67.3		
35	49.5		
60	30.9		
140	18.2		
200	9.7		
270	2.8		

Sample information:
● H5-11
42.0 - 42.5
ASTM Class. SW-SM

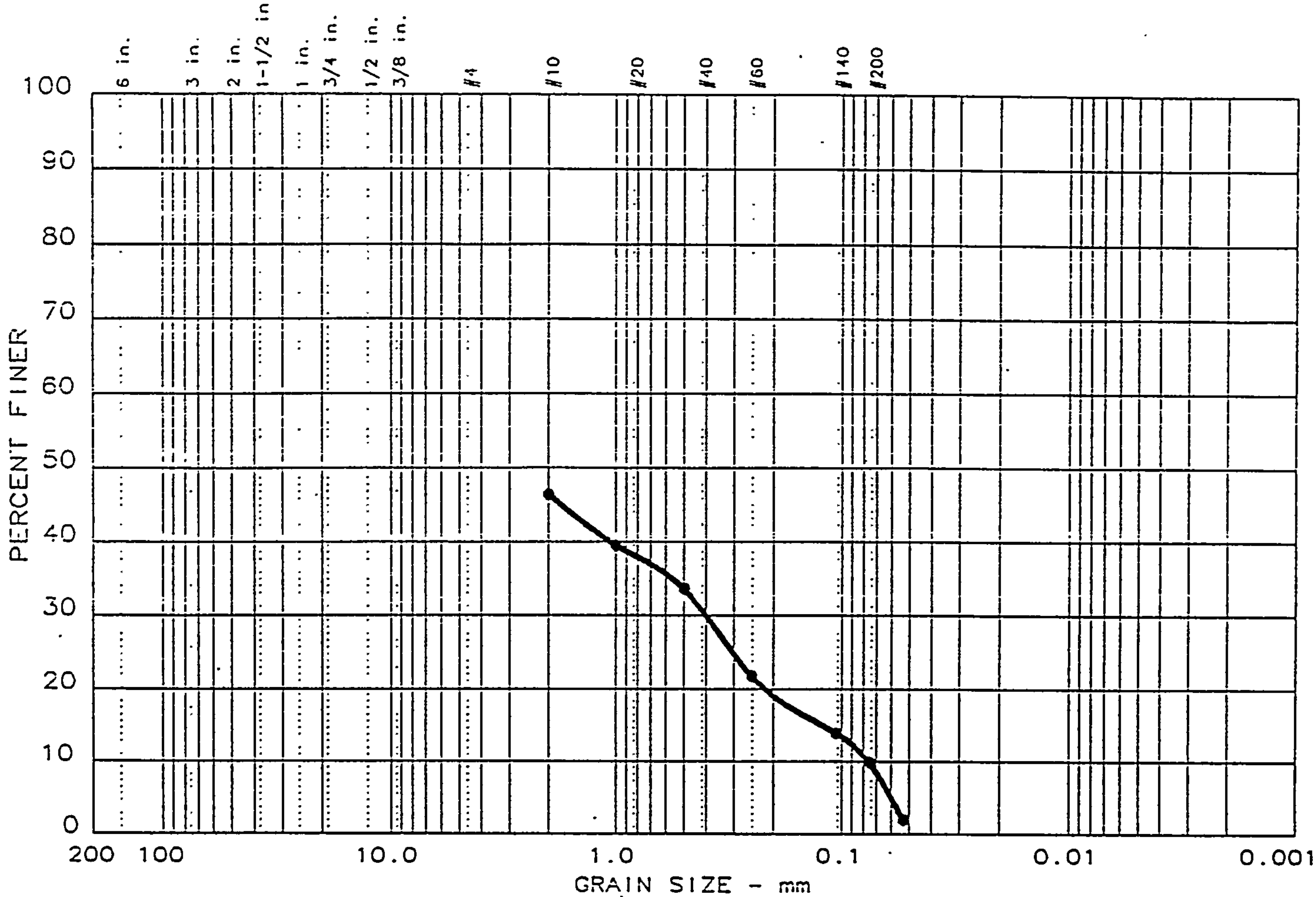
Remarks:
a: gs20sdt

Pacific Northwest Laboratory

Project No.: 100H
Project: 100H Remediation

Date: 4/14/95 Data Sheet No. 20

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	17	0.0	53.6	44.5	1.9		SW-SM		

SIEVE inches size	PERCENT FINER ●		
	GRAIN SIZE		
D_{60}	2.00		
D_{30}	0.40		
D_{10}	0.07		
	COEFFICIENTS		
C_c	1.06		
C_u	26.6		

SIEVE number size	PERCENT FINER ●		
10	46.4		
18	39.5		
35	33.6		
60	21.8		
140	14.0		
200	9.9		
270	1.9		

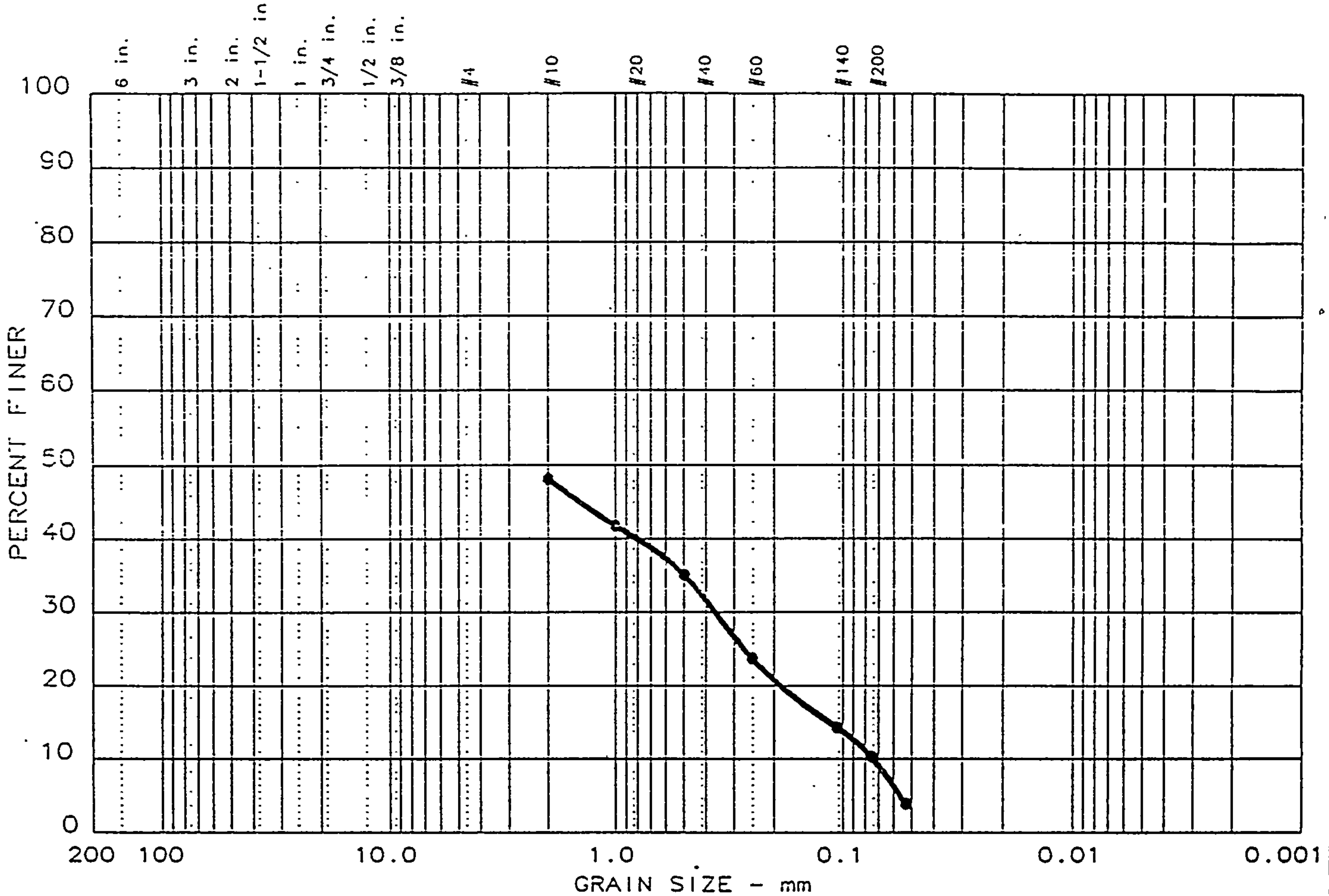
Sample information:
● H5-11
43.0 - 43.5
ASTM Class. SW-SM

Remarks:
a: gs17sdt

Pacific Northwest Laboratory

Project No.: 100H
Project: 100H Remediation
Date: 4/14/95
Data Sheet No. 17

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	18	0.0	51.9	44.2	3.9		SP-SM		

SIEVE inches size	PERCENT FINER ●		
	GRAIN SIZE		
D_{60}	2.00		
D_{30}	0.36		
D_{10}	0.07		
	COEFFICIENTS		
C_c	0.89		
C_u	27.5		

SIEVE number size	PERCENT FINER ●		
10	48.1		
18	41.7		
35	35.1		
60	23.7		
140	14.3		
200	10.4		
270	3.9		

Sample information:
● H5-11
43.5 - 44.0
ASTM Class. SP-SM

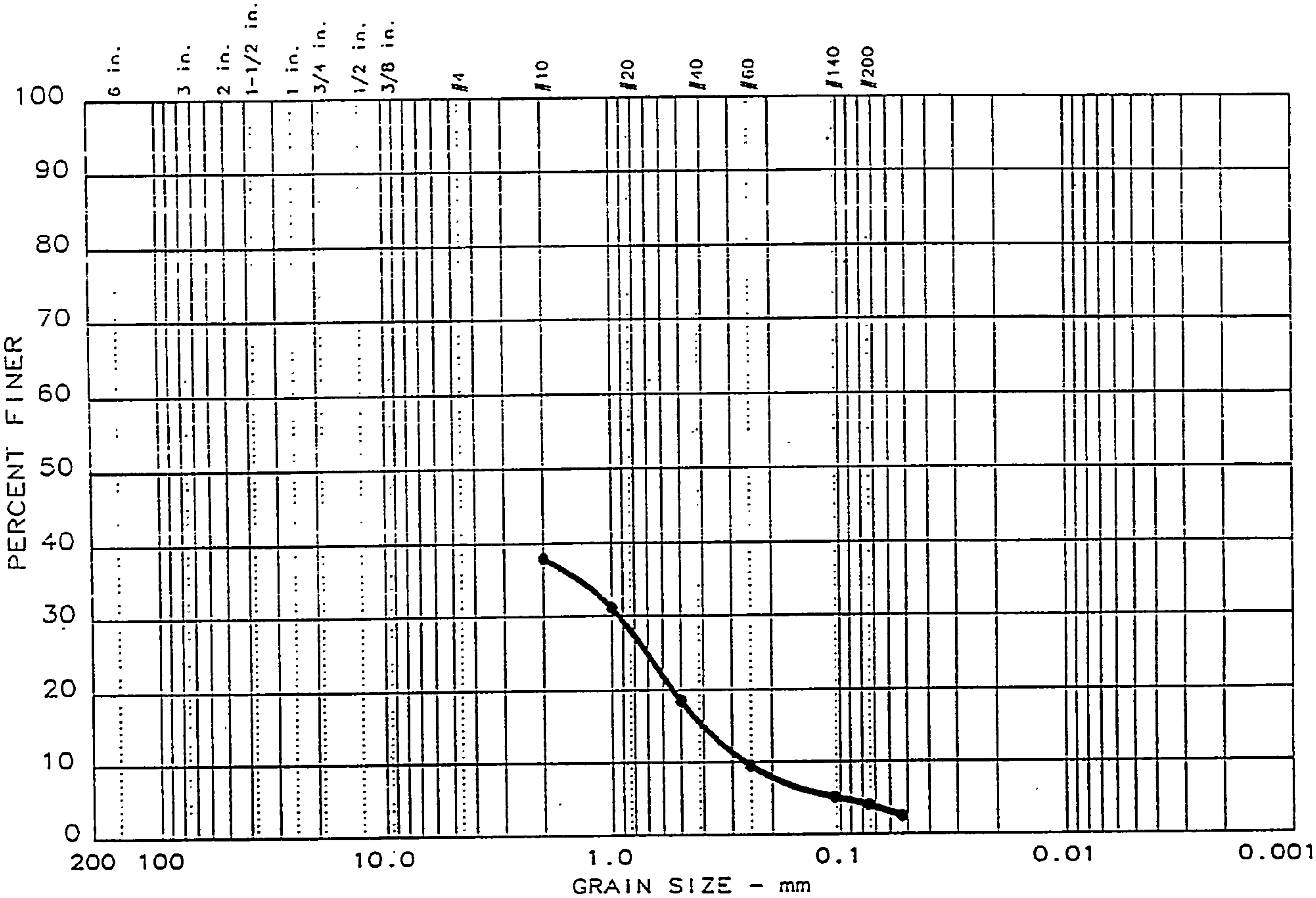
Remarks:
a: gs18sdt

Pacific Northwest Laboratory

Project No.: 100H
Project: 100H Remediation

Date: 4/14/95 Data Sheet No. 18

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	19	0.0	62.1	35.5	2.4		SW		

SIEVE inches size	PERCENT FINER ●		
	GRAIN SIZE		
D_{60}	2.00		
D_{30}	0.92		
D_{10}	0.26		
	COEFFICIENTS		
C_c	1.64		
C_u	7.7		

SIEVE number size	PERCENT FINER ●		
10	37.9		
18	31.1		
35	18.6		
60	9.5		
140	5.1		
200	4.0		
270	2.4		

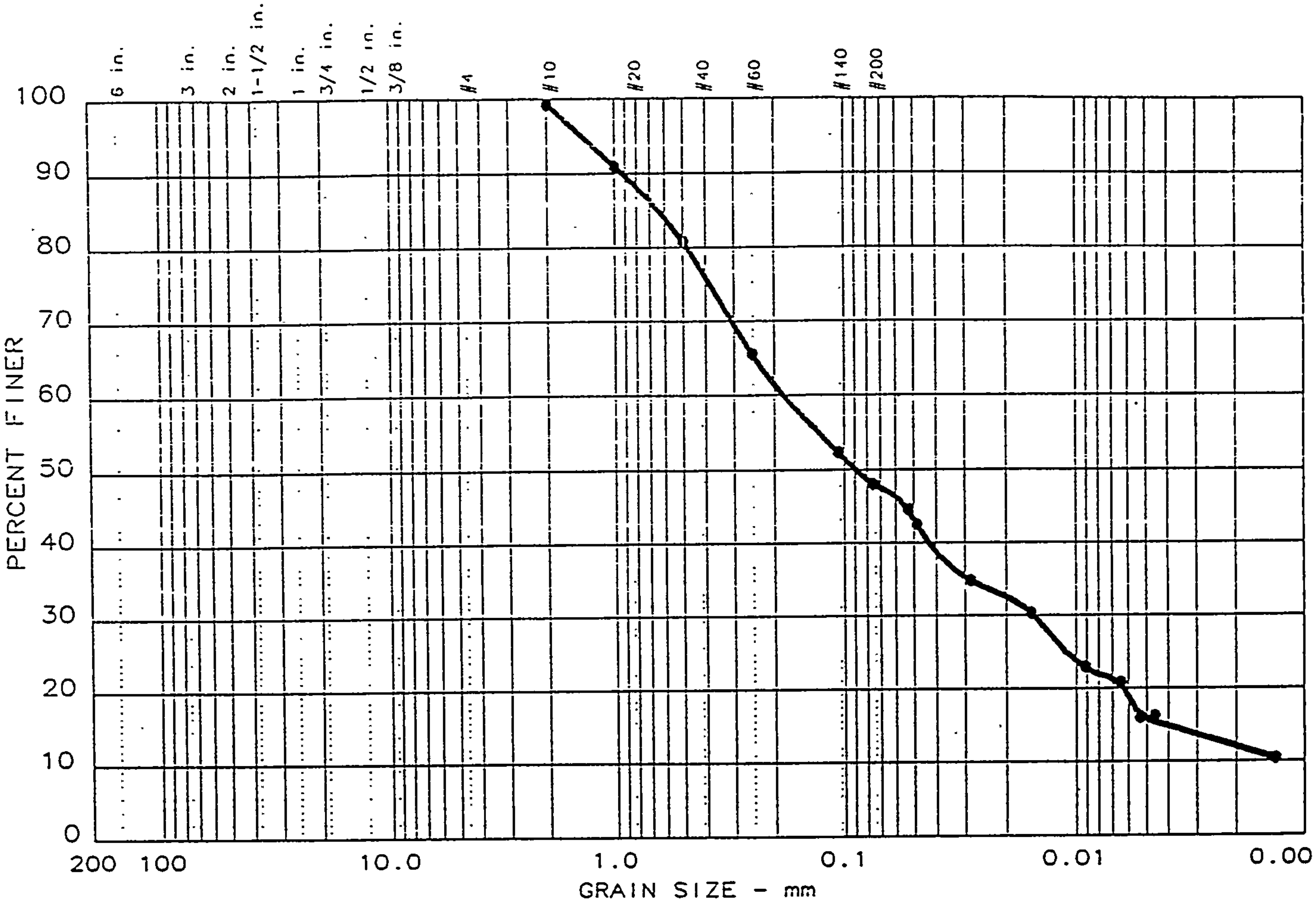
Sample information:
● H5-11
49.5 - 50.0
ASTM Class. SW

Remarks:
a: gs19sdt

Pacific Northwest Laboratory

Project No.: 100H
Project: 100H Remediation
Date: 4/14/95
Data Sheet No. 19

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	1	0.0	0.8	54.6	28.8	15.8	SM		

SIEVE inches size	PERCENT FINER ●		

	GRAIN SIZE		
D_{60}	0.18		
D_{30}	0.02		
D_{10}			

	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ●		
10	99.2		
18	90.9		
35	80.8		
60	65.6		
140	52.3		
200	48.0		
270	44.6		

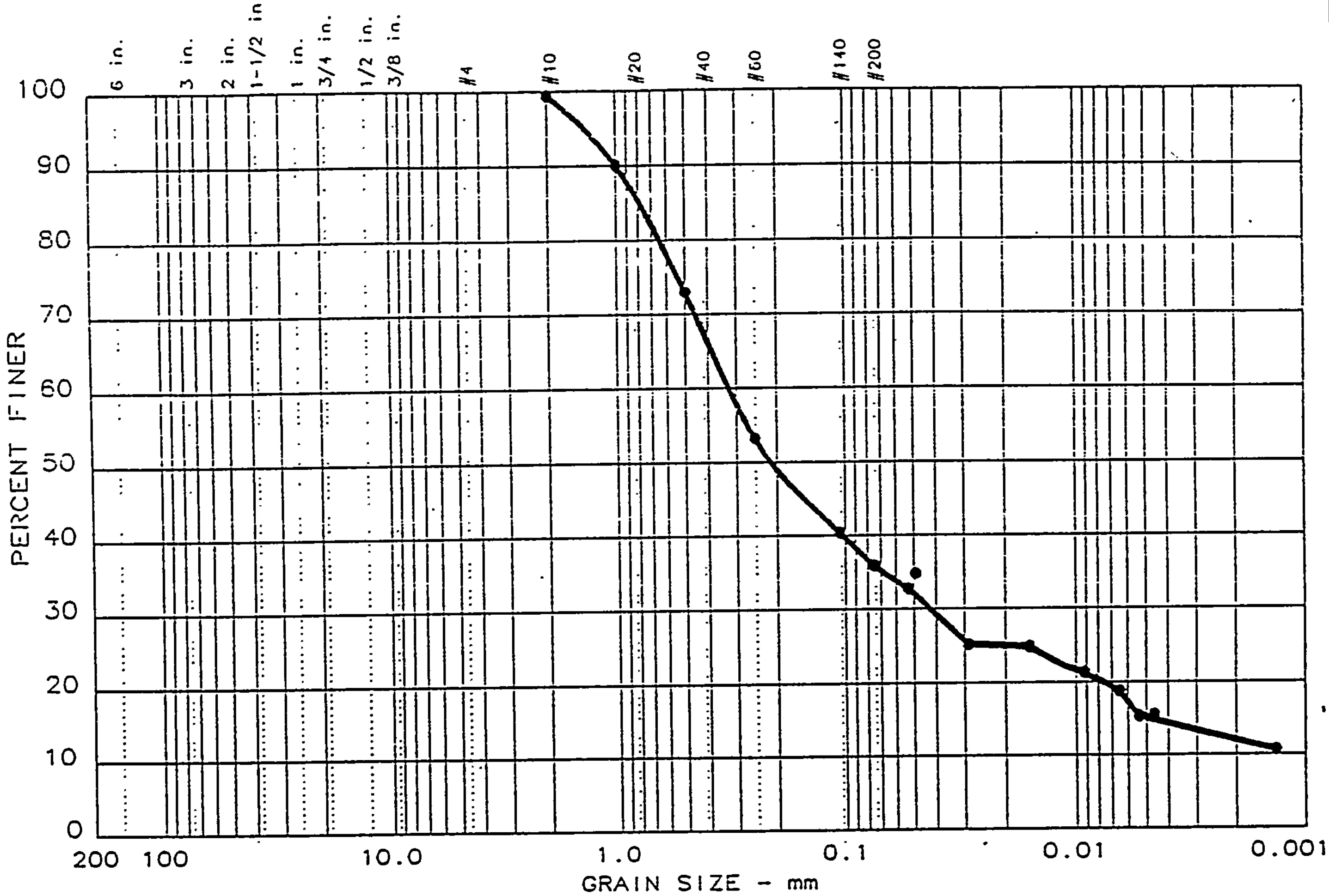
Sample information:
● H5-3
40 - 41 feet
ASTM Classif. SM

Remarks:
a: data2 gs1.sdt

Pacific Northwest Laboratory

Project No.: 100H
Project: 100H Remediation
Date: 4/28/95 Data Sheet No. 1

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	2	0.0	0.6	66.6	17.6	15.2	SM		

SIEVE inches size	PERCENT FINER ●		

	GRAIN SIZE		
D_{60}	0.32		
D_{30}	0.04		
D_{10}			

	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ●		
10	99.4		
18	90.0		
35	73.0		
60	53.2		
140	40.4		
200	35.9		
270	32.8		

Sample information:

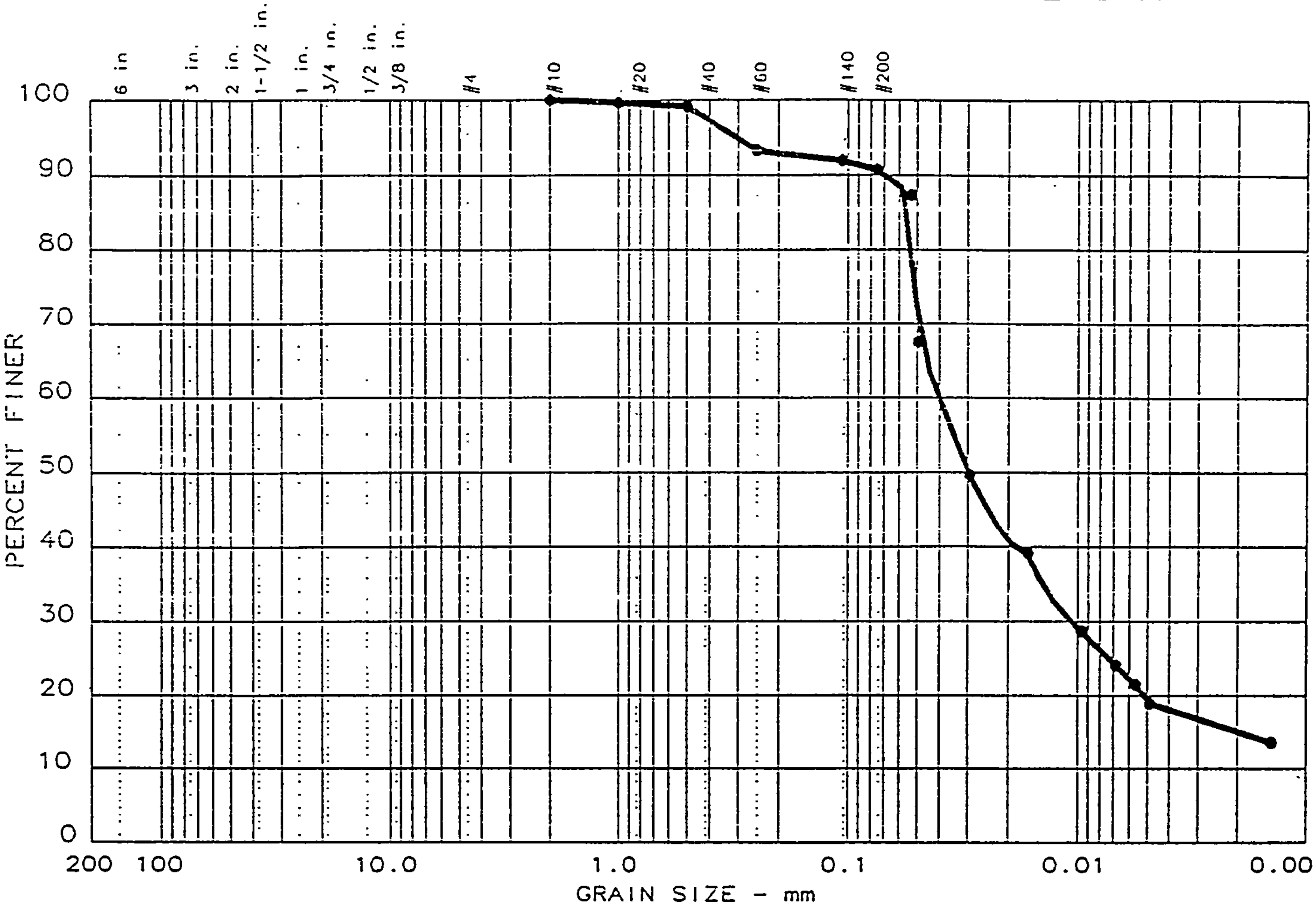
● H5-3
43.75 - 45.0 feet
ASTM Classif. SM

Remarks:
a: data2 gs2.sdt

Pacific Northwest Laboratory

Project No.: 100H
Project: 100H Remediation
Date: 4/28/95
Data Sheet No. 2

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	3	0.0	0.0	12.7	67.9	19.4	ML		

SIEVE inches size	PERCENT FINER ●		

	GRAIN SIZE		
D_{60}			
D_{30}	0.01		
D_{10}			

	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ●		
10	100.0		
18	99.6		
35	99.1		
60	93.2		
140	91.9		
200	90.7		
270	87.3		

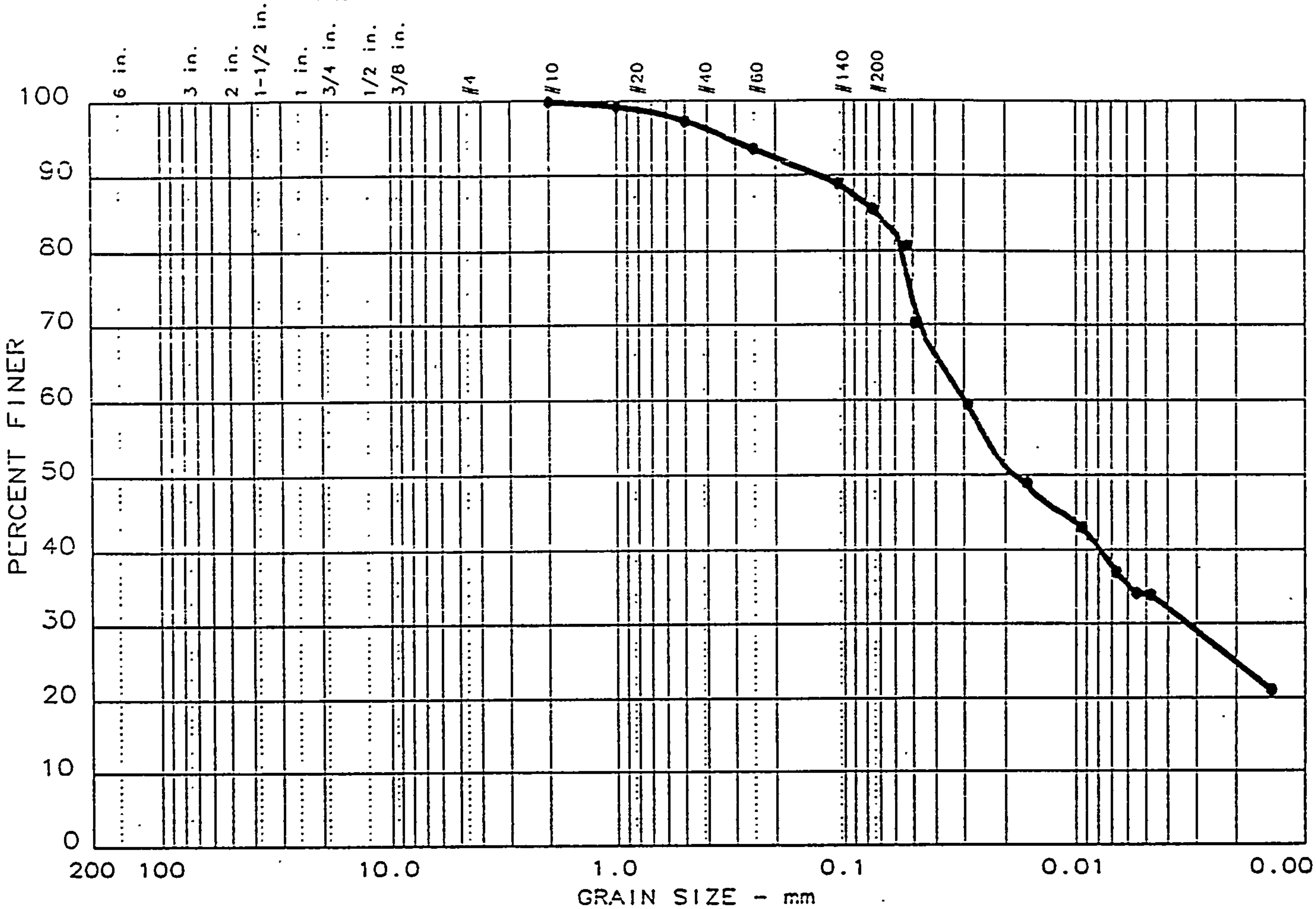
Sample information:
● H5-3
50.5 - 51.0 feet
ASTM Classif. ML

Remarks:
a: data2 gs3.sdt

Pacific Northwest Laboratory

Project No.: 100H
Project: 100H Remediation
Date: 4/28/95
Data Sheet No. 3

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	4	0.0	0.2	19.1	46.8	33.9	ML		

SIEVE inches size	PERCENT FINER ●		
	GRAIN SIZE		
D_{60} D_{30} D_{10}	0.003		
	COEFFICIENTS		
C_c C_u			

SIEVE number size	PERCENT FINER ●		
10	99.8		
18	99.1		
35	97.2		
60	93.5		
140	88.9		
200	85.5		
270	80.7		

Sample information:
● H5-3
52.0 - 52.5 feet
ASTM Classif. ML

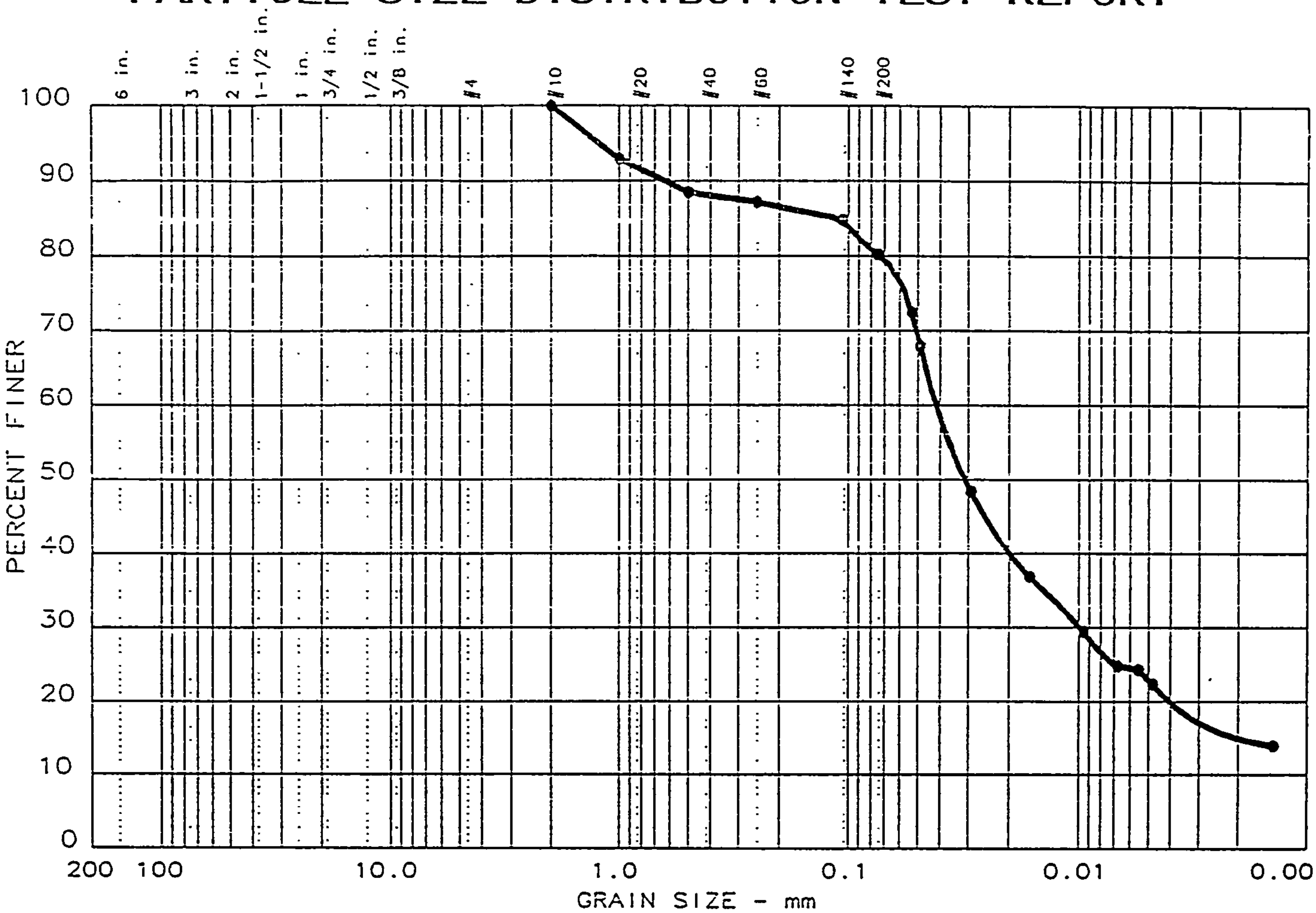
Remarks:
a: data2 gs4.sdt

Pacific Northwest Laboratory

Project No.: 100H
Project: 100H Remediation

Date: 4/28/95 Data Sheet No. 4

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	5	0.0	0.0	27.5	49.4	23.1	ML		

SIEVE inches size	PERCENT FINER ●		
GRAIN SIZE			
D_{60} D_{30} D_{10}	0.01		
COEFFICIENTS			
C_c C_u			

SIEVE number size	PERCENT FINER ●		
10	100.0		
18	92.9		
35	88.5		
60	87.2		
140	84.8		
200	80.2		
270	72.5		

Sample information:
● H5-3
53.0 - 53.5 feet
ASTM Classif. ML

Remarks:
a: data2 gs5.sdt

Pacific Northwest Laboratory

Project No.: 100H
Project: 100H Remediation
Date: 4/28/95
Data Sheet No. 5

PARTICLE DENSITY

Sample	PYC No.	PYC WT (g)	PYC+SOIL(g)	PYC, Soil, H20	PYC+H20	Ps	PS (g/cm3)
H5-2	1	36.47	10.03	92.73	86.31	2.778393352	
48.75-51.0 ft.	2	36.77	10.16	93.10	86.58	2.791208791	
	3	36.95	10.07	93.22	86.81	2.75136612	2.773656088
H5-3	4	36.96	10.07	93.22	86.84	2.72899729	
43.75-45.0 ft.	5	37.09	10.08	93.31	86.90	2.746594005	
	6	32.44	10.15	88.69	82.28	2.713903743	2.72983168
H5-3	7	36.71	10.03	93.06	86.62	2.793871866	
48.7-50.0 ft.	8	36.77	10	93.03	86.63	2.777777778	
	9	38.33	10.02	94.58	88.16	2.783333333	2.784994326
H5-3	10	36.81	10.06	93.02	86.59	2.771349862	
40.0-41.0 ft.	11	28.16	10.01	84.30	77.97	2.720108696	
	12	30.71	10.03	86.94	80.59	2.725543478	2.739000679
H5-3	13	38.19	10.04	94.39	88.05	2.713513514	
47.5-48.0 ft.	14	37.09	10.05	93.37	87.02	2.716216216	
	15	36.45	10.01	92.65	86.31	2.727520436	2.719083389
H5-3	16	32.91	10.07	88.80	82.69	2.542929293	
50.5-51.0 ft.	17	33.47	10.06	89.42	83.32	2.54040404	
	18	33.28	10.07	89.27	83.16	2.542929293	2.542087542
H5-3	19	33.48	10.02	89.35	83.31	2.51758794	
52.0-52.5 ft.	20	32.94	10.08	88.86	82.74	2.545454545	
	21	36.49	10.06	92.45	86.33	2.553299492	2.538780659
H5-3	22	38.14	10.04	94.13	87.99	2.574358974	
53.0-53.5 ft.	23	38.29	10.01	94.26	88.17	2.553571429	
	24	33.11	10.06	89.09	82.92	2.586118252	2.571349552
				Scale/Serial Number:			
Date:				Calibration Date:			

PARTICLE DENSITY

Sample	PYC No.	PYC WT (g)	PYC +Soil (g)	PYC, Soil, H20	PYC+H20	Ps	PS (g/cm3)
H5-2	25	37.98	10	94.17	87.82	2.739726027	
39.0-40.25 ft.	26	38.02	10.01	94.2	87.88	2.712737127	
	27	38.16	10.07	94.37	88.02	2.706989247	2.719817467
H5-2	28	38.31	10.03	94.44	88.16	2.674666667	
46.0-46.5 ft.	29	37.92	10.04	94.08	87.77	2.691689008	
	30	37.94	10.02	94.12	87.81	2.700808625	2.689054767
H5-4	1	36.47	10.08	92.69	86.31	2.724324324	
43-44	2	36.77	10.07	92.95	86.58	2.721621622	
	3	36.95	10.03	93.12	86.81	2.696236559	2.714060835
H5-4	4	36.96	10.14	93.25	86.84	2.71849866	
45.5-46	5	37.09	10.04	93.34	86.90	2.788888889	
	6	32.44	10.01	88.62	82.28	2.727520436	2.744969328
H5-5	7	36.71	10.08	92.99	86.62	2.716981132	
42-42.5	8	36.77	10.06	93.02	86.63	2.741144414	
	9	38.33	10.1	94.6	88.16	2.759562842	2.739229463
H5-5	10	36.81	10.09	93.05	86.59	2.779614325	
49-50	11	28.16	10.04	84.34	77.97	2.735694823	
	12	30.71	10.07	86.98	80.59	2.736413043	2.750574064
CONTROL	35	37.31	10	93.35	87.17	2.617801047	
	36	39.27	10	95.33	89.12	2.638522427	
							2.628161737

Analyst:

Scale/Serial Number:

Date:

Calibration Date:

PARTICLE DENSITY

Sample	PYC No.	PYC WT (g)	PYC +Soil (g)	PYC, Soil, H20	PYC+H20	Ps	PS (g/cm3)
H5-11	13	38.19	10.01	94.40	88.05	2.734972678	
43-43.5	14	37.09	10.01	93.37	87.02	2.734972678	
	15	36.45	10.02	92.69	86.31	2.752747253	2.740897536
H5-11	16	32.91	10.03	89.08	82.69	2.755494505	
43.5-44	17	33.47	10.03	89.65	83.32	2.710810811	
	18	33.28	10.06	89.50	83.16	2.704301075	2.723535464
H5-11	19	33.48	10.04	89.67	83.31	2.72826087	
49.5-50	20	32.94	10.03	89.11	82.74	2.740437158	
	21	36.49	10.04	92.73	86.33	2.758241758	2.742313262
H5-11	22	38.14	10.01	94.35	87.99	2.742465753	
42-42.5	23	38.29	10.02	94.51	88.17	2.722826087	
	24	33.11	10.00	89.27	82.92	2.739726027	2.735005956
H5-8	25	37.98	10.02	94.16	87.82	2.722826087	
48-49	26	38.02	10.00	94.22	87.88	2.732240437	
	27	38.16	10.02	94.38	88.02	2.737704918	2.730923814
H5-8	28	38.31	10.04	94.51	88.16	2.720867209	
44-45	29	37.92	10.03	94.10	87.77	2.710810811	
	30	37.94	10.03	94.16	87.81	2.725543478	2.719073833
CONTROL	33	37.87	10.03	93.93	87.76	2.598445596	
	34	37.37	10.00	93.45	87.30	2.597402597	
							2.597924097

Analyst:

Scale/Serial Number:

Date:

Calibration Date:

Bulk Density/Porosity

Sample No.	Length (cm)	Diameter cm)	% Ret. # 10	Weight of Liner	Pan Weight	Wet Soil Weight	Dry Soil Weight	Particle Density	Bulk Density	Porosity	Comments
H5-3 43.75-45.0	6	8.7	17.7	153.04	54.08	871.90	801.00	2.73	2.09	0.23293564	
H5-3 50.5-51.0	15.2	8.7	1.6	146.64	177.08	2040.58	1849.48	2.54	1.85	0.271324	Large rocks in core.
H5-3 52.0 - 52.5	6.7	8.7	0	131.82	104.31	830.74	699.56	2.54	1.49	0.41161377	Large rocks in core.
H5-3 53.0-53.5	6.1	8.7	0	152.98	142.83	901.44	778.03	2.57	1.75	0.31841638	Large rocks in core.
H5-4 45.5-46.0	15.7	8.7	51.8	170.9	119.60	2301.20	2126.40	2.74	2.15	0.21526054	
H5-5 42.0-42.5	15.15	8.7	24.3	161.4	58.70	1862.80	1847.65	2.74	1.99	0.27505239	
H5-5 49.0-50.0	6.2	8.7	61.9	153.2	61.30	850.70	819.40	2.75	2.06	0.252048	
H5-2 39.0-40.25	8.4	8.7	48.6	89.7	57.80	1164.30	1155.24	2.72	2.20	0.19201331	Had to repack core- disturbed.
H5-2 46.0-46.5	6.9	8.7	62.9	148.08	118.44	991.88	991.42	2.69	2.13	0.20882139	
H5-2 48.75-51.0	15.1	8.7	71	120.05	52.84	1762.40	1688.85	2.77	1.82	0.34203794	Repack ends. Large rock in center.
H5-3 40.0-41.0	6.4	8.7	21.5	137.92	54.55	714.42	693.59	2.74	1.68	0.3869878	Repack ends. Large rock in center.

Bulk Density/Porosity

Sample No.	Length (cm)	Diameter cm)	% Ret. # 10	Weight of Liner	Pan Weight	Wet Soil Weight	Dry Soil Weight	Particle Density	Bulk Density	Porosity	Comments
H5-4 43-44			11.6								Mason jar- no BD
H5-11 43-43.5			53.6		118.66	1199.10	1170.30	2.72			NO BD - too rocky
H5-11 42-42.5	15.23	8.7	22.5	154.5	119.69	1739.90	1620.50	2.74	1.66	0.39501186	
H5-11 43.5 - 44	15.3	8.7	51.9	160.7	105.40	2143.20	1409.20	2.72	1.43	0.47298588	
H5-11 49.5 - 50	15.08	8.7	62.1	164.2	54.70	2231.40	1547.60	2.74	1.67	0.39221437	Large rock in core 900+ grams retained on #10 sieve.
H5-8 44-45	10.15	8.7	22.2	107.5	54.20	1350.10	1257.35	2.72	1.99	0.26691144	
H5-8 48-49	11.4	8.7	77.2	106.7	52.70	1613.60	1510.33	2.73	2.15	0.21213572	

Appendix C

Groundwater Chemistry Data for 199-H5-1A and Dissolved Oxygen Data for Hanford Site Wells

Appendix C

Groundwater Chemistry Data for 199-H5-1A and Dissolved Oxygen Data for Hanford Site Wells

This appendix contains existing groundwater data for well 199-H5-1A and dissolved oxygen data for Hanford Site wells. These data were obtained from the Hanford Environmental Information System (HEIS) database. Groundwater chemistry data for well 199-H5-1A are discussed in Section 6.0. Dissolved oxygen data are discussed in Section 4.3.

Ground-Water Chemistry Data for Well 199-H5-1A

Well Name	Constituent	Sample Date	Filtered	Qualifier	Value	Units
199-H5-1A	1,1,1-T	01-AUG-92	N	U	10	ug/L
199-H5-1A	1,1,1-T	01-AUG-92	N	U	10	ug/L
199-H5-1A	1,1,1-T	18-MAY-92	N	U	10	ug/L
199-H5-1A	1,1,1-T	18-MAY-92	N	U	10	ug/L
199-H5-1A	1,1,1-T	01-NOV-92	N	U	10	ug/L
199-H5-1A	1,1,2-T	01-AUG-92	N	U	10	ug/L
199-H5-1A	1,1,2-T	01-AUG-92	N	U	10	ug/L
199-H5-1A	1,1,2-T	18-MAY-92	N	U	10	ug/L
199-H5-1A	1,1,2-T	18-MAY-92	N	U	10	ug/L
199-H5-1A	1,1,2-T	01-NOV-92	N	U	10	ug/L
199-H5-1A	1,1-DCL	01-AUG-92	N	U	10	ug/L
199-H5-1A	1,1-DCL	18-MAY-92	N	U	10	ug/L
199-H5-1A	1,1-DCL	18-MAY-92	N	U	10	ug/L
199-H5-1A	1,1-DCL	01-NOV-92	N	U	10	ug/L
199-H5-1A	1,1-DCL	01-AUG-92	N	U	10	ug/L
199-H5-1A	1,2-DCL	01-AUG-92	N	U	10	ug/L
199-H5-1A	1,2-DCL	01-AUG-92	N	U	10	ug/L
199-H5-1A	1,2-DCL	18-MAY-92	N	U	10	ug/L
199-H5-1A	1,2-DCL	18-MAY-92	N	U	10	ug/L
199-H5-1A	1,2-DCL	01-NOV-92	N	U	10	ug/L
199-H5-1A	1122-TCE	01-AUG-92	N	U	10	ug/L
199-H5-1A	1122-TCE	18-MAY-92	N	U	10	ug/L
199-H5-1A	1122-TCE	18-MAY-92	N	U	10	ug/L
199-H5-1A	1122-TCE	01-NOV-92	N	U	10	ug/L
199-H5-1A	1122-TCE	01-AUG-92	N	U	10	ug/L
199-H5-1A	12DICHL	01-AUG-92	N	U	10	ug/L
199-H5-1A	12DICHL	18-MAY-92	N	U	10	ug/L
199-H5-1A	12DICHL	01-NOV-92	N	U	10	ug/L
199-H5-1A	12DICHL	18-MAY-92	N	U	10	ug/L
199-H5-1A	12DICHL	01-AUG-92	N	U	10	ug/L
199-H5-1A	12DICLBENZ	18-MAY-92	N	U	10	ug/L
199-H5-1A	12DICLBENZ	01-AUG-92	N	U	10	ug/L
199-H5-1A	12DICLBENZ	01-NOV-92	N	U	10	ug/L
199-H5-1A	13DICLBENZ	18-MAY-92	N	U	10	ug/L
199-H5-1A	13DICLBENZ	01-AUG-92	N	U	10	ug/L
199-H5-1A	13DICLBENZ	01-NOV-92	N	U	10	ug/L
199-H5-1A	14DICLBENZ	18-MAY-92	N	U	10	ug/L
199-H5-1A	14DICLBENZ	01-AUG-92	N	U	10	ug/L
199-H5-1A	14DICLBENZ	01-NOV-92	N	U	10	ug/L
199-H5-1A	245TRCLPHN	18-MAY-92	N	U	25	ug/L
199-H5-1A	245TRCLPHN	01-AUG-92	N	U	25	ug/L
199-H5-1A	245TRCLPHN	01-NOV-92	N	U	25	ug/L
199-H5-1A	246TRCLPHN	18-MAY-92	N	U	10	ug/L
199-H5-1A	246TRCLPHN	01-NOV-92	N	U	10	ug/L
199-H5-1A	246TRCLPHN	01-AUG-92	N	U	10	ug/L
199-H5-1A	24DICLPHEN	18-MAY-92	N	U	10	ug/L
199-H5-1A	24DICLPHEN	01-AUG-92	N	U	10	ug/L
199-H5-1A	24DICLPHEN	01-NOV-92	N	U	10	ug/L
199-H5-1A	24DIMET	18-MAY-92	N	U	10	ug/L
199-H5-1A	24DIMET	01-AUG-92	N	U	10	ug/L
199-H5-1A	24DIMET	01-NOV-92	N	U	10	ug/L
199-H5-1A	24DINITOLU	18-MAY-92	N	U	10	ug/L
199-H5-1A	24DINITOLU	01-AUG-92	N	U	10	ug/L

Ground-Water Chemistry Data for Well 199-H5-1A

Well Name	Constituent	Sample Date	Filtered	Qualifier	Value	Units
199-H5-1A	24DINITOLU	01-NOV-92	N	U	10	ug/L
199-H5-1A	26DINITOLU	18-MAY-92	N	U	10	ug/L
199-H5-1A	26DINITOLU	01-NOV-92	N	U	10	ug/L
199-H5-1A	26DINITOLU	01-AUG-92	N	U	10	ug/L
199-H5-1A	2HEXANONE	01-AUG-92	N	U	10	ug/L
199-H5-1A	2HEXANONE	01-AUG-92	N	U	10	ug/L
199-H5-1A	2HEXANONE	01-NOV-92	N	U	10	ug/L
199-H5-1A	2HEXANONE	18-MAY-92	N	U	10	ug/L
199-H5-1A	2HEXANONE	18-MAY-92	N	U	10	ug/L
199-H5-1A	2MENAPH	18-MAY-92	N	U	10	ug/L
199-H5-1A	2MENAPH	01-AUG-92	N	U	10	ug/L
199-H5-1A	2MENAPH	01-NOV-92	N	U	10	ug/L
199-H5-1A	2METHPH	18-MAY-92	N	U	10	ug/L
199-H5-1A	2METHPH	01-AUG-92	N	U	10	ug/L
199-H5-1A	2METHPH	01-NOV-92	N	U	10	ug/L
199-H5-1A	2NITRAN	18-MAY-92	N	U	25	ug/L
199-H5-1A	2NITRAN	01-AUG-92	N	U	25	ug/L
199-H5-1A	2NITRAN	01-NOV-92	N	U	25	ug/L
199-H5-1A	2NITRPH	18-MAY-92	N	U	10	ug/L
199-H5-1A	2NITRPH	01-NOV-92	N	U	10	ug/L
199-H5-1A	2NITRPH	01-AUG-92	N	U	10	ug/L
199-H5-1A	3NITRAN	18-MAY-92	N	U	25	ug/L
199-H5-1A	3NITRAN	01-AUG-92	N	U	25	ug/L
199-H5-1A	3NITRAN	01-NOV-92	N	U	25	ug/L
199-H5-1A	46DINIT	18-MAY-92	N	U	25	ug/L
199-H5-1A	46DINIT	01-AUG-92	N	U	25	ug/L
199-H5-1A	46DINIT	01-NOV-92	N	U	25	ug/L
199-H5-1A	4CHLOET	18-MAY-92	N	U	10	ug/L
199-H5-1A	4CHLOET	01-NOV-92	N	U	10	ug/L
199-H5-1A	4CHLOET	01-AUG-92	N	U	10	ug/L
199-H5-1A	4METHPH	18-MAY-92	N	U	10	ug/L
199-H5-1A	4METHPH	01-AUG-92	N	U	10	ug/L
199-H5-1A	4METHPH	01-NOV-92	N	U	10	ug/L
199-H5-1A	9H-CARB	18-MAY-92	N	U	10	ug/L
199-H5-1A	9H-CARB	01-AUG-92	N	U	10	ug/L
199-H5-1A	9H-CARB	01-NOV-92	N	U	10	ug/L
199-H5-1A	A-BHC	18-MAY-92	N	UJ	0.05	ug/L
199-H5-1A	A-BHC	01-NOV-92	N	U	0.05	ug/L
199-H5-1A	A-BHC	01-AUG-92	N	UJ	0.05	ug/L
199-H5-1A	ACENAPH	18-MAY-92	N	U	10	ug/L
199-H5-1A	ACENAPH	01-AUG-92	N	U	10	ug/L
199-H5-1A	ACENAPH	01-NOV-92	N	U	10	ug/L
199-H5-1A	ACENATL	18-MAY-92	N	U	10	ug/L
199-H5-1A	ACENATL	01-AUG-92	N	U	10	ug/L
199-H5-1A	ACENATL	01-NOV-92	N	U	10	ug/L
199-H5-1A	ACETONE	01-AUG-92	N	JN	7	ug/L
199-H5-1A	ACETONE	01-AUG-92	N	U	10	ug/L
199-H5-1A	ACETONE	18-MAY-92	N	U	10	ug/L
199-H5-1A	ACETONE	01-NOV-92	N	U	10	ug/L
199-H5-1A	ACETONE	18-MAY-92	N	U	10	ug/L
199-H5-1A	ALDRIN	18-MAY-92	N	U	0.05	ug/L
199-H5-1A	ALDRIN	01-AUG-92	N	UJ	0.05	ug/L
199-H5-1A	ALDRIN	01-NOV-92	N	U	0.05	ug/L

Ground-Water Chemistry Data for Well 199-H5-1A

Well Name	Constituent	Sample Date	Filtered	Qualifier	Value	Units
199-H5-1A	ALKALINITY	01-AUG-92	N		176	mg/L
199-H5-1A	ALKALINITY	01-NOV-92	N		171	mg/L
199-H5-1A	ALPHA	18-MAY-92	N	R	4	pCi/L
199-H5-1A	ALPHA	01-NOV-92	N	R	3.3	pCi/L
199-H5-1A	ALPHA	01-AUG-92	N	R	3.5	pCi/L
199-H5-1A	ALPHA	17-AUG-93	N	R	5.9	pCi/L
199-H5-1A	ALPHA	18-FEB-93	N	J	3.1	pCi/L
199-H5-1A	ALPHCHL	18-MAY-92	N	U	0.05	ug/L
199-H5-1A	ALPHCHL	01-NOV-92	N	U	0.05	ug/L
199-H5-1A	ALPHCHL	01-AUG-92	N	U	0.05	ug/L
199-H5-1A	ALUMINUM	18-MAY-92	Y		22	ug/L
199-H5-1A	ALUMINUM	18-MAY-92	N		1140	ug/L
199-H5-1A	ALUMINUM	01-AUG-92	Y		36.8	ug/L
199-H5-1A	ALUMINUM	18-FEB-93	N		44.2	ug/L
199-H5-1A	ALUMINUM	01-NOV-92	N		34.2	ug/L
199-H5-1A	ALUMINUM	18-FEB-93	Y		21.2	ug/L
199-H5-1A	ALUMINUM	01-NOV-92	Y		14.7	ug/L
199-H5-1A	ALUMINUM	17-AUG-93	Y		20.9	ug/L
199-H5-1A	ALUMINUM	01-AUG-92	N		32.8	ug/L
199-H5-1A	AM-241	18-MAY-92	N	UJ	0	pCi/L
199-H5-1A	AM-241	01-NOV-92	N	U	0	pCi/L
199-H5-1A	AM-241	01-AUG-92	N	UJ	-0.01	pCi/L
199-H5-1A	AMM-ABS	17-AUG-93	N	U	0.05	mg/L
199-H5-1A	AMM-ABS	01-AUG-92	N	J	0.1	mg/L
199-H5-1A	ANTHRACENE	18-MAY-92	N	U	10	ug/L
199-H5-1A	ANTHRACENE	01-NOV-92	N	U	10	ug/L
199-H5-1A	ANTHRACENE	01-AUG-92	N	U	10	ug/L
199-H5-1A	ANTIMONY	18-MAY-92	Y		16	ug/L
199-H5-1A	ANTIMONY	18-MAY-92	N		16	ug/L
199-H5-1A	ANTIMONY	01-AUG-92	Y		16.3	ug/L
199-H5-1A	ANTIMONY	17-AUG-93	Y		15.7	ug/L
199-H5-1A	ANTIMONY	18-FEB-93	Y		19	ug/L
199-H5-1A	ANTIMONY	01-NOV-92	Y		14.8	ug/L
199-H5-1A	ANTIMONY	18-FEB-93	N		18.4	ug/L
199-H5-1A	ANTIMONY	01-NOV-92	N		16.9	ug/L
199-H5-1A	ANTIMONY	01-AUG-92	N		16.5	ug/L
199-H5-1A	AR1016	18-MAY-92	N	U	1	ug/L
199-H5-1A	AR1016	01-AUG-92	N	U	1	ug/L
199-H5-1A	AR1016	01-NOV-92	N	U	1	ug/L
199-H5-1A	AR1221	18-MAY-92	N	U	2	ug/L
199-H5-1A	AR1221	01-NOV-92	N	U	2	ug/L
199-H5-1A	AR1221	01-AUG-92	N	U	2	ug/L
199-H5-1A	AR1232	18-MAY-92	N	U	1	ug/L
199-H5-1A	AR1232	01-AUG-92	N	U	1	ug/L
199-H5-1A	AR1232	01-NOV-92	N	U	1	ug/L
199-H5-1A	AR1242	18-MAY-92	N	U	1	ug/L
199-H5-1A	AR1242	01-NOV-92	N	U	1	ug/L
199-H5-1A	AR1242	01-AUG-92	N	U	1	ug/L
199-H5-1A	AR1248	18-MAY-92	N	U	1	ug/L
199-H5-1A	AR1248	01-NOV-92	N	U	1	ug/L
199-H5-1A	AR1248	01-AUG-92	N	U	1	ug/L
199-H5-1A	AR1254	18-MAY-92	N	U	1	ug/L
199-H5-1A	AR1254	01-NOV-92	N	U	1	ug/L

Ground-Water Chemistry Data for Well 199-H5-1A

Well Name	Constituent	Sample Date	Filtered	Qualifier	Value	Units
199-H5-1A	AR1254	01-AUG-92	N	U	1	ug/L
199-H5-1A	AR1260	18-MAY-92	N	U	1	ug/L
199-H5-1A	AR1260	01-AUG-92	N	U	1	ug/L
199-H5-1A	AR1260	01-NOV-92	N	U	1	ug/L
199-H5-1A	ARSENIC	18-MAY-92	Y		5	ug/L
199-H5-1A	ARSENIC	18-MAY-92	N		4.3	ug/L
199-H5-1A	ARSENIC	18-FEB-93	N		2	ug/L
199-H5-1A	ARSENIC	01-NOV-92	Y		2.5	ug/L
199-H5-1A	ARSENIC	18-FEB-93	Y		3.9	ug/L
199-H5-1A	ARSENIC	17-AUG-93	Y		9.8	ug/L
199-H5-1A	ARSENIC	01-NOV-92	N	W	2.9	ug/L
199-H5-1A	ARSENIC	01-AUG-92	Y		2.6	ug/L
199-H5-1A	ARSENIC	01-AUG-92	N		2.6	ug/L
199-H5-1A	B-BHC	18-MAY-92	N	U	0.05	ug/L
199-H5-1A	B-BHC	01-NOV-92	N	U	0.05	ug/L
199-H5-1A	B-BHC	01-AUG-92	N	U	0.05	ug/L
199-H5-1A	BARIUM	18-MAY-92	Y		77.5	ug/L
199-H5-1A	BARIUM	18-MAY-92	N		87.8	ug/L
199-H5-1A	BARIUM	01-AUG-92	N		62.3	ug/L
199-H5-1A	BARIUM	01-AUG-92	Y		59	ug/L
199-H5-1A	BARIUM	18-FEB-93	N		57.5	ug/L
199-H5-1A	BARIUM	18-FEB-93	Y		56.4	ug/L
199-H5-1A	BARIUM	01-NOV-92	Y		58.7	ug/L
199-H5-1A	BARIUM	17-AUG-93	Y		49.8	ug/L
199-H5-1A	BARIUM	01-NOV-92	N		56.5	ug/L
199-H5-1A	BDCM	01-AUG-92	N	U	10	ug/L
199-H5-1A	BDCM	18-MAY-92	N	U	10	ug/L
199-H5-1A	BDCM	18-MAY-92	N	U	10	ug/L
199-H5-1A	BDCM	01-NOV-92	N	U	10	ug/L
199-H5-1A	BDCM	01-AUG-92	N	U	10	ug/L
199-H5-1A	BENZAAN	18-MAY-92	N	U	10	ug/L
199-H5-1A	BENZAAN	01-AUG-92	N	U	10	ug/L
199-H5-1A	BENZAAN	01-NOV-92	N	U	10	ug/L
199-H5-1A	BENZBFL	18-MAY-92	N	U	10	ug/L
199-H5-1A	BENZBFL	01-NOV-92	N	U	10	ug/L
199-H5-1A	BENZBFL	01-AUG-92	N	U	10	ug/L
199-H5-1A	BENZENE	01-AUG-92	N	U	10	ug/L
199-H5-1A	BENZENE	01-AUG-92	N	U	10	ug/L
199-H5-1A	BENZENE	18-MAY-92	N	U	10	ug/L
199-H5-1A	BENZENE	01-NOV-92	N	U	10	ug/L
199-H5-1A	BENZENE	18-MAY-92	N	U	10	ug/L
199-H5-1A	BENZOPE	18-MAY-92	N	U	10	ug/L
199-H5-1A	BENZOPE	01-AUG-92	N	U	10	ug/L
199-H5-1A	BENZOPE	01-NOV-92	N	U	10	ug/L
199-H5-1A	BENZOPY	18-MAY-92	N	U	10	ug/L
199-H5-1A	BENZOPY	01-NOV-92	N	U	10	ug/L
199-H5-1A	BENZOPY	01-AUG-92	N	U	10	ug/L
199-H5-1A	BERYLLIUM	18-MAY-92	Y		1	ug/L
199-H5-1A	BERYLLIUM	01-NOV-92	N		0.4	ug/L
199-H5-1A	BERYLLIUM	17-AUG-93	Y		1.2	ug/L
199-H5-1A	BERYLLIUM	18-FEB-93	Y		0.9	ug/L
199-H5-1A	BERYLLIUM	01-NOV-92	Y		0.3	ug/L
199-H5-1A	BERYLLIUM	18-FEB-93	N		0.5	ug/L

Ground-Water Chemistry Data for Well 199-H5-1A

Well Name	Constituent	Sample Date	Filtered	Qualifier	Value	Units
199-H5-1A	BERYLLIUM	01-AUG-92	Y		0.81	ug/L
199-H5-1A	BERYLLIUM	18-MAY-92	N		1	ug/L
199-H5-1A	BERYLLIUM	01-AUG-92	N		0.4	ug/L
199-H5-1A	BETA	18-MAY-92	N	J	7.3	pCi/L
199-H5-1A	BETA	01-AUG-92	N		6.9	pCi/L
199-H5-1A	BETA	01-NOV-92	N		8.4	pCi/L
199-H5-1A	BETA	18-FEB-93	N	J	7.9	pCi/L
199-H5-1A	BETA	17-AUG-93	N	R	4.2	pCi/L
199-H5-1A	BIS2CHE	18-MAY-92	N	U	10	ug/L
199-H5-1A	BIS2CHE	01-NOV-92	N	U	10	ug/L
199-H5-1A	BIS2CHE	01-AUG-92	N	U	10	ug/L
199-H5-1A	BIS2CHM	18-MAY-92	N	U	10	ug/L
199-H5-1A	BIS2CHM	01-AUG-92	N	U	10	ug/L
199-H5-1A	BIS2CHM	01-NOV-92	N	U	10	ug/L
199-H5-1A	BIS2EPH	18-MAY-92	N	U	10	ug/L
199-H5-1A	BIS2EPH	01-NOV-92	N	U	10	ug/L
199-H5-1A	BIS2EPH	01-AUG-92	N	U	10	ug/L
199-H5-1A	BIS2ETH	18-MAY-92	N	U	10	ug/L
199-H5-1A	BIS2ETH	01-AUG-92	N	U	10	ug/L
199-H5-1A	BIS2ETH	01-NOV-92	N	U	10	ug/L
199-H5-1A	BNZKFLU	18-MAY-92	N	U	10	ug/L
199-H5-1A	BNZKFLU	01-AUG-92	N	U	10	ug/L
199-H5-1A	BNZKFLU	01-NOV-92	N	U	10	ug/L
199-H5-1A	BROMOFORM	01-AUG-92	N	U	10	ug/L
199-H5-1A	BROMOFORM	18-MAY-92	N	U	10	ug/L
199-H5-1A	BROMOFORM	01-NOV-92	N	U	10	ug/L
199-H5-1A	BROMOFORM	18-MAY-92	N	U	10	ug/L
199-H5-1A	BROMOFORM	01-AUG-92	N	U	10	ug/L
199-H5-1A	BROPHEN	18-MAY-92	N	U	10	ug/L
199-H5-1A	BROPHEN	01-AUG-92	N	U	10	ug/L
199-H5-1A	BROPHEN	01-NOV-92	N	U	10	ug/L
199-H5-1A	BUTBENP	18-MAY-92	N	U	10	ug/L
199-H5-1A	BUTBENP	01-AUG-92	N	U	10	ug/L
199-H5-1A	BUTBENP	01-NOV-92	N	U	10	ug/L
199-H5-1A	C-14	18-MAY-92	N	J	66	pCi/L
199-H5-1A	C-14	01-AUG-92	N	UX	14	pCi/L
199-H5-1A	C-14	01-NOV-92	N	UJ	23	pCi/L
199-H5-1A	CADMIUM	18-MAY-92	Y		2	ug/L
199-H5-1A	CADMIUM	18-MAY-92	N		3.4	ug/L
199-H5-1A	CADMIUM	01-AUG-92	N		1.4	ug/L
199-H5-1A	CADMIUM	01-NOV-92	N		2.2	ug/L
199-H5-1A	CADMIUM	17-AUG-93	Y		1.5	ug/L
199-H5-1A	CADMIUM	18-FEB-93	Y		1.4	ug/L
199-H5-1A	CADMIUM	01-NOV-92	Y		1.5	ug/L
199-H5-1A	CADMIUM	18-FEB-93	N		1.6	ug/L
199-H5-1A	CADMIUM	01-AUG-92	Y		1.5	ug/L
199-H5-1A	CALCIUM	18-MAY-92	Y		60200	ug/L
199-H5-1A	CALCIUM	01-NOV-92	N		61600	ug/L
199-H5-1A	CALCIUM	18-FEB-93	N		62800	ug/L
199-H5-1A	CALCIUM	18-FEB-93	Y		61200	ug/L
199-H5-1A	CALCIUM	01-NOV-92	Y		59300	ug/L
199-H5-1A	CALCIUM	17-AUG-93	Y		59400	ug/L
199-H5-1A	CALCIUM	01-AUG-92	Y		59500	ug/L

Ground-Water Chemistry Data for Well 199-H5-1A

Well Name	Constituent	Sample Date	Filtered	Qualifier	Value	Units
199-H5-1A	CALCIUM	18-MAY-92	N		59800	ug/L
199-H5-1A	CALCIUM	01-AUG-92	N		60800	ug/L
199-H5-1A	CARBIDE	01-AUG-92	N	U	10	ug/L
199-H5-1A	CARBIDE	01-AUG-92	N	U	10	ug/L
199-H5-1A	CARBIDE	18-MAY-92	N	U	10	ug/L
199-H5-1A	CARBIDE	01-NOV-92	N	U	10	ug/L
199-H5-1A	CARBIDE	18-MAY-92	N	U	10	ug/L
199-H5-1A	CARBTET	01-AUG-92	N	U	10	ug/L
199-H5-1A	CARBTET	18-MAY-92	N	U	10	ug/L
199-H5-1A	CARBTET	01-NOV-92	N	U	10	ug/L
199-H5-1A	CARBTET	18-MAY-92	N	U	10	ug/L
199-H5-1A	CARBTET	01-AUG-92	N	U	10	ug/L
199-H5-1A	CDBM	01-AUG-92	N	U	10	ug/L
199-H5-1A	CDBM	01-AUG-92	N	U	10	ug/L
199-H5-1A	CDBM	18-MAY-92	N	U	10	ug/L
199-H5-1A	CDBM	01-NOV-92	N	U	10	ug/L
199-H5-1A	CDBM	18-MAY-92	N	U	10	ug/L
199-H5-1A	CHLANIL	18-MAY-92	N	U	10	ug/L
199-H5-1A	CHLANIL	01-NOV-92	N	U	10	ug/L
199-H5-1A	CHLANIL	01-AUG-92	N	U	10	ug/L
199-H5-1A	CHLCRES	18-MAY-92	N	U	10	ug/L
199-H5-1A	CHLCRES	01-NOV-92	N	U	10	ug/L
199-H5-1A	CHLCRES	01-AUG-92	N	U	10	ug/L
199-H5-1A	CHLNAPH	18-MAY-92	N	U	10	ug/L
199-H5-1A	CHLNAPH	01-AUG-92	N	U	10	ug/L
199-H5-1A	CHLNAPH	01-NOV-92	N	U	10	ug/L
199-H5-1A	CHLORIDE	01-AUG-92	N		13.1	mg/L
199-H5-1A	CHLORIDE	17-AUG-93	N		11.9	mg/L
199-H5-1A	CHLORIDE	01-NOV-92	N		12.9	mg/L
199-H5-1A	CHLORIDE	18-MAY-92	N		17.2	mg/L
199-H5-1A	CHLOROBENZ	01-AUG-92	N	U	10	ug/L
199-H5-1A	CHLOROBENZ	01-AUG-92	N	U	10	ug/L
199-H5-1A	CHLOROBENZ	18-MAY-92	N	U	10	ug/L
199-H5-1A	CHLOROBENZ	01-NOV-92	N	U	10	ug/L
199-H5-1A	CHLOROBENZ	18-MAY-92	N	U	10	ug/L
199-H5-1A	CHLOROFORM	01-AUG-92	N	U	10	ug/L
199-H5-1A	CHLOROFORM	01-AUG-92	N	J	2	ug/L
199-H5-1A	CHLOROFORM	18-MAY-92	N	U	10	ug/L
199-H5-1A	CHLOROFORM	01-NOV-92	N	J	1	ug/L
199-H5-1A	CHLOROFORM	18-MAY-92	N	U	10	ug/L
199-H5-1A	CHLPHEN	18-MAY-92	N	U	10	ug/L
199-H5-1A	CHLPHEN	01-NOV-92	N	U	10	ug/L
199-H5-1A	CHLPHEN	01-AUG-92	N	U	10	ug/L
199-H5-1A	CHROMIUM	18-MAY-92	Y		44.8	ug/L
199-H5-1A	CHROMIUM	01-AUG-92	Y		66.3	ug/L
199-H5-1A	CHROMIUM	01-AUG-92	N		74.9	ug/L
199-H5-1A	CHROMIUM	18-MAY-92	N		127	ug/L
199-H5-1A	CHROMIUM	01-NOV-92	N		84.4	ug/L
199-H5-1A	CHROMIUM	17-AUG-93	Y		5.1	ug/L
199-H5-1A	CHROMIUM	18-FEB-93	Y		71	ug/L
199-H5-1A	CHROMIUM	01-NOV-92	Y		72.2	ug/L
199-H5-1A	CHROMIUM	18-FEB-93	N		99.9	ug/L
199-H5-1A	CHRYSENE	18-MAY-92	N	U	10	ug/L

Ground-Water Chemistry Data for Well 199-H5-1A

Well Name	Constituent	Sample Date	Filtered	Qualifier	Value	Units
199-H5-1A	CHRYSENE	01-AUG-92	N	U	10	ug/L
199-H5-1A	CHRYSENE	01-NOV-92	N	U	10	ug/L
199-H5-1A	CIS13DI	01-AUG-92	N	U	10	ug/L
199-H5-1A	CIS13DI	01-AUG-92	N	U	10	ug/L
199-H5-1A	CIS13DI	18-MAY-92	N	U	10	ug/L
199-H5-1A	CIS13DI	18-MAY-92	N	U	10	ug/L
199-H5-1A	CIS13DI	01-NOV-92	N	U	10	ug/L
199-H5-1A	CLETHAN	01-AUG-92	N	U	10	ug/L
199-H5-1A	CLETHAN	18-MAY-92	N	U	10	ug/L
199-H5-1A	CLETHAN	01-AUG-92	N	U	10	ug/L
199-H5-1A	CLETHAN	18-MAY-92	N	U	10	ug/L
199-H5-1A	CLETHAN	01-NOV-92	N	U	10	ug/L
199-H5-1A	CO-60	18-MAY-92	N	UJ	16	pCi/L
199-H5-1A	CO-60	01-AUG-92	N	U	13	pCi/L
199-H5-1A	CO-60	01-NOV-92	N	U	20	pCi/L
199-H5-1A	COBALT	18-MAY-92	Y		3	ug/L
199-H5-1A	COBALT	01-NOV-92	Y		1.3	ug/L
199-H5-1A	COBALT	17-AUG-93	Y		2.5	ug/L
199-H5-1A	COBALT	18-FEB-93	Y		3.2	ug/L
199-H5-1A	COBALT	01-AUG-92	N		2.3	ug/L
199-H5-1A	COBALT	01-AUG-92	Y		3.5	ug/L
199-H5-1A	COBALT	18-FEB-93	N		2.5	ug/L
199-H5-1A	COBALT	01-NOV-92	N		2.7	ug/L
199-H5-1A	COBALT	18-MAY-92	N		4.3	ug/L
199-H5-1A	COD	01-AUG-92	N	UJ	30	mg/L
199-H5-1A	CONDUCT	18-MAY-92	N		452	umhos/cm
199-H5-1A	CONDUCT	01-AUG-92	N		451	umhos/cm
199-H5-1A	CONDUCT	18-FEB-93	N		509	umhos/cm
199-H5-1A	CONDUCT	06-APR-94	N		567	umhos/cm
199-H5-1A	CONDUCT	01-NOV-92	N		494	umhos/cm
199-H5-1A	COPPER	18-MAY-92	Y		2	ug/L
199-H5-1A	COPPER	01-AUG-92	Y		3.8	ug/L
199-H5-1A	COPPER	18-FEB-93	N		5.4	ug/L
199-H5-1A	COPPER	01-NOV-92	Y		1.9	ug/L
199-H5-1A	COPPER	18-FEB-93	Y		4.9	ug/L
199-H5-1A	COPPER	17-AUG-93	Y		4	ug/L
199-H5-1A	COPPER	01-NOV-92	N		3.5	ug/L
199-H5-1A	COPPER	18-MAY-92	N		10.6	ug/L
199-H5-1A	COPPER	01-AUG-92	N		2.4	ug/L
199-H5-1A	CR-51	18-MAY-92	N	UJ	380	pCi/L
199-H5-1A	CR-51	01-NOV-92	N	U	700	pCi/L
199-H5-1A	CR-51	01-AUG-92	N	U	340	pCi/L
199-H5-1A	CS-134	18-MAY-92	N	UJ	15	pCi/L
199-H5-1A	CS-134	01-AUG-92	N	U	11	pCi/L
199-H5-1A	CS-134	01-NOV-92	N	U	10	pCi/L
199-H5-1A	CS-137	18-MAY-92	N	UJ	15	pCi/L
199-H5-1A	CS-137	01-AUG-92	N	U	13	pCi/L
199-H5-1A	CS-137	01-NOV-92	N	U	20	pCi/L
199-H5-1A	CYANIDE	18-MAY-92	N		10	ug/L
199-H5-1A	CYANIDE	01-AUG-92	N		10	ug/L
199-H5-1A	CYANIDE	01-NOV-92	N		10	ug/L
199-H5-1A	D-BHC	18-MAY-92	N	UJ	0.05	ug/L
199-H5-1A	D-BHC	01-AUG-92	N	UJ	0.05	ug/L

Ground-Water Chemistry Data for Well 199-H5-1A

Well Name	Constituent	Sample Date	Filtered	Qualifier	Value	Units
199-H5-1A	D-BHC	01-NOV-92	N	U	0.05	ug/L
199-H5-1A	DDD	18-MAY-92	N	UJ	0.1	ug/L
199-H5-1A	DDD	01-AUG-92	N	U	0.1	ug/L
199-H5-1A	DDD	01-NOV-92	N	U	0.1	ug/L
199-H5-1A	DDE	18-MAY-92	N	UJ	0.1	ug/L
199-H5-1A	DDE	01-NOV-92	N	U	0.1	ug/L
199-H5-1A	DDE	01-AUG-92	N	U	0.1	ug/L
199-H5-1A	DDT	18-MAY-92	N	U	0.1	ug/L
199-H5-1A	DDT	01-AUG-92	N	U	0.1	ug/L
199-H5-1A	DDT	01-NOV-92	N	U	0.1	ug/L
199-H5-1A	DIBAHAN	18-MAY-92	N	U	10	ug/L
199-H5-1A	DIBAHAN	01-AUG-92	N	U	10	ug/L
199-H5-1A	DIBAHAN	01-NOV-92	N	U	10	ug/L
199-H5-1A	DIBENFR	18-MAY-92	N	U	10	ug/L
199-H5-1A	DIBENFR	01-AUG-92	N	U	10	ug/L
199-H5-1A	DIBENFR	01-NOV-92	N	U	10	ug/L
199-H5-1A	DIBPHTH	18-MAY-92	N	U	10	ug/L
199-H5-1A	DIBPHTH	01-NOV-92	N	U	10	ug/L
199-H5-1A	DIBPHTH	01-AUG-92	N	U	10	ug/L
199-H5-1A	DICETHY	01-AUG-92	N	U	10	ug/L
199-H5-1A	DICETHY	01-AUG-92	N	U	10	ug/L
199-H5-1A	DICETHY	18-MAY-92	N	U	10	ug/L
199-H5-1A	DICETHY	01-NOV-92	N	U	10	ug/L
199-H5-1A	DICETHY	18-MAY-92	N	U	10	ug/L
199-H5-1A	DICHBEN	18-MAY-92	N	U	10	ug/L
199-H5-1A	DICHBEN	01-NOV-92	N	U	10	ug/L
199-H5-1A	DICHBEN	01-AUG-92	N	U	10	ug/L
199-H5-1A	DICPANE	01-AUG-92	N	U	10	ug/L
199-H5-1A	DICPANE	01-NOV-92	N	U	10	ug/L
199-H5-1A	DICPANE	01-AUG-92	N	U	10	ug/L
199-H5-1A	DICPANE	18-MAY-92	N	U	10	ug/L
199-H5-1A	DICPANE	18-MAY-92	N	U	10	ug/L
199-H5-1A	DIELDRIN	18-MAY-92	N	U	0.1	ug/L
199-H5-1A	DIELDRIN	01-AUG-92	N	U	0.1	ug/L
199-H5-1A	DIELDRIN	01-NOV-92	N	U	0.1	ug/L
199-H5-1A	DIEPHTH	18-MAY-92	N	U	10	ug/L
199-H5-1A	DIEPHTH	01-NOV-92	N	U	10	ug/L
199-H5-1A	DIEPHTH	01-AUG-92	N	U	10	ug/L
199-H5-1A	DIMPHTH	18-MAY-92	N	U	10	ug/L
199-H5-1A	DIMPHTH	01-NOV-92	N	U	10	ug/L
199-H5-1A	DIMPHTH	01-AUG-92	N	U	10	ug/L
199-H5-1A	DINPHEN	18-MAY-92	N	U	25	ug/L
199-H5-1A	DINPHEN	01-AUG-92	N	U	25	ug/L
199-H5-1A	DINPHEN	01-NOV-92	N	U	25	ug/L
199-H5-1A	DIOPHTH	18-MAY-92	N	U	10	ug/L
199-H5-1A	DIOPHTH	01-AUG-92	N	U	10	ug/L
199-H5-1A	DIOPHTH	01-NOV-92	N	U	10	ug/L
199-H5-1A	DIPRNIT	18-MAY-92	N	U	10	ug/L
199-H5-1A	DIPRNIT	01-AUG-92	N	U	10	ug/L
199-H5-1A	DIPRNIT	01-NOV-92	N	U	10	ug/L
199-H5-1A	ENDHYDE	18-MAY-92	N	U	0.1	ug/L
199-H5-1A	ENDHYDE	01-AUG-92	N	U	0.1	ug/L
199-H5-1A	ENDHYDE	01-NOV-92	N	U	0.1	ug/L

Ground-Water Chemistry Data for Well 199-H5-1A

Well Name	Constituent	Sample Date	Filtered	Qualifier	Value	Units
199-H5-1A	ENDO1	18-MAY-92	N	U	0.05	ug/L
199-H5-1A	ENDO1	01-AUG-92	N	U	0.05	ug/L
199-H5-1A	ENDO1	01-NOV-92	N	U	0.05	ug/L
199-H5-1A	ENDOS2	18-MAY-92	N	U	0.1	ug/L
199-H5-1A	ENDOS2	01-AUG-92	N	U	0.1	ug/L
199-H5-1A	ENDOS2	01-NOV-92	N	U	0.1	ug/L
199-H5-1A	ENDRIN	18-MAY-92	N	U	0.1	ug/L
199-H5-1A	ENDRIN	01-AUG-92	N	U	0.1	ug/L
199-H5-1A	ENDRIN	01-NOV-92	N	U	0.1	ug/L
199-H5-1A	ENDRKETONE	18-MAY-92	N	U	0.1	ug/L
199-H5-1A	ENDRKETONE	01-AUG-92	N	U	0.1	ug/L
199-H5-1A	ENDRKETONE	01-NOV-92	N	U	0.1	ug/L
199-H5-1A	ENDSFAN	18-MAY-92	N	U	0.1	ug/L
199-H5-1A	ENDSFAN	01-NOV-92	N	U	0.1	ug/L
199-H5-1A	ENDSFAN	01-AUG-92	N	U	0.1	ug/L
199-H5-1A	ETHBENZENE	01-AUG-92	N	U	10	ug/L
199-H5-1A	ETHBENZENE	01-AUG-92	N	U	10	ug/L
199-H5-1A	ETHBENZENE	18-MAY-92	N	U	10	ug/L
199-H5-1A	ETHBENZENE	01-NOV-92	N	U	10	ug/L
199-H5-1A	ETHBENZENE	18-MAY-92	N	U	10	ug/L
199-H5-1A	EU-152	01-AUG-92	N	U	23	pCi/L
199-H5-1A	EU-152	01-NOV-92	N	U	30	pCi/L
199-H5-1A	EU-154	01-AUG-92	N	U	15	pCi/L
199-H5-1A	EU-154	01-NOV-92	N	U	20	pCi/L
199-H5-1A	FE-59	01-AUG-92	N	U	71	pCi/L
199-H5-1A	FE-59	01-NOV-92	N	U	90	pCi/L
199-H5-1A	FLDCOND	18-MAY-92	N		514	umhos/cm
199-H5-1A	FLDCOND	01-NOV-92	N		460	umhos/cm
199-H5-1A	FLDCOND	01-NOV-92	N		460	umhos/cm
199-H5-1A	FLDCOND	01-AUG-92	Y		561	umhos/cm
199-H5-1A	FLDCOND	18-FEB-93	Y		530	umhos/cm
199-H5-1A	FLDCOND	18-FEB-93	N		530	umhos/cm
199-H5-1A	FLDCOND	01-NOV-92	N		460	umhos/cm
199-H5-1A	FLDCOND	01-AUG-92	N		561	umhos/cm
199-H5-1A	FLDCOND	01-AUG-92	N		561	umhos/cm
199-H5-1A	FLDCOND	01-AUG-92	N		561	umhos/cm
199-H5-1A	FLDCOND	01-AUG-92	N		561	umhos/cm
199-H5-1A	FLDCOND	01-NOV-92	Y		460	umhos/cm
199-H5-1A	FLDCOND	18-MAY-92	Y		514	umhos/cm
199-H5-1A	FLDTEMP	18-MAY-92	N		18.5	Deg C
199-H5-1A	FLDTEMP	01-NOV-92	N		17.3	Deg C
199-H5-1A	FLDTEMP	01-NOV-92	N		17.3	Deg C
199-H5-1A	FLDTEMP	18-MAY-92	Y		18.5	Deg C
199-H5-1A	FLDTEMP	01-NOV-92	Y		17.3	Deg C
199-H5-1A	FLDTEMP	01-AUG-92	Y		18.1	Deg C
199-H5-1A	FLDTEMP	18-FEB-93	Y		17.3	Deg C
199-H5-1A	FLDTEMP	18-FEB-93	N		17.3	Deg C
199-H5-1A	FLDTEMP	01-AUG-92	N		18.1	Deg C
199-H5-1A	FLDTEMP	01-AUG-92	N		18.1	Deg C
199-H5-1A	FLDTEMP	01-AUG-92	N		18.1	Deg C
199-H5-1A	FLDTEMP	01-NOV-92	N		17.3	Deg C
199-H5-1A	FLDTEMP	01-AUG-92	N		18.1	Deg C
199-H5-1A	FLUORAN	18-MAY-92	N	U	10	ug/L

Ground-Water Chemistry Data for Well 199-H5-1A

Well Name	Constituent	Sample Date	Filtered	Qualifier	Value	Units
199-H5-1A	FLUORAN	01-NOV-92	N	U	10	ug/L
199-H5-1A	FLUORAN	01-AUG-92	N	U	10	ug/L
199-H5-1A	FLUORENE	18-MAY-92	N	U	10	ug/L
199-H5-1A	FLUORENE	01-NOV-92	N	U	10	ug/L
199-H5-1A	FLUORENE	01-AUG-92	N	U	10	ug/L
199-H5-1A	FLUORIDE	18-MAY-92	N		0.5	mg/L
199-H5-1A	FLUORIDE	01-NOV-92	N		0.4	mg/L
199-H5-1A	FLUORIDE	17-AUG-93	N		0.3	mg/L
199-H5-1A	FLUORIDE	01-AUG-92	N		0.3	mg/L
199-H5-1A	GAM-BHC	18-MAY-92	N	UJ	0.05	ug/L
199-H5-1A	GAM-BHC	01-AUG-92	N	UJ	0.05	ug/L
199-H5-1A	GAM-BHC	01-NOV-92	N	U	0.05	ug/L
199-H5-1A	GAMMCHL	18-MAY-92	N	U	0.05	ug/L
199-H5-1A	GAMMCHL	01-NOV-92	N	U	0.05	ug/L
199-H5-1A	GAMMCHL	01-AUG-92	N	U	0.05	ug/L
199-H5-1A	HEPTACHLOR	18-MAY-92	N	U	0.05	ug/L
199-H5-1A	HEPTACHLOR	01-NOV-92	N	U	0.05	ug/L
199-H5-1A	HEPTACHLOR	01-AUG-92	N	U	0.05	ug/L
199-H5-1A	HEPTIDE	18-MAY-92	N	U	0.05	ug/L
199-H5-1A	HEPTIDE	01-AUG-92	N	U	0.05	ug/L
199-H5-1A	HEPTIDE	01-NOV-92	N	U	0.05	ug/L
199-H5-1A	HEXCBEN	18-MAY-92	N	U	10	ug/L
199-H5-1A	HEXCBEN	01-NOV-92	N	U	10	ug/L
199-H5-1A	HEXCBEN	01-AUG-92	N	U	10	ug/L
199-H5-1A	HEXCBUT	18-MAY-92	N	U	10	ug/L
199-H5-1A	HEXCBUT	01-NOV-92	N	U	10	ug/L
199-H5-1A	HEXCBUT	01-AUG-92	N	U	10	ug/L
199-H5-1A	HEXCCYC	18-MAY-92	N	U	10	ug/L
199-H5-1A	HEXCCYC	01-NOV-92	N	U	10	ug/L
199-H5-1A	HEXCCYC	01-AUG-92	N	U	10	ug/L
199-H5-1A	HEXCETH	18-MAY-92	N	U	10	ug/L
199-H5-1A	HEXCETH	01-AUG-92	N	U	10	ug/L
199-H5-1A	HEXCETH	01-NOV-92	N	U	10	ug/L
199-H5-1A	HEXONE	01-AUG-92	N	U	10	ug/L
199-H5-1A	HEXONE	18-MAY-92	N	U	10	ug/L
199-H5-1A	HEXONE	01-NOV-92	N	U	10	ug/L
199-H5-1A	HEXONE	18-MAY-92	N	U	10	ug/L
199-H5-1A	HEXONE	01-AUG-92	N	U	10	ug/L
199-H5-1A	HYDRAZINE	01-NOV-92	N	U	3	ug/L
199-H5-1A	HYDRAZINE	01-AUG-92	Y	R	3	ug/L
199-H5-1A	I-129	06-APR-94	N		-0.26	pCi/L
199-H5-1A	INDENOP	18-MAY-92	N	U	10	ug/L
199-H5-1A	INDENOP	01-AUG-92	N	U	10	ug/L
199-H5-1A	INDENOP	01-NOV-92	N	U	10	ug/L
199-H5-1A	IRON	18-MAY-92	Y		35.7	ug/L
199-H5-1A	IRON	18-FEB-93	Y		6	ug/L
199-H5-1A	IRON	01-NOV-92	Y		11.4	ug/L
199-H5-1A	IRON	17-AUG-93	Y		15.5	ug/L
199-H5-1A	IRON	18-FEB-93	N		173	ug/L
199-H5-1A	IRON	01-NOV-92	N		91.2	ug/L
199-H5-1A	IRON	01-AUG-92	Y		20.3	ug/L
199-H5-1A	IRON	18-MAY-92	N		2070	ug/L
199-H5-1A	IRON	01-AUG-92	N		33.2	ug/L

Ground-Water Chemistry Data for Well 199-H5-1A

Well Name	Constituent	Sample Date	Filtered	Qualifier	Value	Units
199-H5-1A	ISOPHORONE	18-MAY-92	N	U	10	ug/L
199-H5-1A	ISOPHORONE	01-NOV-92	N	U	10	ug/L
199-H5-1A	ISOPHORONE	01-AUG-92	N	U	10	ug/L
199-H5-1A	K-40	18-MAY-92	N	UJ	250	pCi/L
199-H5-1A	K-40	01-NOV-92	N	U	300	pCi/L
199-H5-1A	K-40	01-AUG-92	N	U	160	pCi/L
199-H5-1A	LEAD	18-MAY-92	Y		1	ug/L
199-H5-1A	LEAD	18-FEB-93	Y	W	1.2	ug/L
199-H5-1A	LEAD	01-NOV-92	Y		2	ug/L
199-H5-1A	LEAD	17-AUG-93	Y		3.4	ug/L
199-H5-1A	LEAD	18-MAY-92	N		5.1	ug/L
199-H5-1A	LEAD	01-AUG-92	N		6.9	ug/L
199-H5-1A	LEAD	01-AUG-92	Y		2.3	ug/L
199-H5-1A	LEAD	18-FEB-93	N		1.8	ug/L
199-H5-1A	LEAD	01-NOV-92	N	*	2.9	ug/L
199-H5-1A	LPHENOL	18-MAY-92	N	U	10	ug/L
199-H5-1A	LPHENOL	01-AUG-92	N	U	10	ug/L
199-H5-1A	LPHENOL	01-NOV-92	N	U	10	ug/L
199-H5-1A	M-XYLE	01-AUG-92	N	U	10	ug/L
199-H5-1A	M-XYLE	01-NOV-92	N	U	10	ug/L
199-H5-1A	M-XYLE	01-AUG-92	N	U	10	ug/L
199-H5-1A	M-XYLE	18-MAY-92	N	U	10	ug/L
199-H5-1A	M-XYLE	18-MAY-92	N	U	10	ug/L
199-H5-1A	MAGNESIUM	18-MAY-92	Y		15800	ug/L
199-H5-1A	MAGNESIUM	01-NOV-92	N	E	16600	ug/L
199-H5-1A	MAGNESIUM	18-FEB-93	N		16700	ug/L
199-H5-1A	MAGNESIUM	18-FEB-93	Y		16200	ug/L
199-H5-1A	MAGNESIUM	01-NOV-92	Y		15900	ug/L
199-H5-1A	MAGNESIUM	17-AUG-93	Y		18900	ug/L
199-H5-1A	MAGNESIUM	01-AUG-92	Y		16000	ug/L
199-H5-1A	MAGNESIUM	18-MAY-92	N		15900	ug/L
199-H5-1A	MAGNESIUM	01-AUG-92	N		16300	ug/L
199-H5-1A	MANGANESE	18-MAY-92	Y		175	ug/L
199-H5-1A	MANGANESE	18-MAY-92	N		206	ug/L
199-H5-1A	MANGANESE	01-AUG-92	N		56.2	ug/L
199-H5-1A	MANGANESE	01-NOV-92	N		18	ug/L
199-H5-1A	MANGANESE	17-AUG-93	Y		1.6	ug/L
199-H5-1A	MANGANESE	18-FEB-93	Y		9.1	ug/L
199-H5-1A	MANGANESE	01-NOV-92	Y		20	ug/L
199-H5-1A	MANGANESE	18-FEB-93	N		18.3	ug/L
199-H5-1A	MANGANESE	01-AUG-92	Y		53	ug/L
199-H5-1A	MERCURY	18-MAY-92	Y		0.2	ug/L
199-H5-1A	MERCURY	01-NOV-92	N		0.1	ug/L
199-H5-1A	MERCURY	17-AUG-93	Y		0.2	ug/L
199-H5-1A	MERCURY	18-FEB-93	N		0.1	ug/L
199-H5-1A	MERCURY	16-JUN-94	N	U		ug/L
199-H5-1A	MERCURY	18-FEB-93	Y		0.1	ug/L
199-H5-1A	MERCURY	01-NOV-92	Y		0.1	ug/L
199-H5-1A	MERCURY	01-AUG-92	Y		0.2	ug/L
199-H5-1A	MERCURY	18-MAY-92	N		0.2	ug/L
199-H5-1A	MERCURY	01-AUG-92	N		0.2	ug/L
199-H5-1A	METHBRO	01-AUG-92	N	U	10	ug/L
199-H5-1A	METHBRO	18-MAY-92	N	U	10	ug/L

Ground-Water Chemistry Data for Well 199-H5-1A

Well Name	Constituent	Sample Date	Filtered	Qualifier	Value	Units
199-H5-1A	METHBRO	01-NOV-92	N	U	10	ug/L
199-H5-1A	METHBRO	18-MAY-92	N	U	10	ug/L
199-H5-1A	METHBRO	01-AUG-92	N	U	10	ug/L
199-H5-1A	METHCHL	01-AUG-92	N	U	10	ug/L
199-H5-1A	METHCHL	18-MAY-92	N	U	10	ug/L
199-H5-1A	METHCHL	18-MAY-92	N	U	10	ug/L
199-H5-1A	METHCHL	01-AUG-92	N	U	10	ug/L
199-H5-1A	METHCHL	01-NOV-92	N	U	10	ug/L
199-H5-1A	METHLOR	18-MAY-92	N	U	0.5	ug/L
199-H5-1A	METHLOR	01-AUG-92	N	UJ	0.5	ug/L
199-H5-1A	METHLOR	01-NOV-92	N	U	0.5	ug/L
199-H5-1A	METHONE	01-AUG-92	N	U	10	ug/L
199-H5-1A	METHONE	18-MAY-92	N	U	10	ug/L
199-H5-1A	METHONE	01-AUG-92	N	U	10	ug/L
199-H5-1A	METHONE	18-MAY-92	N	U	10	ug/L
199-H5-1A	METHONE	01-NOV-92	N	U	10	ug/L
199-H5-1A	METHYCH	01-AUG-92	N	U	10	ug/L
199-H5-1A	METHYCH	18-MAY-92	N	U	10	ug/L
199-H5-1A	METHYCH	01-NOV-92	N	J	4	ug/L
199-H5-1A	METHYCH	18-MAY-92	N	BJ	3	ug/L
199-H5-1A	METHYCH	01-AUG-92	N	U	10	ug/L
199-H5-1A	NAPHTHA	18-MAY-92	N	U	10	ug/L
199-H5-1A	NAPHTHA	01-AUG-92	N	U	10	ug/L
199-H5-1A	NAPHTHA	01-NOV-92	N	U	10	ug/L
199-H5-1A	NICKEL	18-MAY-92	Y		9.3	ug/L
199-H5-1A	NICKEL	18-MAY-92	N		56.1	ug/L
199-H5-1A	NICKEL	01-AUG-92	Y		3.9	ug/L
199-H5-1A	NICKEL	18-FEB-93	N		14.3	ug/L
199-H5-1A	NICKEL	01-NOV-92	Y		2.6	ug/L
199-H5-1A	NICKEL	18-FEB-93	Y		5.4	ug/L
199-H5-1A	NICKEL	17-AUG-93	Y		4.7	ug/L
199-H5-1A	NICKEL	01-NOV-92	N		5.9	ug/L
199-H5-1A	NICKEL	01-AUG-92	N		6	ug/L
199-H5-1A	NITBENZ	18-MAY-92	N	U	10	ug/L
199-H5-1A	NITBENZ	01-AUG-92	N	U	10	ug/L
199-H5-1A	NITBENZ	01-NOV-92	N	U	10	ug/L
199-H5-1A	NITPHENOL	18-MAY-92	N	U	25	ug/L
199-H5-1A	NITPHENOL	01-AUG-92	N	U	25	ug/L
199-H5-1A	NITPHENOL	01-NOV-92	N	U	25	ug/L
199-H5-1A	NITRANILIN	18-MAY-92	N	U	25	ug/L
199-H5-1A	NITRANILIN	01-AUG-92	N	U	25	ug/L
199-H5-1A	NITRANILIN	01-NOV-92	N	U	25	ug/L
199-H5-1A	NITRATE	18-MAY-92	N		8.4	mg/L
199-H5-1A	NITRITE	18-MAY-92	N	U	0.1	mg/L
199-H5-1A	NNDIPHA	18-MAY-92	N	U	10	ug/L
199-H5-1A	NNDIPHA	01-AUG-92	N	U	10	ug/L
199-H5-1A	NNDIPHA	01-NOV-92	N	U	10	ug/L
199-H5-1A	NO2+NO3	01-AUG-92	N	J	6.32	mgN/L
199-H5-1A	NO2+NO3	01-NOV-92	N		4.82	mg/L
199-H5-1A	NO2+NO3	18-FEB-93	N		6.89	mg/L
199-H5-1A	NO2+NO3	17-AUG-93	N		5.68	mg/L
199-H5-1A	NO2-N	17-AUG-93	N	R	0.1	mg/L
199-H5-1A	NO3-N	17-AUG-93	N	R	6.4	mg/L

Ground-Water Chemistry Data for Well 199-H5-1A

Well Name	Constituent	Sample Date	Filtered	Qualifier	Value	Units
199-H5-1A	PENTCHP	18-MAY-92	N	U	25	ug/L
199-H5-1A	PENTCHP	01-AUG-92	N	U	25	ug/L
199-H5-1A	PENTCHP	01-NOV-92	N	U	25	ug/L
199-H5-1A	PERCENE	01-AUG-92	N	U	10	ug/L
199-H5-1A	PERCENE	18-MAY-92	N	U	10	ug/L
199-H5-1A	PERCENE	01-NOV-92	N	U	10	ug/L
199-H5-1A	PERCENE	18-MAY-92	N	U	10	ug/L
199-H5-1A	PERCENE	01-AUG-92	N	U	10	ug/L
199-H5-1A	PH	18-MAY-92	N		8.2	pH
199-H5-1A	PH	01-AUG-92	N	R	7.8	pH
199-H5-1A	PH	01-NOV-92	N		7.7	pH
199-H5-1A	PH	18-FEB-93	N		7.86	pH
199-H5-1A	PH	06-APR-94	N		7.53	pH
199-H5-1A	PHENANT	18-MAY-92	N	U	10	ug/L
199-H5-1A	PHENANT	01-AUG-92	N	U	10	ug/L
199-H5-1A	PHENANT	01-NOV-92	N	U	10	ug/L
199-H5-1A	PHFIELD	18-MAY-92	N		7.61	pH
199-H5-1A	PHFIELD	01-AUG-92	N		7.69	pH
199-H5-1A	PHFIELD	01-AUG-92	N		7.69	pH
199-H5-1A	PHFIELD	01-AUG-92	N		7.69	pH
199-H5-1A	PHFIELD	01-AUG-92	N		7.69	pH
199-H5-1A	PHFIELD	01-NOV-92	N		7.6	pH
199-H5-1A	PHFIELD	18-FEB-93	N		8.19	pH
199-H5-1A	PHFIELD	01-AUG-92	Y		7.69	pH
199-H5-1A	PHFIELD	18-FEB-93	Y		8.19	pH
199-H5-1A	PHFIELD	18-MAY-92	Y		7.61	pH
199-H5-1A	PHFIELD	01-NOV-92	Y		7.6	pH
199-H5-1A	PHFIELD	01-NOV-92	N		7.6	pH
199-H5-1A	PHFIELD	01-NOV-92	N		7.6	pH
199-H5-1A	PHOSPHATE	18-MAY-92	N	U	0.4	mg/L
199-H5-1A	PHOSPHATE	17-AUG-93	N	R	0.4	mg/L
199-H5-1A	PHOSPHATE	01-NOV-92	N	U	0.4	mg/L
199-H5-1A	PHOSPHATE	01-AUG-92	N	R	0.4	mg/L
199-H5-1A	POTASSIUM	18-MAY-92	Y		6550	ug/L
199-H5-1A	POTASSIUM	01-AUG-92	Y		6250	ug/L
199-H5-1A	POTASSIUM	01-NOV-92	N		6480	ug/L
199-H5-1A	POTASSIUM	01-AUG-92	N		6360	ug/L
199-H5-1A	POTASSIUM	18-MAY-92	N		6510	ug/L
199-H5-1A	POTASSIUM	18-FEB-93	N		6430	ug/L
199-H5-1A	POTASSIUM	18-FEB-93	Y		6250	ug/L
199-H5-1A	POTASSIUM	01-NOV-92	Y		6170	ug/L
199-H5-1A	POTASSIUM	17-AUG-93	Y		6960	ug/L
199-H5-1A	PU-238	18-MAY-92	N	UJ	0.01	pCi/L
199-H5-1A	PU-238	01-AUG-92	N	U	0.01	pCi/L
199-H5-1A	PU-238	01-NOV-92	N	U	-0.01	pCi/L
199-H5-1A	PU39-40	18-MAY-92	N	UJ	-0.01	pCi/L
199-H5-1A	PU39-40	01-AUG-92	N	U	0	pCi/L
199-H5-1A	PU39-40	01-NOV-92	N	U	0.01	pCi/L
199-H5-1A	PYRENE	18-MAY-92	N	U	10	ug/L
199-H5-1A	PYRENE	01-NOV-92	N	U	10	ug/L
199-H5-1A	PYRENE	01-AUG-92	N	U	10	ug/L
199-H5-1A	RA-226	18-MAY-92	N	UJ	26	pCi/L
199-H5-1A	RA-226	01-NOV-92	N	U	30	pCi/L

Ground-Water Chemistry Data for Well 199-H5-1A

Well Name	Constituent	Sample Date	Filtered	Qualifier	Value	Units
199-H5-1A	RA-226	01-AUG-92	N	U	35	pCi/L
199-H5-1A	RU-106	01-AUG-92	N	U	100	pCi/L
199-H5-1A	RU-106	01-NOV-92	N	U	100	pCi/L
199-H5-1A	SELENIUM	18-MAY-92	Y		4	ug/L
199-H5-1A	SELENIUM	01-AUG-92	N	WN	2.8	ug/L
199-H5-1A	SELENIUM	01-NOV-92	N	WN	19	ug/L
199-H5-1A	SELENIUM	17-AUG-93	Y		3.4	ug/L
199-H5-1A	SELENIUM	18-FEB-93	N	WN	3.8	ug/L
199-H5-1A	SELENIUM	18-FEB-93	Y	WN	3.1	ug/L
199-H5-1A	SELENIUM	01-NOV-92	Y	WN	3.6	ug/L
199-H5-1A	SELENIUM	01-AUG-92	Y		3.7	ug/L
199-H5-1A	SELENIUM	18-MAY-92	N		4	ug/L
199-H5-1A	SILVER	18-MAY-92	Y		2	ug/L
199-H5-1A	SILVER	01-AUG-92	Y		4.8	ug/L
199-H5-1A	SILVER	18-FEB-93	N		3.9	ug/L
199-H5-1A	SILVER	18-FEB-93	Y		4.6	ug/L
199-H5-1A	SILVER	01-NOV-92	Y		3.6	ug/L
199-H5-1A	SILVER	17-AUG-93	Y	N	5	ug/L
199-H5-1A	SILVER	01-NOV-92	N		2.5	ug/L
199-H5-1A	SILVER	01-AUG-92	N		2.3	ug/L
199-H5-1A	SILVER	18-MAY-92	N		2	ug/L
199-H5-1A	SODIUM	18-MAY-92	Y		27600	ug/L
199-H5-1A	SODIUM	01-AUG-92	N		26200	ug/L
199-H5-1A	SODIUM	18-MAY-92	N		27000	ug/L
199-H5-1A	SODIUM	01-AUG-92	Y		25500	ug/L
199-H5-1A	SODIUM	18-FEB-93	N		26900	ug/L
199-H5-1A	SODIUM	01-NOV-92	Y		26100	ug/L
199-H5-1A	SODIUM	18-FEB-93	Y		26800	ug/L
199-H5-1A	SODIUM	17-AUG-93	Y		55900	ug/L
199-H5-1A	SODIUM	01-NOV-92	N		27300	ug/L
199-H5-1A	SR-90	18-MAY-92	N	UJ	0.5	pCi/L
199-H5-1A	SR-90	01-AUG-92	N	U	-0.16	pCi/L
199-H5-1A	SR-90	18-FEB-93	N	UJ	-0.01	pCi/L
199-H5-1A	SR-90	17-AUG-93	N	R	0.1	pCi/L
199-H5-1A	SR-90	01-NOV-92	N	R	1.4	pCi/L
199-H5-1A	STYRENE	01-AUG-92	N	U	10	ug/L
199-H5-1A	STYRENE	01-AUG-92	N	U	10	ug/L
199-H5-1A	STYRENE	18-MAY-92	N	U	10	ug/L
199-H5-1A	STYRENE	18-MAY-92	N	U	10	ug/L
199-H5-1A	STYRENE	01-NOV-92	N	U	10	ug/L
199-H5-1A	SULFATE	01-AUG-92	N		68	mg/L
199-H5-1A	SULFATE	01-NOV-92	N		68	mg/L
199-H5-1A	SULFATE	18-MAY-92	N		88	mg/L
199-H5-1A	SULFATE	17-AUG-93	N		66	mg/L
199-H5-1A	SULFIDE	17-AUG-93	N	U	1	mg/L
199-H5-1A	SULFIDE	01-AUG-92	N	R	1	mg/L
199-H5-1A	SULFIDE	01-NOV-92	N	U	1	mg/L
199-H5-1A	TC-99	18-MAY-92	N	UJ	0.14	pCi/L
199-H5-1A	TC-99	01-AUG-92	N	U	3.4	pCi/L
199-H5-1A	TC-99	01-NOV-92	N	U	0.3	pCi/L
199-H5-1A	TDS	01-AUG-92	N		375	mg/L
199-H5-1A	TDS	01-NOV-92	N		356	mg/L
199-H5-1A	TEMPERATUR	06-APR-94	N		17.2	Deg C

Ground-Water Chemistry Data for Well 199-H5-1A

Well Name	Constituent	Sample Date	Filtered	Qualifier	Value	Units
199-H5-1A	TH-228	18-MAY-92	N	UJ	24	pCi/L
199-H5-1A	TH-228	01-AUG-92	N	U	23	pCi/L
199-H5-1A	TH-228	01-NOV-92	N	U	20	pCi/L
199-H5-1A	TH-232	18-MAY-92	N	UJ	67	pCi/L
199-H5-1A	TH-232	01-AUG-92	N	U	55	pCi/L
199-H5-1A	TH-232	01-NOV-92	N	U	60	pCi/L
199-H5-1A	THALLIUM	18-MAY-92	Y		1	ug/L
199-H5-1A	THALLIUM	01-AUG-92	Y	WN	0.9	ug/L
199-H5-1A	THALLIUM	01-NOV-92	N	WN	1.3	ug/L
199-H5-1A	THALLIUM	01-AUG-92	N	WN	1.3	ug/L
199-H5-1A	THALLIUM	18-MAY-92	N		4	ug/L
199-H5-1A	THALLIUM	18-FEB-93	N	WN	1.9	ug/L
199-H5-1A	THALLIUM	01-NOV-92	Y		3.8	ug/L
199-H5-1A	THALLIUM	17-AUG-93	Y		1.1	ug/L
199-H5-1A	THALLIUM	18-FEB-93	Y	W	2.6	ug/L
199-H5-1A	TOC	01-AUG-92	N		1.2	mg/L
199-H5-1A	TOC	01-NOV-92	N		2.8	mg/L
199-H5-1A	TOLUENE	18-MAY-92	N	BJ	28	ug/L
199-H5-1A	TOLUENE	01-AUG-92	N	U	10	ug/L
199-H5-1A	TOLUENE	18-MAY-92	N	U	10	ug/L
199-H5-1A	TOLUENE	18-MAY-92	N	U	10	ug/L
199-H5-1A	TOLUENE	01-AUG-92	N	U	10	ug/L
199-H5-1A	TOLUENE	01-NOV-92	N	U	10	ug/L
199-H5-1A	TOX	01-AUG-92	N	R	35.8	ug/L
199-H5-1A	TOX	01-NOV-92	N		45	ug/L
199-H5-1A	TOXAPHENE	18-MAY-92	N	U	5	ug/L
199-H5-1A	TOXAPHENE	01-AUG-92	N	U	5	ug/L
199-H5-1A	TOXAPHENE	01-NOV-92	N	U	5	ug/L
199-H5-1A	TRANS13	01-AUG-92	N	U	10	ug/L
199-H5-1A	TRANS13	01-AUG-92	N	U	10	ug/L
199-H5-1A	TRANS13	18-MAY-92	N	U	10	ug/L
199-H5-1A	TRANS13	01-NOV-92	N	U	10	ug/L
199-H5-1A	TRANS13	18-MAY-92	N	U	10	ug/L
199-H5-1A	TRICELN	01-AUG-92	N	U	10	ug/L
199-H5-1A	TRICELN	18-MAY-92	N	U	10	ug/L
199-H5-1A	TRICELN	01-NOV-92	N	U	10	ug/L
199-H5-1A	TRICELN	18-MAY-92	N	U	10	ug/L
199-H5-1A	TRICELN	01-AUG-92	N	U	10	ug/L
199-H5-1A	TRICHLB	18-MAY-92	N	U	10	ug/L
199-H5-1A	TRICHLB	01-AUG-92	N	U	10	ug/L
199-H5-1A	TRICHLB	01-NOV-92	N	U	10	ug/L
199-H5-1A	TRITIUM	18-MAY-92	N	J	9900	pCi/L
199-H5-1A	TRITIUM	01-AUG-92	N		9300	pCi/L
199-H5-1A	TRITIUM	01-NOV-92	N		9100	pCi/L
199-H5-1A	TRITIUM	18-FEB-93	N		9300	pCi/L
199-H5-1A	TRITIUM	17-AUG-93	N	R	7500	pCi/L
199-H5-1A	TRITIUM	06-APR-94	N		7880	pCi/L
199-H5-1A	U-233/4	18-MAY-92	N	J	1.8	pCi/L
199-H5-1A	U-233/4	01-AUG-92	N		2	pCi/L
199-H5-1A	U-233/4	01-NOV-92	N		1.9	pCi/L
199-H5-1A	U-235	18-MAY-92	N	J	0.13	pCi/L
199-H5-1A	U-235	01-NOV-92	N	U	0.08	pCi/L
199-H5-1A	U-235	01-AUG-92	N	U	0.08	pCi/L

Ground-Water Chemistry Data for Well 199-H5-1A

Well Name	Constituent	Sample Date	Filtered	Qualifier	Value	Units
199-H5-1A	U-238	18-MAY-92	N	J	1.6	pCi/L
199-H5-1A	U-238	01-AUG-92	N		1.6	pCi/L
199-H5-1A	U-238	01-NOV-92	N		2.2	pCi/L
199-H5-1A	URANIUM	06-APR-94	N		7.15	ug/L
199-H5-1A	VANADIUM	18-MAY-92	Y		2	ug/L
199-H5-1A	VANADIUM	01-AUG-92	N		4.6	ug/L
199-H5-1A	VANADIUM	01-NOV-92	N		6.7	ug/L
199-H5-1A	VANADIUM	17-AUG-93	Y		17.2	ug/L
199-H5-1A	VANADIUM	18-FEB-93	Y		4.9	ug/L
199-H5-1A	VANADIUM	01-NOV-92	Y		2.5	ug/L
199-H5-1A	VANADIUM	18-FEB-93	N		5.2	ug/L
199-H5-1A	VANADIUM	01-AUG-92	Y		4.2	ug/L
199-H5-1A	VANADIUM	18-MAY-92	N		6.8	ug/L
199-H5-1A	VINYIDE	01-AUG-92	N	U	10	ug/L
199-H5-1A	VINYIDE	18-MAY-92	N	U	10	ug/L
199-H5-1A	VINYIDE	01-NOV-92	N	U	10	ug/L
199-H5-1A	VINYIDE	18-MAY-92	N	U	10	ug/L
199-H5-1A	VINYIDE	01-AUG-92	N	U	10	ug/L
199-H5-1A	ZINC	18-MAY-92	Y		123	ug/L
199-H5-1A	ZINC	18-FEB-93	Y		97.7	ug/L
199-H5-1A	ZINC	01-NOV-92	Y		98.8	ug/L
199-H5-1A	ZINC	17-AUG-93	Y		3.7	ug/L
199-H5-1A	ZINC	18-FEB-93	N		184	ug/L
199-H5-1A	ZINC	01-AUG-92	N		137	ug/L
199-H5-1A	ZINC	01-AUG-92	Y		51.9	ug/L
199-H5-1A	ZINC	18-MAY-92	N		684	ug/L
199-H5-1A	ZINC	01-NOV-92	N		195	ug/L
199-H5-1A	ZN-65	18-MAY-92	N	UJ	33	pCi/L
199-H5-1A	ZN-65	01-AUG-92	N	U	30	pCi/L
199-H5-1A	ZN-65	01-NOV-92	N	U	40	pCi/L

Qualifier Abbreviations:
U = less than detection limit
J = estimated value
R = data are unusable
X = see the hardcopy data package for specific notes
E = calibration range exceeded
B = blank contamination
W = post-digestion spike for furnace AA analysis out of control limits
N = spiked sample recovery not within control limits

Dissolved Oxygen Data for Hanford Site Wells

Well Name	Constituent	Sample Date	Filtered	Qualifier	Value	Units
199-B5-1	DISS O2	03-JUN-87	N		7.74	ppm
199-B5-1	DISS O2	03-JUN-87	N		7.75	ppm
199-B5-1	DISS O2	03-JUN-87	N		7.44	ppm
199-B5-1	DISS O2	03-JUN-87	N		7.78	ppm
299-E25-7	DISS O2	17-JUN-87	N		8.71	ppm
299-E25-7	DISS O2	17-JUN-87	N		8.75	ppm
299-E25-7	DISS O2	17-JUN-87	N		8.82	ppm
299-E25-7	DISS O2	17-JUN-87	N		8.85	ppm
299-E26-1	DISS O2	16-JUN-87	N		5.5	ppm
299-E26-1	DISS O2	16-JUN-87	N		0.67	ppm
299-E26-1	DISS O2	16-JUN-87	N		1.32	ppm
299-E26-1	DISS O2	16-JUN-87	N		0.47	ppm
299-E26-3	DISS O2	16-JUN-87	N		8.83	ppm
299-E26-3	DISS O2	16-JUN-87	N		8.85	ppm
299-E26-3	DISS O2	16-JUN-87	N		8.84	ppm
299-E26-3	DISS O2	16-JUN-87	N		8.88	ppm
299-E28-17	DISS O2	23-JUN-87	N		7.52	ppm
299-E28-17	DISS O2	23-JUN-87	N		7.57	ppm
299-E28-17	DISS O2	23-JUN-87	N		7.51	ppm
299-E28-17	DISS O2	23-JUN-87	N		7.58	ppm
299-E28-7	DISS O2	22-JUN-87	N		8.23	ppm
299-E28-7	DISS O2	22-JUN-87	N		8.23	ppm
299-E28-7	DISS O2	22-JUN-87	N		8.23	ppm
299-E28-7	DISS O2	22-JUN-87	N		8.25	ppm
299-E33-2	DISS O2	23-JUN-87	N		7.95	ppm
299-E33-2	DISS O2	23-JUN-87	N		7.81	ppm
299-E33-2	DISS O2	23-JUN-87	N		7.81	ppm
299-E33-2	DISS O2	23-JUN-87	N		7.95	ppm
299-W12-1	DISS O2	04-JUN-87	N		9.19	ppm
299-W12-1	DISS O2	04-JUN-87	N		9.37	ppm
299-W12-1	DISS O2	04-JUN-87	N		9.45	ppm
299-W12-1	DISS O2	04-JUN-87	N		9.3	ppm
299-W19-1	DISS O2	10-JUN-87	N		6.42	ppm
299-W19-1	DISS O2	10-JUN-87	N		5.44	ppm
299-W19-1	DISS O2	10-JUN-87	N		6.65	ppm
299-W19-1	DISS O2	10-JUN-87	N		6.4	ppm
299-W23-1	DISS O2	09-JUN-87	N		6.31	ppm
299-W23-1	DISS O2	09-JUN-87	N		5.78	ppm
299-W23-1	DISS O2	09-JUN-87	N		5.32	ppm
299-W23-1	DISS O2	09-JUN-87	N		6.11	ppm
299-W23-11	DISS O2	04-JUN-87	N		7.42	ppm
299-W23-11	DISS O2	04-JUN-87	N		7.42	ppm
299-W23-11	DISS O2	04-JUN-87	N		7.41	ppm
299-W23-11	DISS O2	04-JUN-87	N		7.38	ppm
299-W23-7	DISS O2	09-JUN-86	N		6.86	ppm
299-W23-7	DISS O2	09-JUN-86	N		6.67	ppm
299-W23-7	DISS O2	09-JUN-86	N		7.15	ppm
299-W23-7	DISS O2	09-JUN-86	N		6.7	ppm
299-W6-1	DISS O2	10-JUN-87	N		10.01	ppm
299-W6-1	DISS O2	10-JUN-87	N		8.25	ppm
299-W6-1	DISS O2	10-JUN-87	N		9.92	ppm
299-W6-1	DISS O2	10-JUN-87	N		8.95	ppm

Appendix D

Hydraulic Test Analyses

Appendix D

Hydraulic Test Analyses

D.1 Introduction

This appendix provides a detailed description of hydrologic testing activities at the ISRM test site and analytical techniques used to analyze the test response data.

D.2 Slug Displacement Testing

Single-well slug tests were conducted during well installation to assess the vertical distribution of horizontal hydraulic conductivity. Tests were conducted as the borehole was advanced; generally the upper 1.5 m (5 ft) and the lower 1.5 m (5 ft) of the aquifer was tested. Test intervals were screened by drilling and driving temporary casing to the desired depth, installing a temporary telescoping screen, and pulling back the temporary casing to expose the desired test interval. The slug stress was applied by instantaneously withdrawing a slug of known volume from the test interval. The resulting pressure response was monitored using Keller Series 173 pressure transducers. Early-time test response was monitored with a sampling interval of 0.5 sec to adequately describe the instantaneous pressure change initiated at the beginning of the test.

D.2.1 Analytical Methods

Slug tests conducted in unconfined aquifers are commonly analyzed using the Bouwer and Rice (1976) method. The method is relatively easy to use and can be applied to analyze slug tests conducted in wells that partially penetrate the aquifer. Recently, however, articles (e.g., Hyder and Butler 1995) have indicated that unconfined aquifer slug tests may be susceptible to considerable analytical error (e.g., by 30%, to an order of magnitude) when the analysis method described in Bouwer and Rice (1976) and Bouwer (1989) is used. This is attributed to the assumptions of inelasticity, isotropy, and semi-empirical basis of the Bouwer and Rice (1976) method. Because of these limiting analytical assumptions, the analytical methods described in Spane (1994) and Hyder and Butler (1995) are considered to be more appropriate for the analysis of unconfined aquifer slug tests.

The type-curve method described in Spane (1994) was used for the analysis of slug tests conducted at the ISRM test site. The type-curve method, which was presented in Spane (1994) for the analysis of slug interference response, is based on the relationship that slug tests can be represented as a specialized form of constant-rate pumping tests. A detailed description of the slug and constant-rate analytical solution derivations is not presented in this section. However, a brief discussion of the analytical basis is taken from Spane (1994). The general relationship between the slug test (H_D) and constant-rate pumping test (p_D) solutions is shown by Peres (1989) and Peres et al. (1989) to be

$$H_D(t_D, r_D, C_D) = C_D \frac{\partial P_D}{\partial t_D}(t_D, r_D, C_D) \tag{1}$$

where the dimensionless parameters for head (H_D), time (t_D), distance (r_D), wellbore storage constant (C_D), and pressure (P_D) are defined

$$H_D = \frac{H}{H_o} \tag{2}$$

$$t_D = \frac{Tt}{r_w^2 S} \tag{3}$$

$$r_D = \frac{r}{r_w} = 1 \tag{4}$$

$$C_D = \frac{r_c^2}{2r_w^2 S} \tag{5}$$

$$P_D = \frac{2\pi T}{Q} \Delta H \tag{6}$$

where

- H = observed head at time, t, minus pretest static head level in well [L].
- H_o = instantaneous head change applied to stress well at the start of the slug test [L].
- T = transmissivity [L^2/T].
- t = test time [T].
- S = aquifer storativity [dimensionless].
- Q = pumping discharge rate [L^3/T].
- r = distance to point of observation; for single-well tests, $r = r_w$ [L].
- r_w = effective stress well radius [L].
- r_c = stress well casing radius [L].

Equation (1) indicates that the slug test wellbore solution, H_D, can be obtained directly from the time derivative of the constant-rate wellbore storage solution, p_D. Although equation (1) was developed for conditions of fully penetrating wells in confined aquifers, Peres (1989) and Peres et al. (1989) show that through the use of Duhamel's principle, equation (1) is also valid for any aquifer/ well system, for any position within the aquifer, and does not require radial flow conditions.

The general procedure for developing unconfined aquifer slug interference test type curves relies on converting constant-rate pumping type curves for the given test well configuration and aquifer conditions. Neuman (1975) provides type curves for the analysis of anisotropic unconfined aquifer constant-rate pumping tests. The type curves are based on the line-source solution presented earlier in Neuman (1972, 1974). Available software programs can also be used to develop Neuman unconfined aquifer type curves for specific test site and aquifer conditions (e.g., Dawson and Istok 1991; Moench 1993). To account for the effects of pumping wellbore storage, type curves based on the line-source solution are adjusted using the analytical method described by Boulton and Streltsova (1976) or Fenske (1977). The dimensionless drawdown derivative (s_D') with respect to dimensionless times are then calculated for the wellbore storage type curve using the method described in Spane and Wurstner (1993).

The dimensionless slug test head response, H_D, is then calculated by dividing s_D' for the respective pumping test type curves by the associated dimensionless time parameter group, $2(t_D/C_D)$, as indicated in Spane (1994). Of particular importance is the fact that the calculated slug interference response does not require a pumping rate for the conversion of constant-rate discharge type curves. Dimensional observation well head values, H, can be determined directly from the relationship presented in equation (2) and the known stress level, H_o, applied at the well to initiate the slug test.

Individual slug test data plots (i.e., H_D versus time) were matched with calculated dimensionless unconfined aquifer slug test type curves (H_D versus t_D/C_D), following the same procedure originally used for confined aquifer type-curve analysis as presented in Cooper et al. (1967). For comparison purposes with parameters presented in Cooper et al. (1967), $t_D/C_D = 2$ Beta and $C_D = 1/(2$ Alpha). Based on the type-curve time and curve match, transmissivity and storativity can be calculated. For partially penetrating unconfined aquifer wells, storativity exerts little influence on the calculated type-curve shape or time position; therefore, the analysis is relatively insensitive to this parameter determination. For the ISRM site slug test analyses, a storativity value of 0.0001 was used in the type-curve generation.

Vertical anisotropy, K_v/K_h, also exerts little influence on the shape of calculated slug test type curve response within partially penetrating unconfined aquifer wells. Time position shifts, however, up to a factor of 3 can be produced for vertical anisotropy values ranging between 0.01 and 1.0. Therefore, uncertainty in knowing the vertical anisotropy causes an equal uncertainty in the calculated transmissivity, which is based on the type-curve time match. To minimize this error an anisotropy value of 0.1, which falls within the middle of the cited anisotropy range, was used.

To facilitate slug test analysis, the simultaneous slug test type curve and slug test type-curve derivative (H_D') matching method, as described in Spane and Wurstner (1993), was also used. The simultaneous slug test type curve and derivative matching method reduces the ambiguity of the type-curve selection process.

D.2.2 Slug Test Analyses

The following sections contain a description of testing activities for each of the slug tests conducted at the ISRM field test site. Analytical techniques have been referenced in the previous section in the event a more detailed description of the analytical methods are required.

D.2.2.1 Upper Test Interval of 199-H5-2

On January 25, 1995, two slug withdrawal tests were conducted over the upper test interval of the injection/withdrawal well 199-H5-2 from 41.1 to 44.5 ft below ground surface. Both slug withdrawal tests resulted in a similar pressure response so only one of the two data sets was selected for analysis. The temporary test completion consisted of a 6-in. nominal (6.75-in. outside diameter [OD]) 10-slot telescoping screen placed inside a 10.25-in. inside diameter (ID) temporary casing. The temporary casing was pulled back 5.5 ft allowing the formation to collapse on the screen. The instantaneous water-level change took place within the screened interval.

The slug withdrawal test was conducted by withdrawing a 4-in. diameter slug submerged approximately 3 ft, resulting in a stress level of 0.78 ft. Combined type-curve and derivative analysis (Figure D.1) resulted in transmissivity and equivalent hydraulic conductivity estimates of (1100 ft^2/d and 120 ft/d, respectively.)

D.2.2.2 Lower Test Interval of 199-H5-2

On February 1, 1995, two slug withdrawal tests were conducted over the lower test interval of the injection/withdrawal well 199-H5-2 from 45.0 to 50.0 ft below ground surface. Both slug withdrawal tests resulted in a similar pressure response so only one of the two data sets was selected for analysis. The temporary test completion consisted of a 6-in. nominal (6.75-in. OD) 10-slot telescoping screen placed inside a 10.25-in. ID temporary casing. The temporary casing was pulled back 5.0 ft allowing the formation to collapse on the screen. The instantaneous water-level change took place within the temporary casing.

The slug withdrawal test was conducted by withdrawing a 4-in. diameter slug submerged approximately 3 ft, resulting in a stress level of 0.39 ft. Combined type-curve and derivative analysis (Figure D.2) resulted in transmissivity and equivalent hydraulic conductivity estimates of (1100 ft^2/d and 120 ft/d, respectively.)

D.2.2.3 Upper Test Interval of 199-H5-3P

On February 7, 1995, two slug withdrawal tests were conducted over the upper test interval of monitoring well 199-H5-3P from 42.0 to 46.9 ft below ground surface. Both slug withdrawal tests resulted in a similar pressure response so only one of the two data sets was selected for analysis. The temporary test completion consisted of a 3-in. nominal (3.75-in OD) 10-slot telescoping screen placed inside a 5.75-in. ID temporary casing. The temporary casing was pulled back 4.9 ft allowing the formation to collapse on the screen. The instantaneous water-level change took place within the temporary casing.

The slug withdrawal test was conducted by withdrawing a 2-in. diameter slug submerged approximately 4 ft, resulting in a stress level of 0.78 ft. Combined type-curve and derivative analysis (Figure D.3) resulted in transmissivity and equivalent hydraulic conductivity estimates of (1200 ft^2/d and 130 ft/d, respectively.)

D.2.2.4 Lower Test Interval of 199-H5-3P

On February 7, 1995, two slug withdrawal tests were conducted over the lower test interval of monitoring well 199-H5-3P from 45.0 to 50.2 ft below ground surface. Both slug withdrawal tests resulted in a similar pressure response so only one of the two data sets was selected for analysis. The temporary test completion consisted of a 3-in. nominal (3.75-in. OD) 10-slot telescoping screen placed inside a 5.75-in. ID temporary casing. The temporary casing was pulled back 5.2 ft allowing the formation to collapse on the screen. The instantaneous water-level change took place within the temporary casing.

The slug withdrawal test was conducted by withdrawing a 2-in. diameter slug submerged approximately 3 ft, resulting in a stress level of 0.58 ft. Combined type-curve and derivative analysis (Figure D.4) resulted in transmissivity and equivalent hydraulic conductivity estimates of (540 ft^2/d and 59 ft/d, respectively.)

D.2.2.5 Upper Test Interval of 199-H5-4P

On February 9, 1995, two slug withdrawal tests were conducted over the upper test interval of monitoring well 199-H5-4P from 42.0 to 47.7 ft below ground surface. Both slug withdrawal tests resulted in a similar pressure response so only one of the two data sets was selected for analysis. The temporary test completion consisted of a 4-in. nominal (4.75-in. OD) 10-slot telescoping screen placed inside a 5.75-in. ID temporary casing. The temporary casing was pulled back 5.7 ft allowing the formation to collapse on the screen. The instantaneous water-level change took place within the temporary casing.

The slug withdrawal test was conducted by withdrawing a 3-in. diameter slug submerged approximately 4 ft, resulting in a stress level of 0.77 ft. Combined type-curve and derivative analysis (Figure D.5) resulted in transmissivity and equivalent hydraulic conductivity estimates of (1500 ft^2/d and 160 ft/d, respectively.)

D.2.2.6 Lower Test Interval of 199-H5-4P

On February 9, 1995, two slug withdrawal tests were conducted over the lower test interval of monitoring well 199-H5-4P from 45.0 to 49.8 ft below ground surface. Both slug withdrawal tests resulted in a similar pressure response so only one of the two data sets was selected for analysis. The temporary test completion consisted of a 4-in. nominal (4.75-in. OD) 10-slot telescoping screen placed inside a 5.75-in. ID temporary casing. The temporary casing was pulled back 4.8 ft allowing the formation to collapse on the screen. The instantaneous water-level change took place within the temporary casing.

The slug withdrawal test was conducted by withdrawing a 3-in. diameter slug submerged approximately 4 ft, resulting in a stress level of 0.70 ft. Combined type-curve and derivative analysis (Figure D.6) resulted in transmissivity and equivalent hydraulic conductivity estimates of (320 ft^2/d and 36 ft/d respectively.)

D.2.3 Conclusions

Table D.1 contains a summary of results from slug displacement tests conducted during well installation at the ISRM test site. Note that transmissivity estimates obtained from the analysis of single-well slug test data should be considered qualitative estimates. Ferris et al. (1962) state that:

> The duration of a slug test is very short, hence the estimated transmissibility determined from the test will be representative only of the water-bearing material close to the well. Serious errors will be introduced unless the ... well is fully developed and completely penetrates the aquifer.

Table D.1. Summary of Single-well Slug Test Analysis

Well ID	Test Interval (ft)	Equivalent Hydraulic Conductivity (ft/d)
199-H5-2	41.1 - 44.5	120
199-H5-2	45.0 - 50.0	120
199-H5-3P	42.0 - 46.9	130
199-H5-3P	45.0 - 50.2	59
199-H5-4P	42.0 - 47.7	160
199-H5-4P	45.0 - 49.8	36

Although the analytical methods discussed previously have been formulated to account for partial penetration effects, the stipulation that the well be "fully developed" was not met. Fines generated and/or mobilized during drilling, which were observed during geologic sample collection and during well development activities following well installation (see Section 5.2), likely affected the permeability of the "near well" formation materials. Because well development was not conducted at any of the test locations before the slug displacement testing and data from the single-well slug tests do not correlate well with results from the full-field constant-rate discharge test, slug displacement testing results are considered suspect.

D.3 Constant-Rate Discharge Testing

Following installation, completion, and development of the injection/withdrawal well and all test site monitoring wells, a 24-h constant-rate discharge test was conducted to assess the horizontal hydraulic conductivity and its spatial variability, storativity and specific yield, and formation anisotropy. The test was conducted between March 27 and 28, 1995. Groundwater was pumped at a constant-rate using a 5-Hp submersible pump; flow rate was regulated by adjusting an in-line gate valve. Flow rate was monitored with an Omega Engineering turbine flow meter and verified using volumetric techniques (i.e., measurement of time required to fill a known volume). The average discharge rate during the test was 20.9 gal/min. Pressure response was monitored using Keller Series 173 pressure transducers at the stress well and at 10 of the 15 available monitoring wells (see Figure 1.2, Section 1.0). The remaining five monitoring wells were periodically measured for pressure response using a calibrated steel electric water-level indicator; monitoring wells equipped with pressure transducers were also periodically measured with a calibrated steel electric water-level indicator to verify the transducer calibration.

D.3.1 Analytical Methods

The quantitative analysis procedure applied for each monitoring location included a diagnostic derivative analysis of drawdown and/or recovery data, and type-curve matching of the observed drawdown or recovery response. The derivative of each test response was calculated using the DERIV program described in Spane and Wurstner (1993). The derivative plots were then examined to diagnose the type of test behavior (i.e., presence of wellbore storage, delayed-yield response). Results of the diagnostic analysis indicated that elastic and delayed-yield, unconfined aquifer response were exhibited at the test sites analyzed. In addition, wellbore storage effects of the pumping well were also evident within early-time test response at the observation wells. Additional information pertaining to the use of data derivative analysis for diagnosing hydraulic test behavior is presented in Spane and Wurstner (1993).

Unconfined aquifer type curves that account for the effects of wellbore storage at the pumping well were generated using either the method described in Fenske (1977) or using a computer program (Model Number 15) presented in Dawson and Istok (1991), which is based on the method described by Boulton and Streltsova (1976). The program accounts for the effects of partial penetration, aquifer anisotropy, and pumping well wellbore storage on the Type A type-curves presented by Neuman (1975). Complete unconfined aquifer type curves were developed by combining the calculated Type A curve including wellbore storage effects with the appropriate (i.e., same beta value) Type B curve generated using the WTAQ1 program described in Moench (1993). The development of complete unconfined aquifer type curves was similar to the graphical procedure described in Prickett (1965) and Neuman (1975) for combining Type A and Type B curves. In this instance, however, the generated Type A curves include the effects of pumping wellbore storage.

The preceding discussion on type curve generation is valid for the analysis of drawdown pumping test data. However, recovery data obtained following termination of pumping can also be analyzed using drawdown type curves, provided that the recovery buildup pressure (i.e., the observed formation pressure during recovery minus the observed formation pressure at the termination of testing) are plotted versus the equivalent time function described in Agarwal (1980). The Agarwal equivalent time function accounts for the duration of the discharge period, thereby permitting the use of drawdown type curves for the analysis of recovery data. The equivalent time function (t_e) is defined in Agarwal (1980) as

$$t_e = (t \times t')/(t + t') \qquad (7)$$

where t is duration of the discharge period [T], and t' is time since discharge terminated [T]. A more detailed discussion of the development of unconfined aquifer type curves for the analysis of drawdown and recovery pumping test data is presented in Spane (1993a) and Spane and Wurstner (1993a).

D.3.2 Constant-Rate Discharge Analyses

Analysis of the constant-rate pumping test data for the ISRM test site included two approaches: 1) individual analyses for each of the observation well sites, and 2) simultaneous composite analysis of selected groups of observation well test data. In both instances the type-curve matching technique was applied, which was based on a homogeneous porous media continuum approach. For the individual test well analyses, the degree of correspondence between the hydrologic property estimates obtained for the various test sites indicates whether a homogeneous model approach is valid for the test site area. Individual analytical results also provide information concerning the spatial distribution of hydraulic properties within the test site region. In contrast, the simultaneous composite analysis approach provides information as to which overall aquifer test conditions best match observed test response characteristics over the monitored area. This analysis approach provides the best average, area-weighted estimates for aquifer properties, again assuming that the test aquifer can be represented by a homogeneous porous media model. Results for both analysis approaches are presented in the following sections of this report.

D.3.2.1 Individual Observation Well Analysis Results

Results of individual observation well analyses are listed in Table D.2. The results listed represent the best combined type-curve and derivative matches for individual recovery water-level responses recorded at each ISRM test site observation well. Recovery water-level data were analyzed instead of drawdown data, because of adverse effects caused by discharge fluctuations that occurred during the initial minutes of the pumping test. Drawdown data, however, were compared with recovery data to corroborate the similarity of intermediate and late-time test response for both phases of the pumping test. For all observation wells, intermediate and late-time data provided nearly identical drawdown and recovery test responses. Because the recovery data provides a complete analysis record of the test response (including the early-time, elastic response phase of the test) recovery rather than drawdown data was the focus of the individual test well analysis effort. In addition, test data collected after approximately 1400 min into the recovery period exhibit adverse effects associated with barometric fluctuations. For this reason, late-time recovery data after this time were omitted from the test analysis.

The Jacob correction ($s - \{s^2/2b\}$; where s = drawdown and b = aquifer thickness) for dewatering of thin unconfined aquifers was also examined for significance in modifying the observation wells' recovery response. Only for well H5-5P (the closest observation well to the pumped well) did this correction make a discernable change in the analysis results.

Figures D.8 through D.16 provide individual results of the observation well recovery type-curve and derivative plot match analyses, and their associated hydraulic property determinations. Results of the individual observation well analyses indicate the following ranges for the identified hydraulic properties: transmissivity = 1700 to 3200 ft^2/d; storativity = 0.004 to 0.009; specific yield = 0.018 to 0.086; and vertical anisotropy ($K_D = K_v/K_h$) = 0.06 to 0.09.

Table D.2. Results of Constant-Rate Discharge Test Recovery Analysis for Individual ISRM Test Site Observation Well Locations

Well	Distance (ft)	Screened Interval (ft)[(a)]	T (ft^2/d)	S	S_y	K_D
H5-3'O'	20.0	41.1 - 43.6	3200	0.008	0.057	0.07
H5-3P	20.0	46.3 - 48.8	2600	0.0055	0.037	0.07
H5-4'O'	12.5	41.7 - 44.2	2700	0.0055	0.018	0.07
H5-4P	12.4	47.7 - 50.2	2200	0.0055	0.028	0.07
H5-5P	5.0	48.5 - 50.9	1700	0.006	0.086	0.09
H5-6	7.6	45.9 - 48.4	2200	0.009	0.036	0.09
H5-8	22.7	46.8 - 49.3	3200	0.005	0.025	0.08
H5-9	10.1	47.2 - 49.7	2100	0.004	0.026	0.06
H5-11	24.5	46.3 - 48.8	3000	0.004	0.027	0.06

(a) Static water level at test site before initiation of constant-rate pumping test was approximately 41.1 ft.

Of the hydraulic properties determined, only transmissivity exhibited any spatial dependence. A general dependence between transmissivity and well screen/aquifer depth was evident (Figure D.17). As indicated in Table D.2, for locations having two closely-spaced observation well installations (i.e., H5-3'O' -3P and H5-4'O' -4P), significantly lower transmissivities were exhibited for the wells completed at greater depth within the aquifer. A possible decreasing transmissivity with increasing depth relationship is consistent with geologic descriptions of well logs available for the ISRM test site. In addition, a general relationship of increasing transmissivity with increased distance from pumping well H5-2 was evident (Figure D.18). This general association was exhibited irrespective of azimuth direction for observation wells at the ISRM test site. The cause for this distance correspondence is not known. This distance dependence may be associated with changes in aquifer characteristics (e.g., increasing aquifer thickness or hydraulic conductivity with distance) or inherent deficiencies in the analytical solution for analyzing tests conducted in shallow thin unconfined aquifers.

Note that because of the short test duration (i.e., 1440 min), estimates determined for specific yield are expected to be highly qualitative and may significantly underestimate actual in situ conditions.

D.3.2.2 Composite Analysis Results

Weeks (1978) and Moench (1994) have demonstrated the usefulness of simultaneously analyzing the responses from multiple wells for a single test event. This composite test response analysis facilitates the determination of more areally representative aquifer hydraulic properties. Spane (1993b) also reports the advantage of this analysis method for assessing the homogeneity of the aquifer, which is commonly assumed in analysis of individual test well responses.

To examine areal average characteristics of the test aquifer, three composite analyses of observation well recovery data were completed. Two of the composite analyses were for locations where two wells were completed at different depths in the aquifer (well sites H5-3'0' -3P and H5-4'O' -4P), and a third composite analysis for selected observation wells located at distances greater than 12 ft from the pumping well (Figures D.19, D.20, and D.21, respectively). Because the third composite analysis included data for observation wells located at different distances from the pumping well, the recovery data for each well were normalized (as is standard practice) by dividing time by the square of their radial distance. Summary results of the composite analysis are presented in Table D.3.

Table D.3. Results of Constant-Rate Discharge Test Composite Analysis for ISRM Test Site Observation Well Locations

Well Grouping	T (ft^2/d)	S	S_y	K_D
H5-3'O' & 3P	2800	0.0055	0.055	0.05
H5-4'O' & 4P	2300	0.006	0.03	0.07
H5-3P, 4P, 8, & 11	2700	0.0055	0.037	0.06

The composite analysis results generally support findings previously obtained from the individual observation well analyses, specifically that average aquifer transmissivity exhibits a distance dependence with lower transmissivity values indicated for wells located closer to the pumping well (as noted by comparing the composite analysis for wells H5-4'O' -4P to results obtained for wells H5-3'O' -3P). As discussed earlier, whether or not this distance dependence is associated with changes in aquifer characteristics (e.g., increasing aquifer thickness or hydraulic conductivity with distance) or inherent deficiencies in the analytical solution for analyzing tests conducted in shallow, thin unconfined aquifers is not known. Of particular interest is the third composite analysis for selected wells located at distances greater than 12 ft from the pumping well. As indicated in composite analysis Figure D.21, the normalized observation well recovery responses converge and become asymptotic with the Theis curve in late test times. This suggests that the values estimated for transmissivity (2700 ft^2/d) and specific yield (0.037) are probably close to the actual large-scale aquifer characteristics in the vicinity of the ISRM test site.

D.3.3 Conclusions

Analysis of the constant-rate discharge test data for the ISRM test site, using the two approaches discussed above (i.e., individual analyses for each of the observation well sites and simultaneous composite analysis of selected groups of observation well test data) provided comparable results. Results of these analyses indicate the following "best estimate" for test site-scale hydraulic properties: transmissivity = 2700 ft^2/d, storativity = 0.0055, specific yield = 0.037, and vertical anisotropy ($K_D = K_v/K_h$) = 0.06.

Of the hydraulic properties determined, only transmissivity exhibited any spatial dependence. A general dependence between transmissivity and well screen/aquifer depth was indicated. A possible decreasing transmissivity with increasing depth relationship is consistent with geologic descriptions of well logs available for the ISRM test site. In addition, a general relationship of increasing transmissivity with increased distance from pumping well H5-2 was indicated. This general association was exhibited irrespective of azimuth direction for observation wells at the ISRM test site. The cause for this distance correspondence is not known. This distance dependence may be associated with changes in aquifer characteristics (e.g., increasing aquifer thickness or hydraulic conductivity with distance) or inherent deficiencies in the analytical solution for analyzing tests conducted in shallow thin unconfined aquifers.

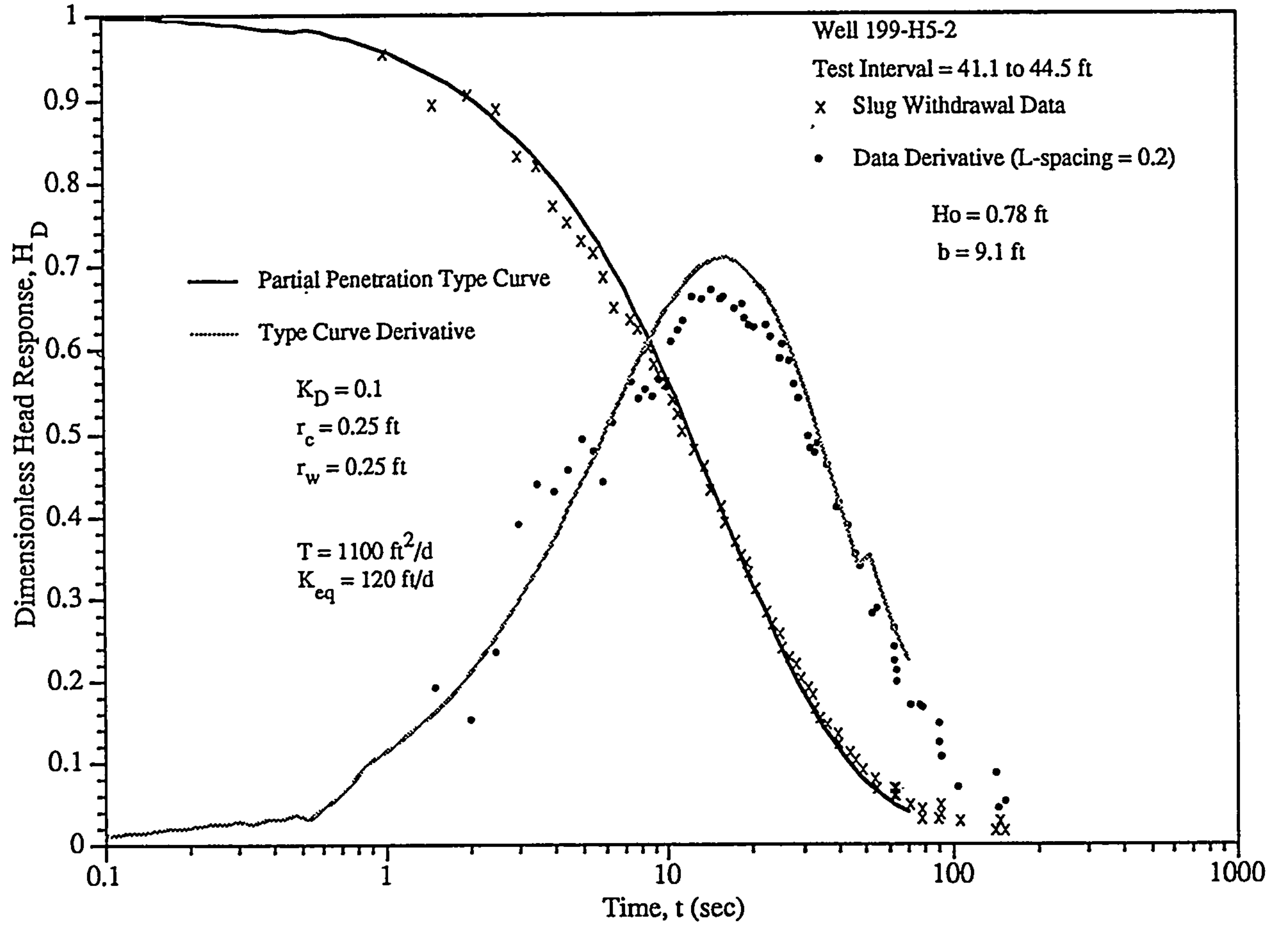


Figure D.1. Combined Type-Curve and Derivative Slug Test Analysis for the Upper Zone of Injection/Withdrawal Well 199-H5-2

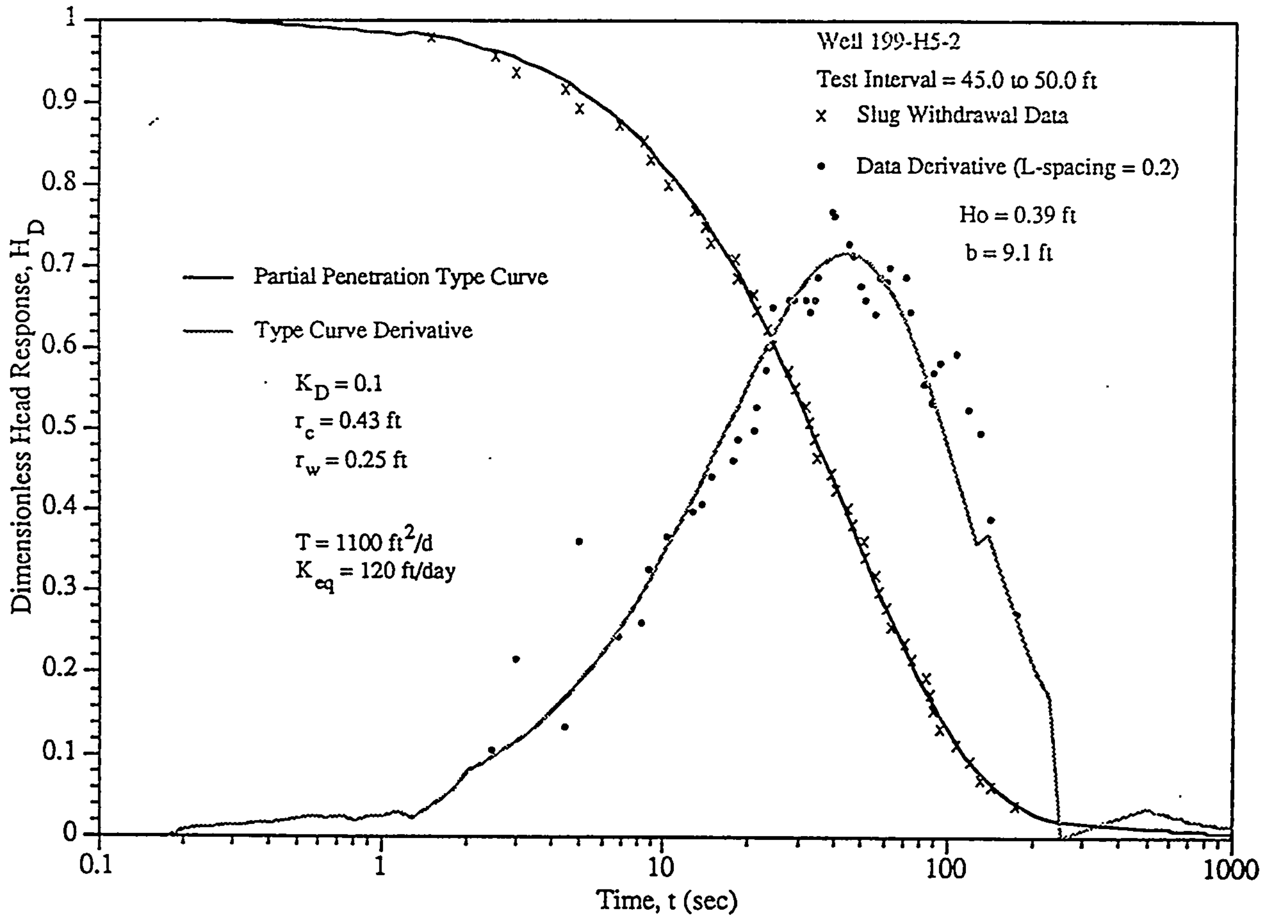


Figure D.2. Combined Type-Curve and Derivative Slug Test Analysis for the Lower Zone of Injection/Withdrawal Well 199-H5-2

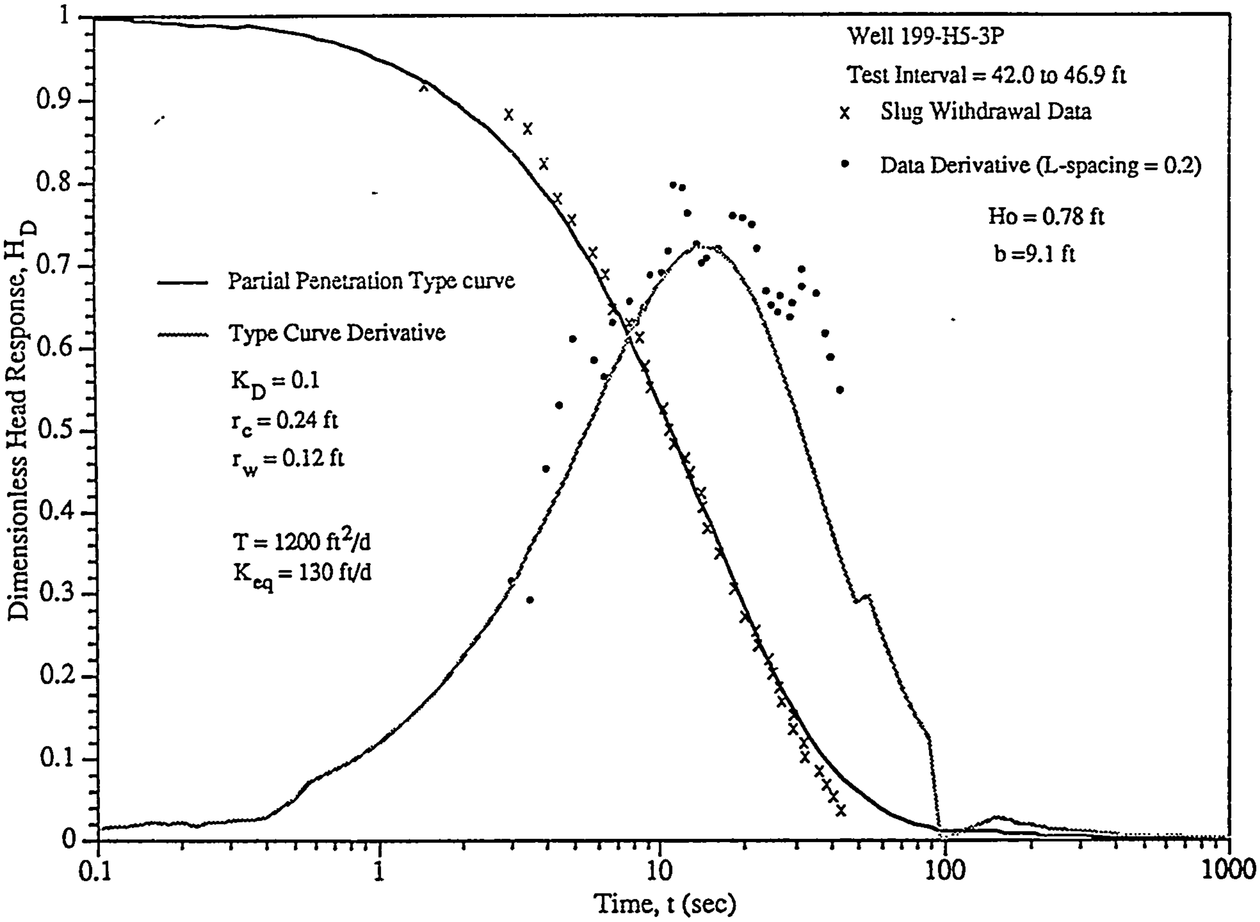


Figure D.3. Combined Type-Curve and Derivative Slug Test Analysis for the Upper Zone of Monitoring Well 199-H5-3P

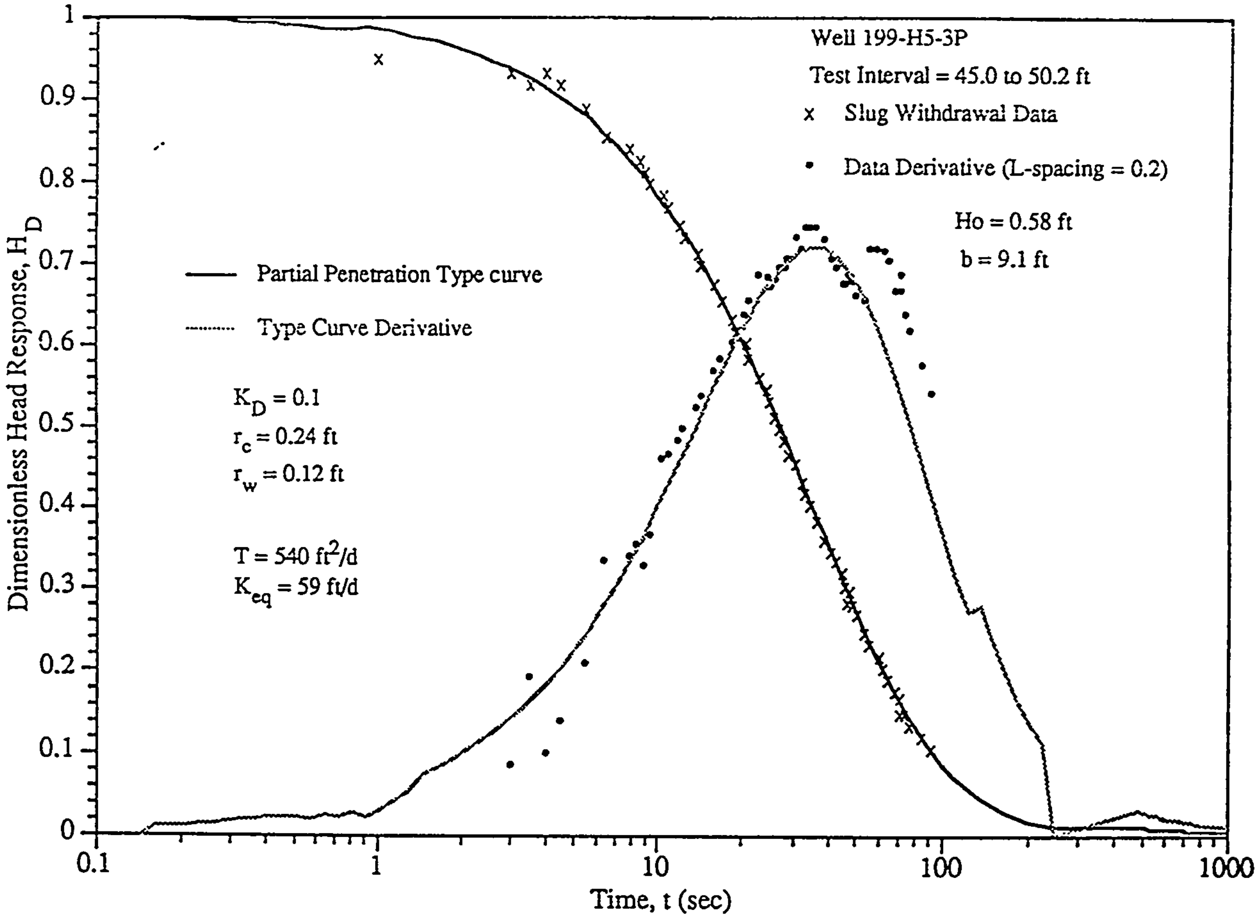


Figure D.4. Combined Type-Curve and Derivative Slug Test Analysis for the Lower Zone of Monitoring Well 199-H5-3P

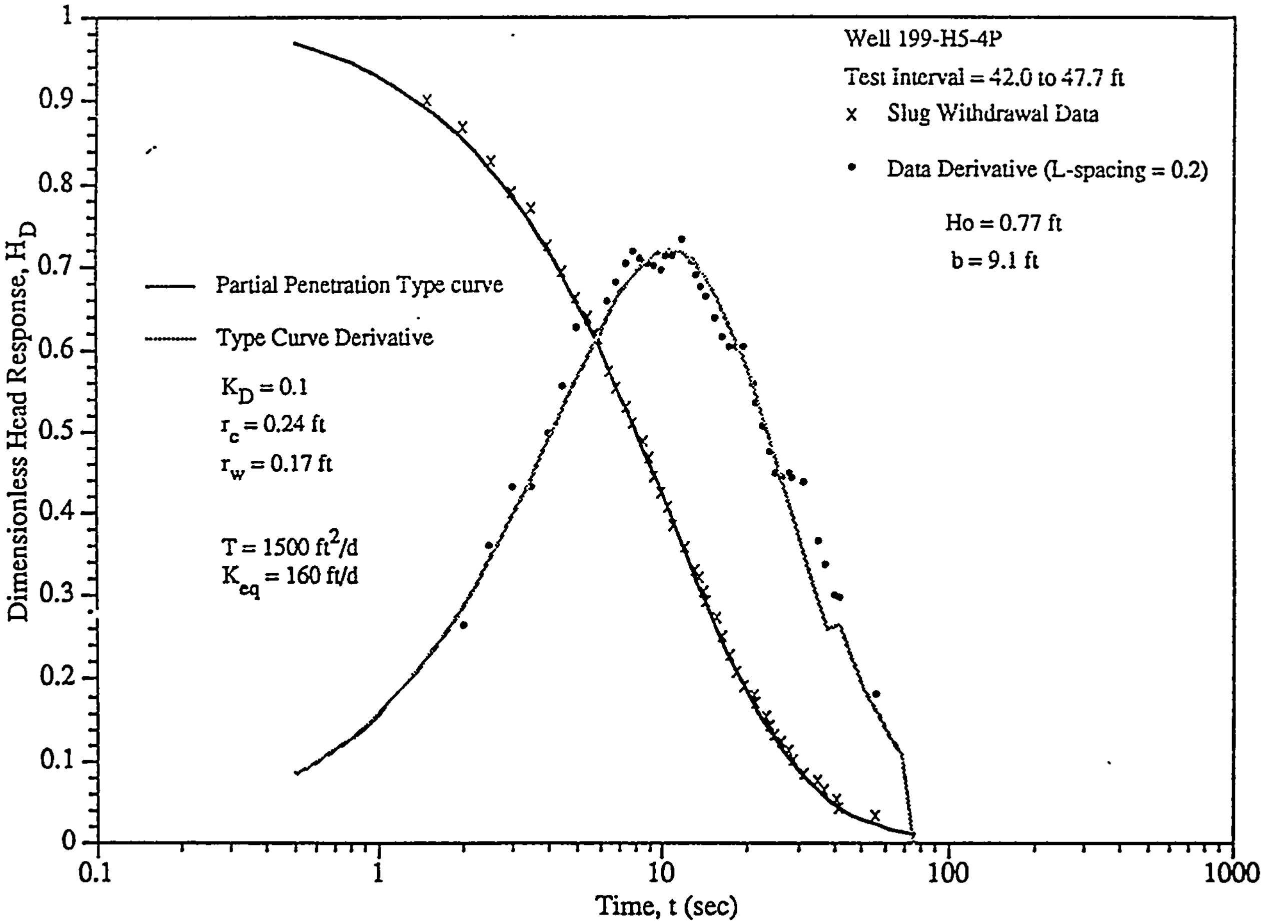


Figure D.5. Combined Type-Curve and Derivative Slug Test Analysis for the Upper Zone of Monitoring Well 199-H5-4P.

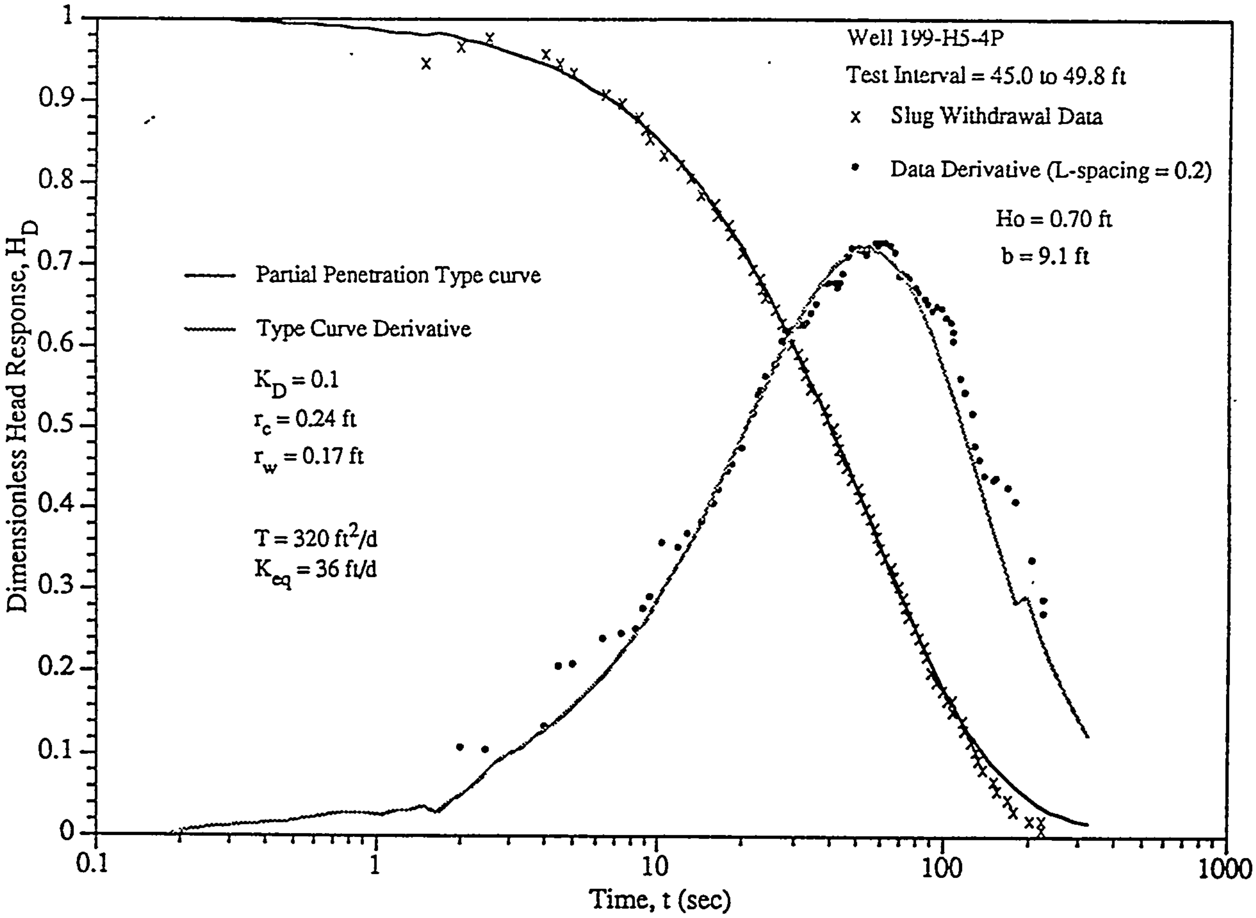


Figure D.6. Combined Type-Curve and Derivative Slug Test Analysis for the Lower Zone of Monitoring Well 199-H5-4P

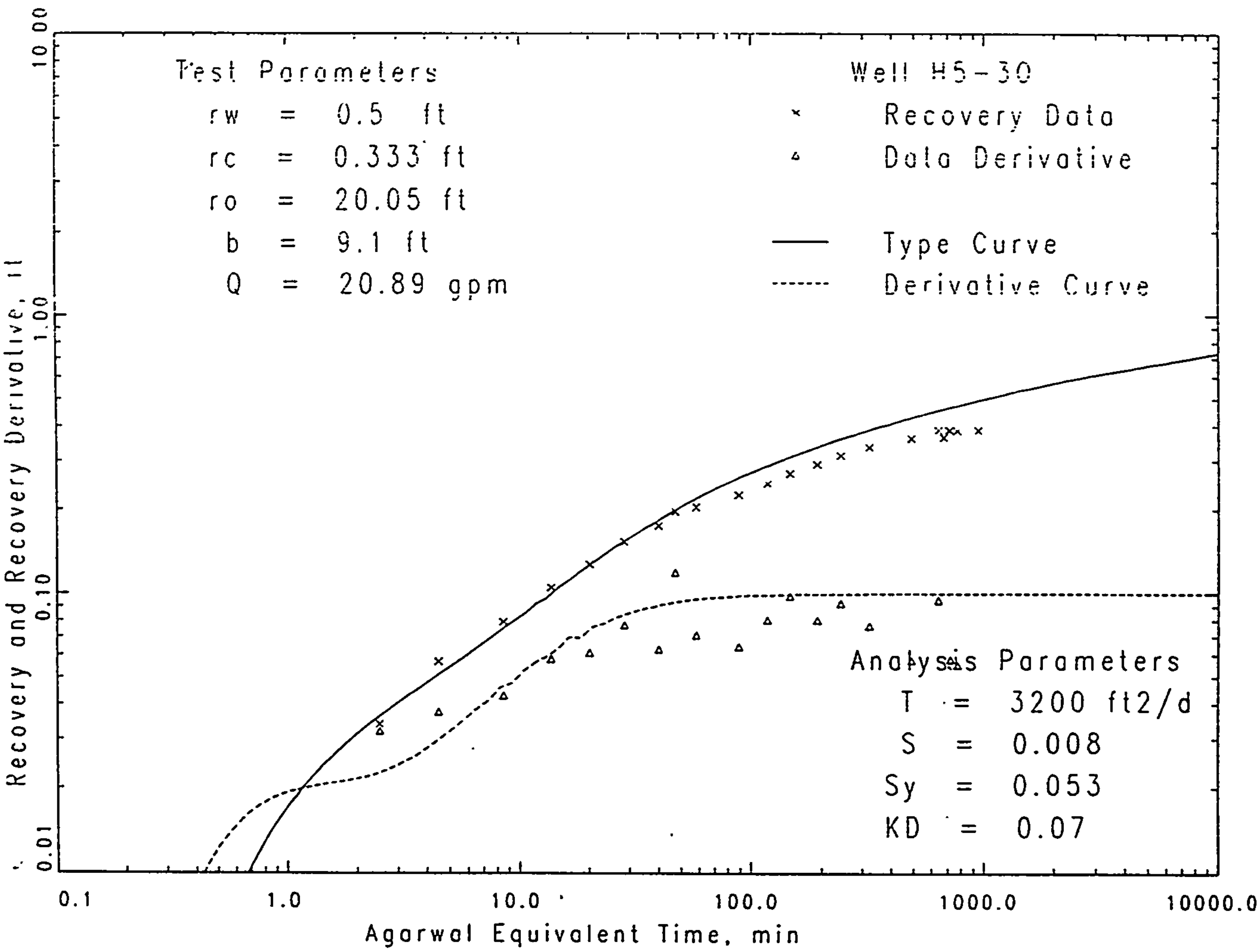


Figure D.7. Composite Type-Curve and Derivative Plot Analysis of Recovery Test Data for Pumping Well H5-3O

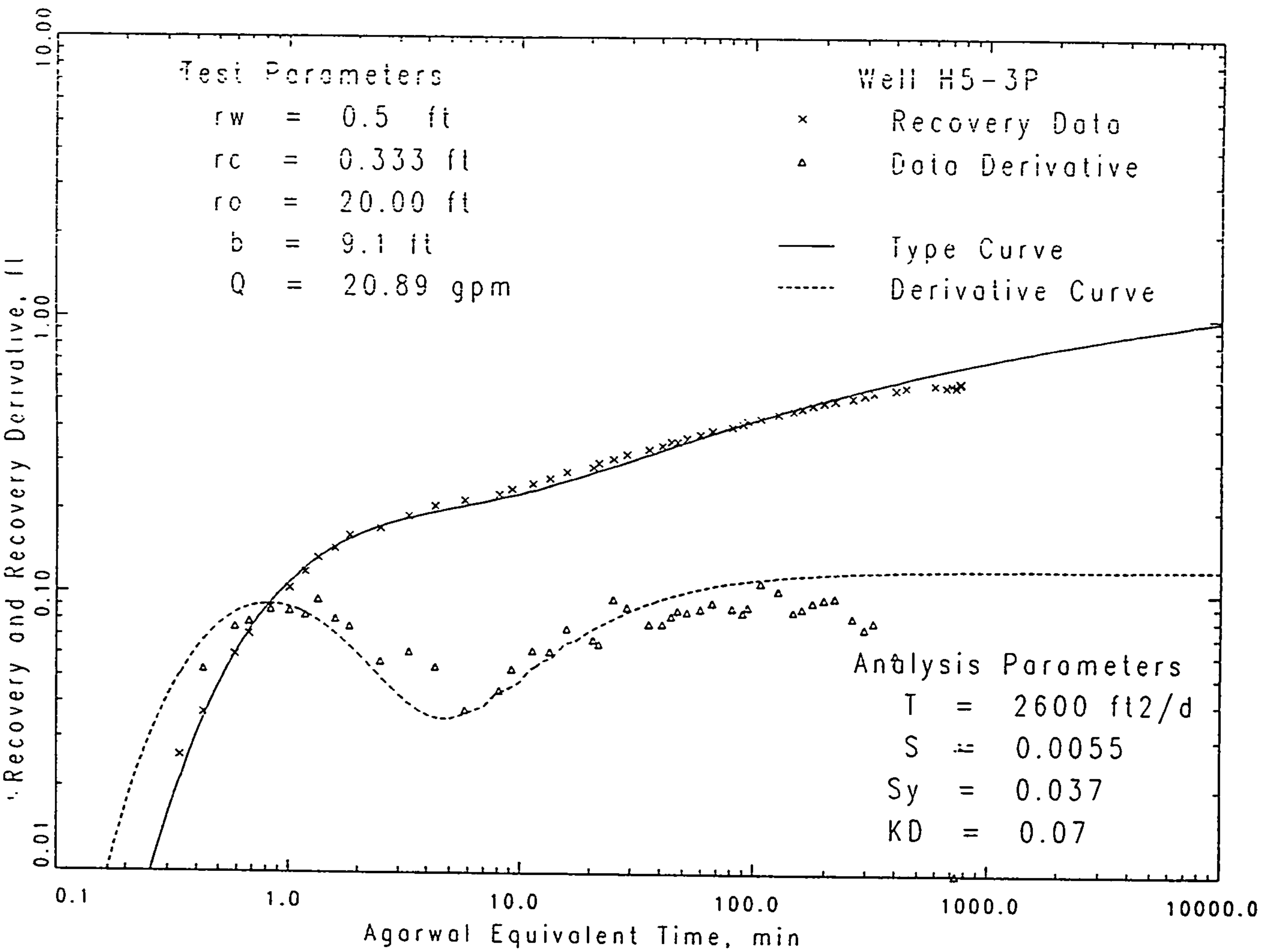


Figure D.8. Composite Type-Curve and Derivative Plot Analysis of Recovery Test Data for Pumping Well H5-3P

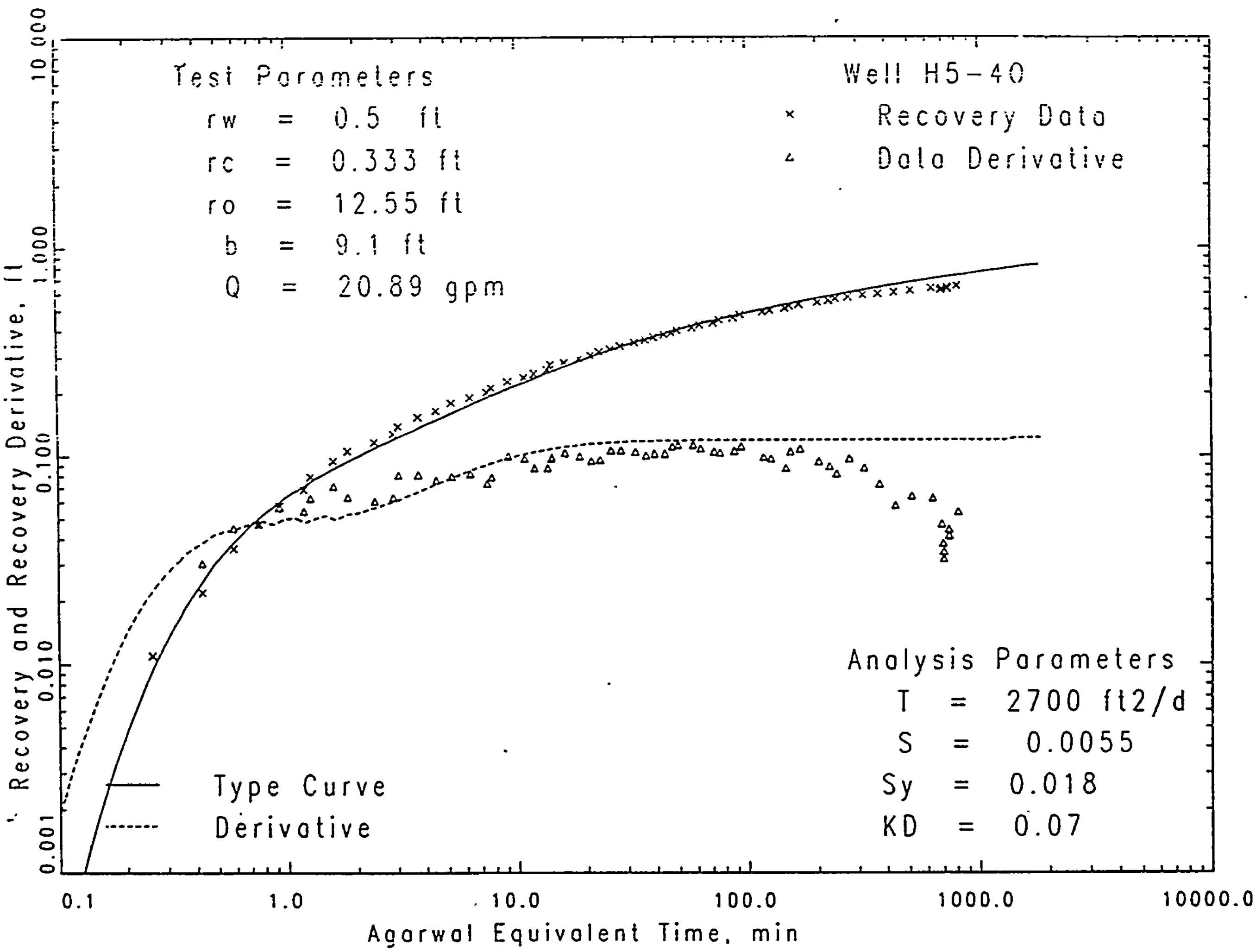


Figure D.9. Composite Type-Curve and Derivative Plot Analysis of Recovery Test Data for Pumping Well H5-4O

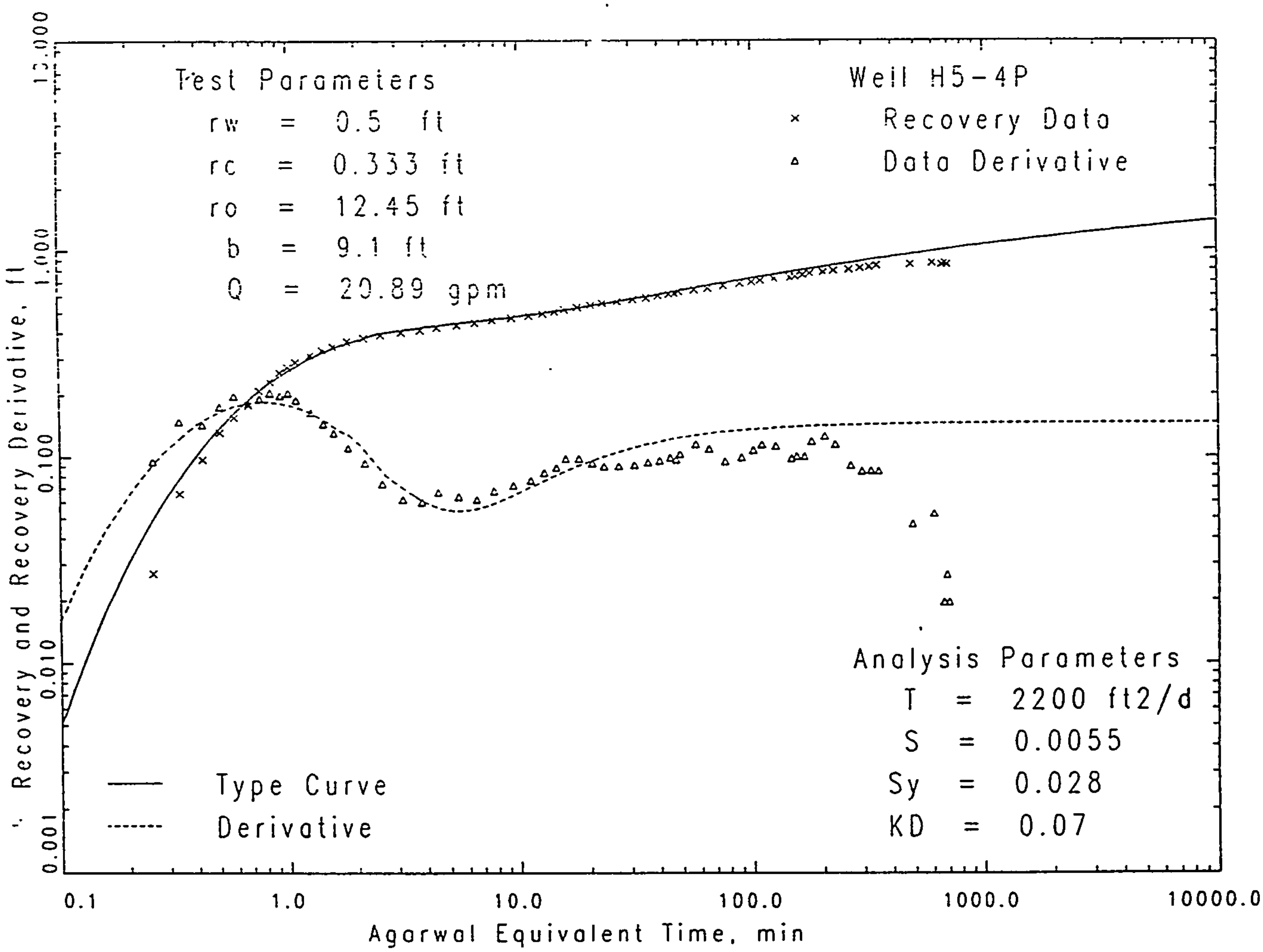


Figure D.10. Composite Type-Curve and Derivative Plot Analysis of Recovery Test Data for Pumping Well H5-4P

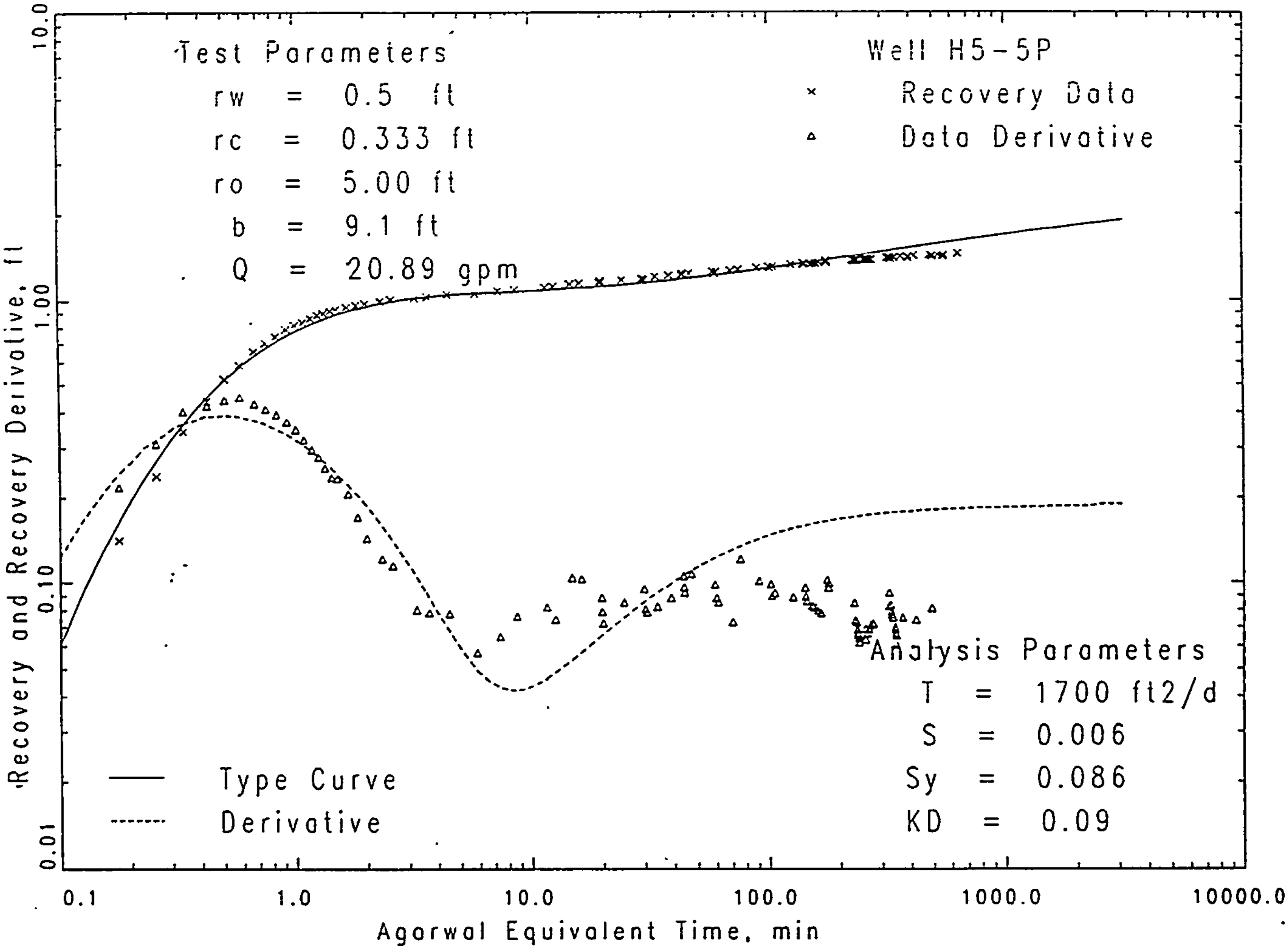


Figure D.11. Composite Type-Curve and Derivative Plot Analysis of Recovery Test Data for Pumping Well H5-5 .

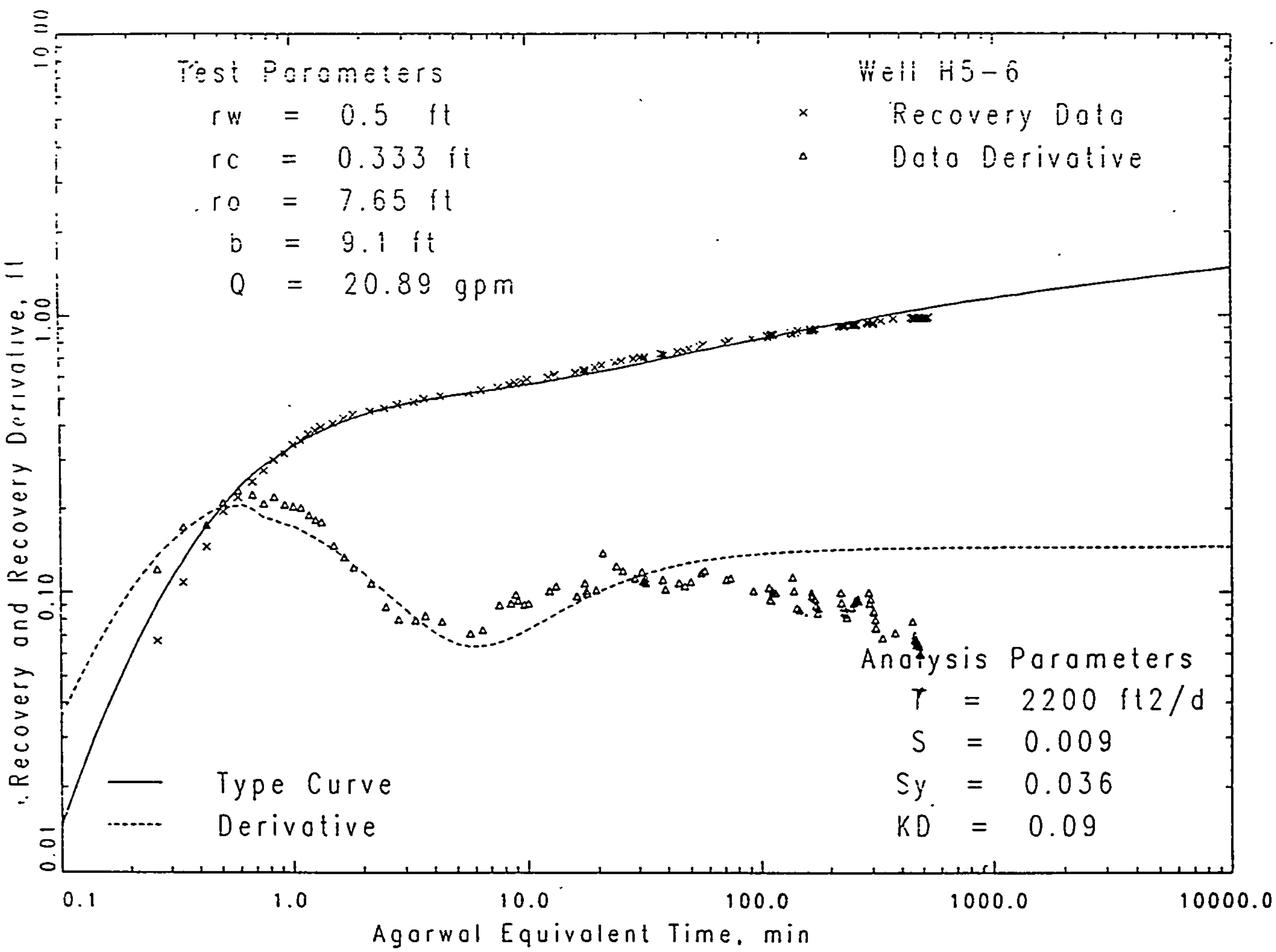


Figure D.12. Composite Type-Curve and Derivative Plot Analysis of Recovery Test Data for Pumping Well H5-6

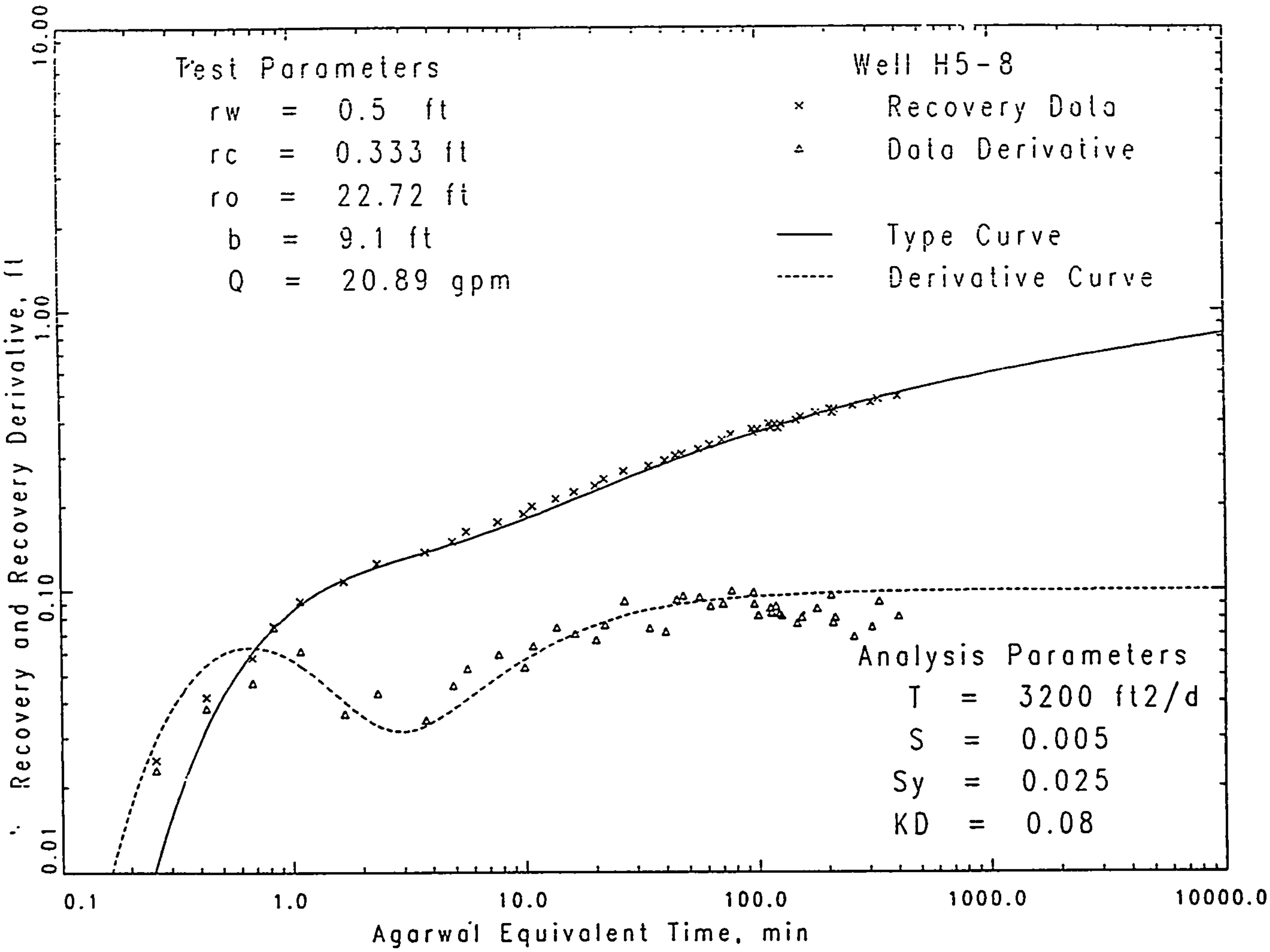


Figure D.13. Composite Type-Curve and Derivative Plot Analysis of Recovery Test Data for Pumping Well H5-8

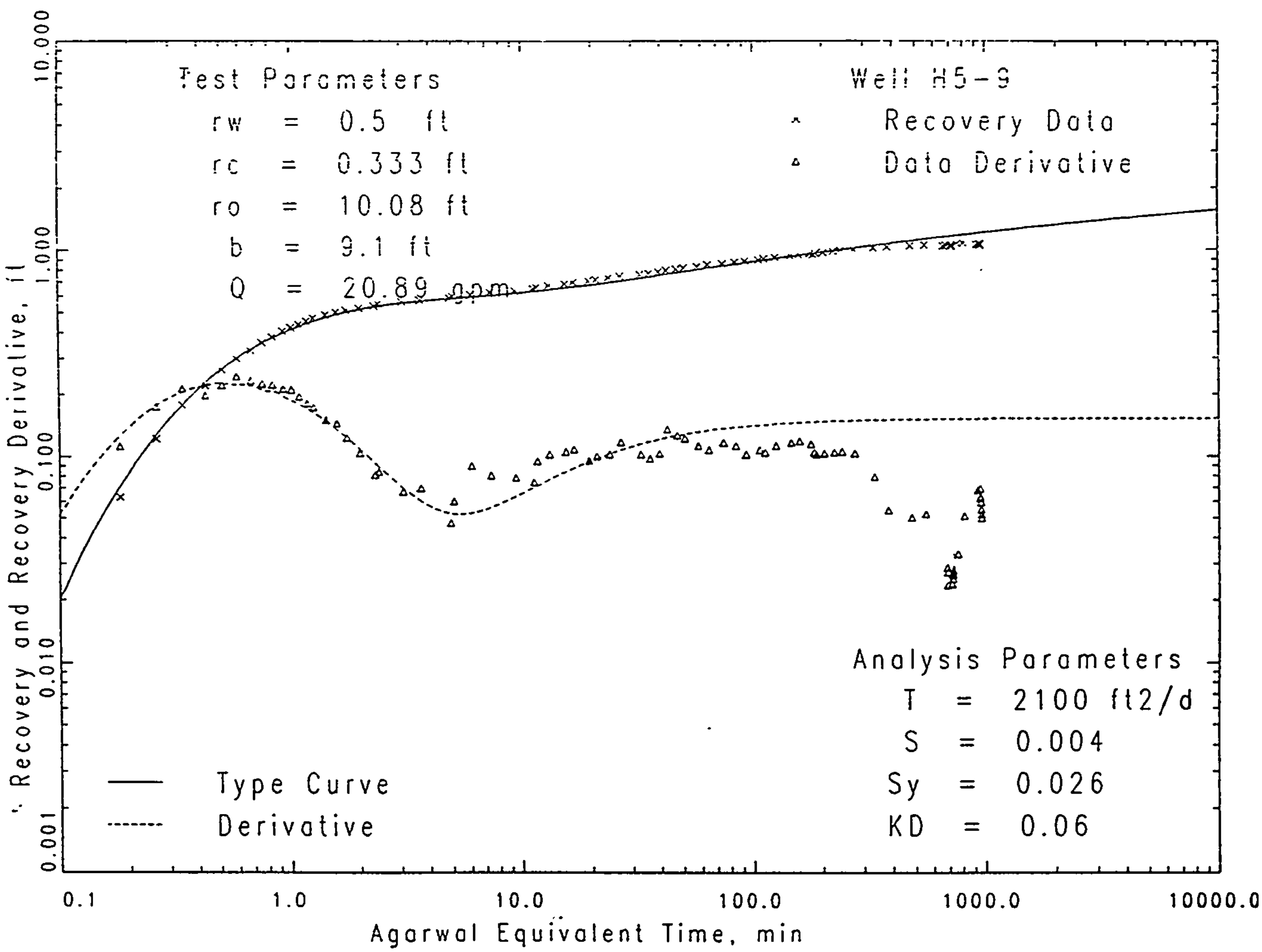


Figure D.14. Composite Type-Curve and Derivative Plot Analysis of Recovery Test Data for Pumping Well H5-9

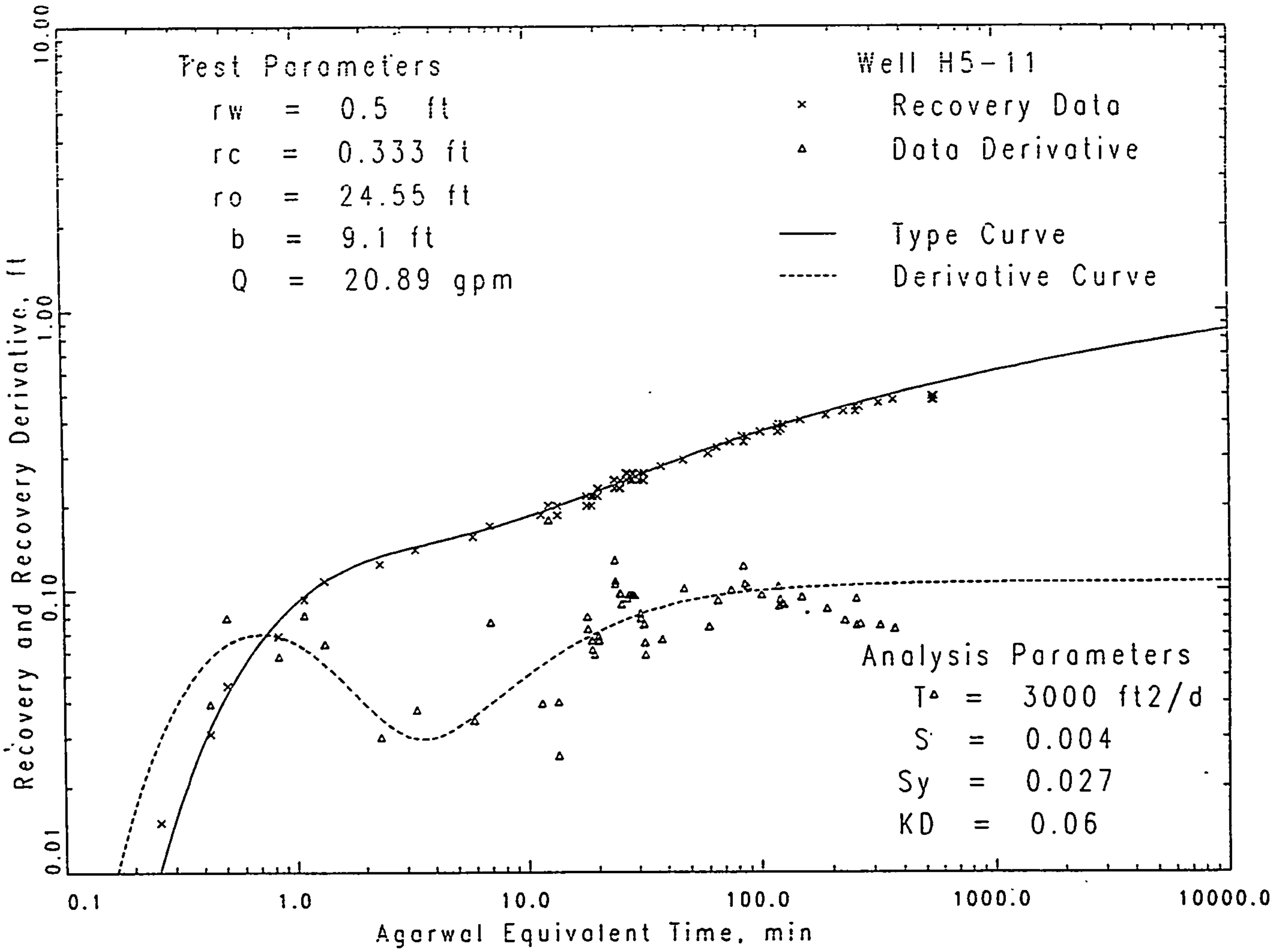


Figure D.15. Composite Type-Curve and Derivative Plot Analysis of Recovery Test Data for Pumping Well H5-11

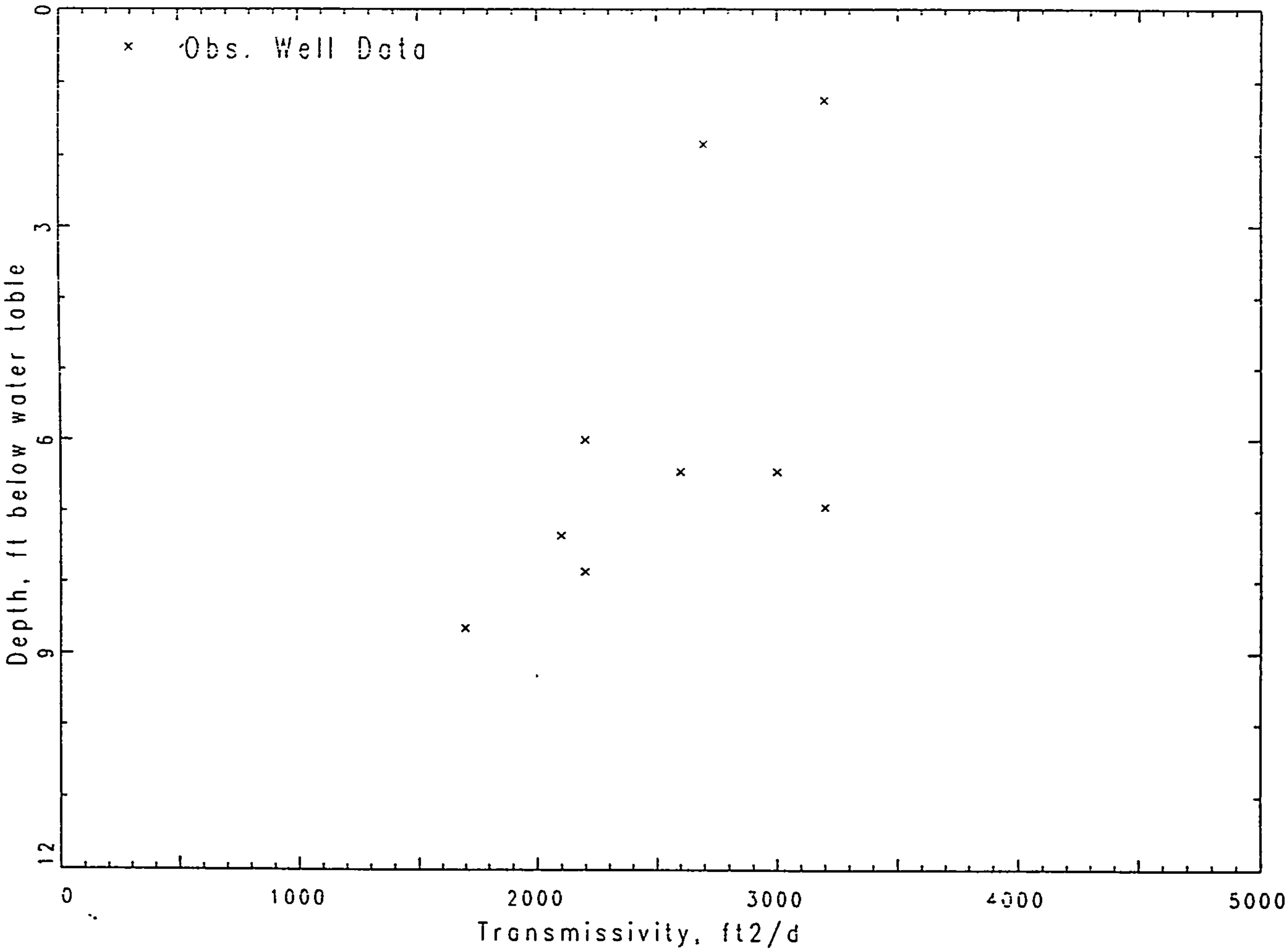


Figure D.16. Correspondence of Transmissivity and Test Interval Depth

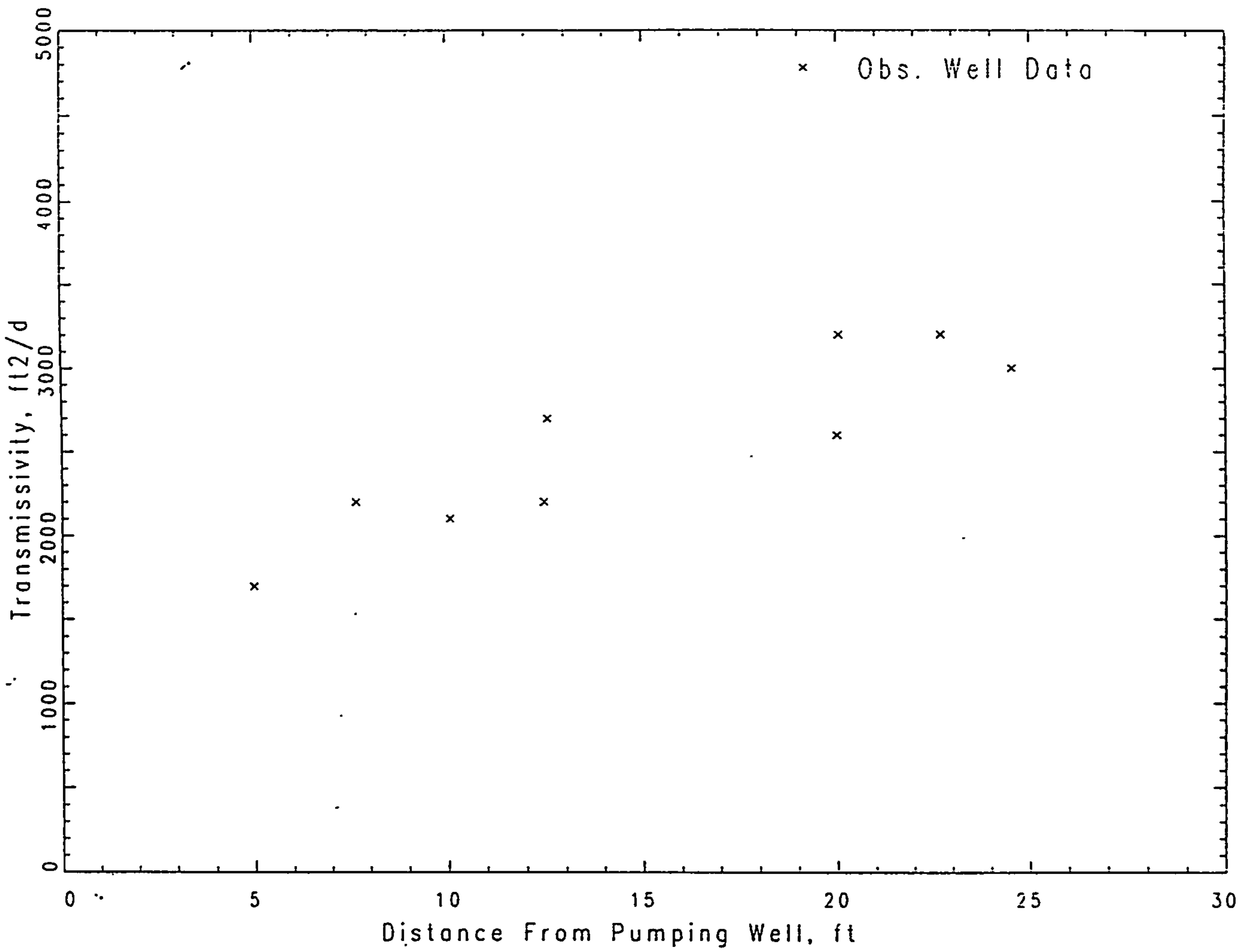


Figure D.17. Correspondence of Transmissivity and Distance from Pumping Well H5-2

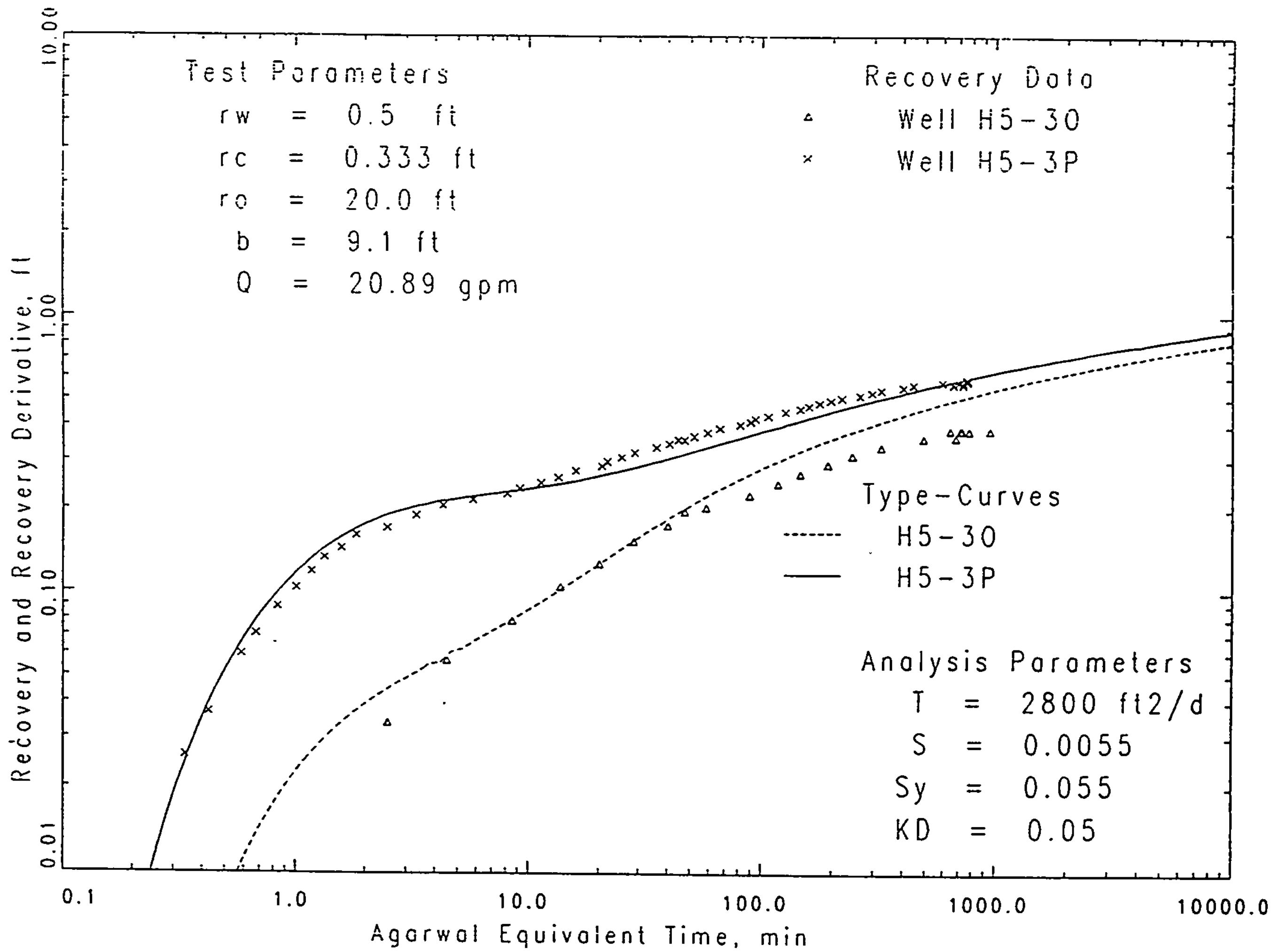


Figure D.18. Composite Analysis of Recovery Response from Monitoring Wells H5-3'O' and H5-3P

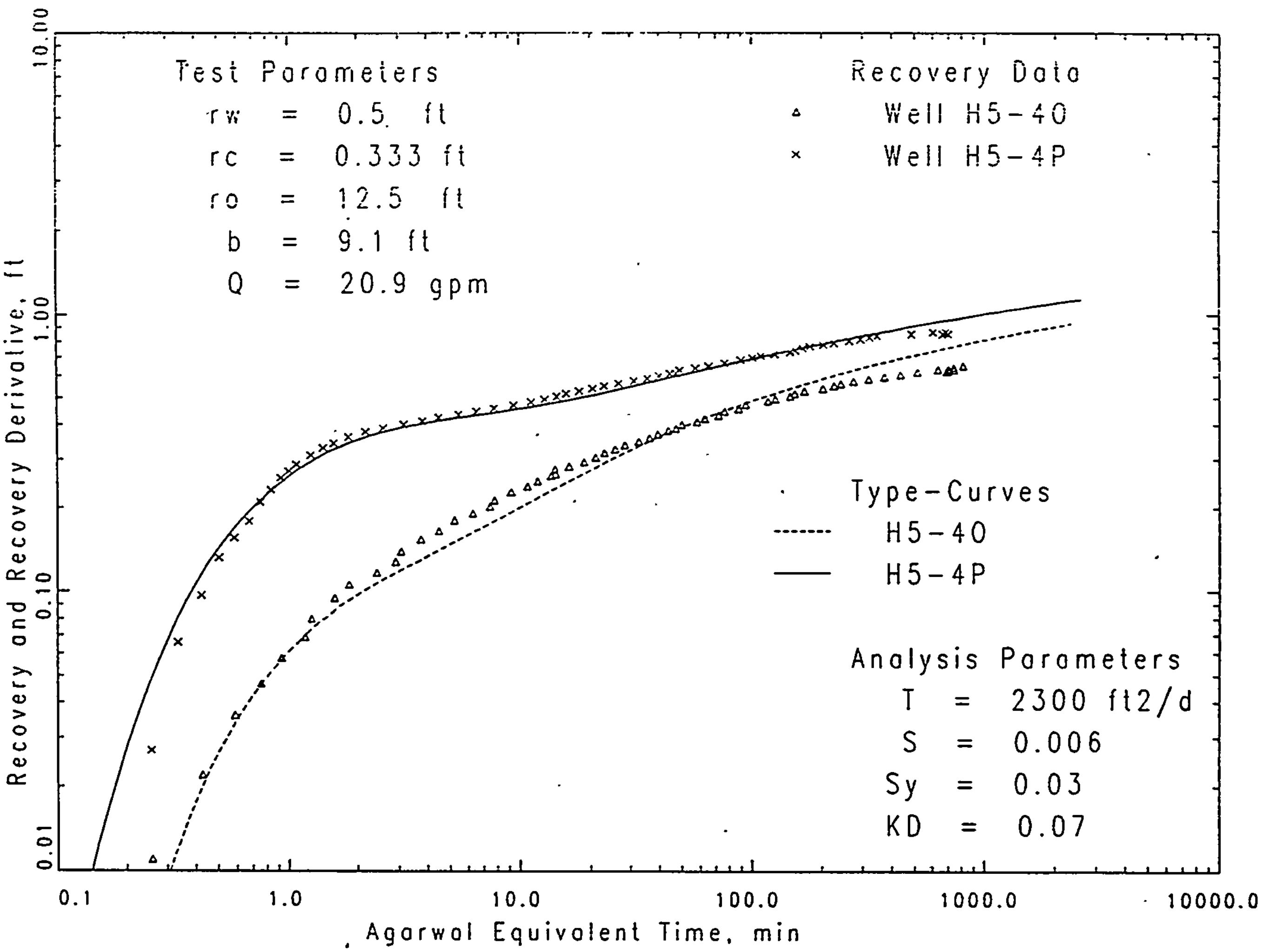


Figure D.19. Composite Analysis of Recovery Response from Monitoring Wells H5-4'O' and H5-4P

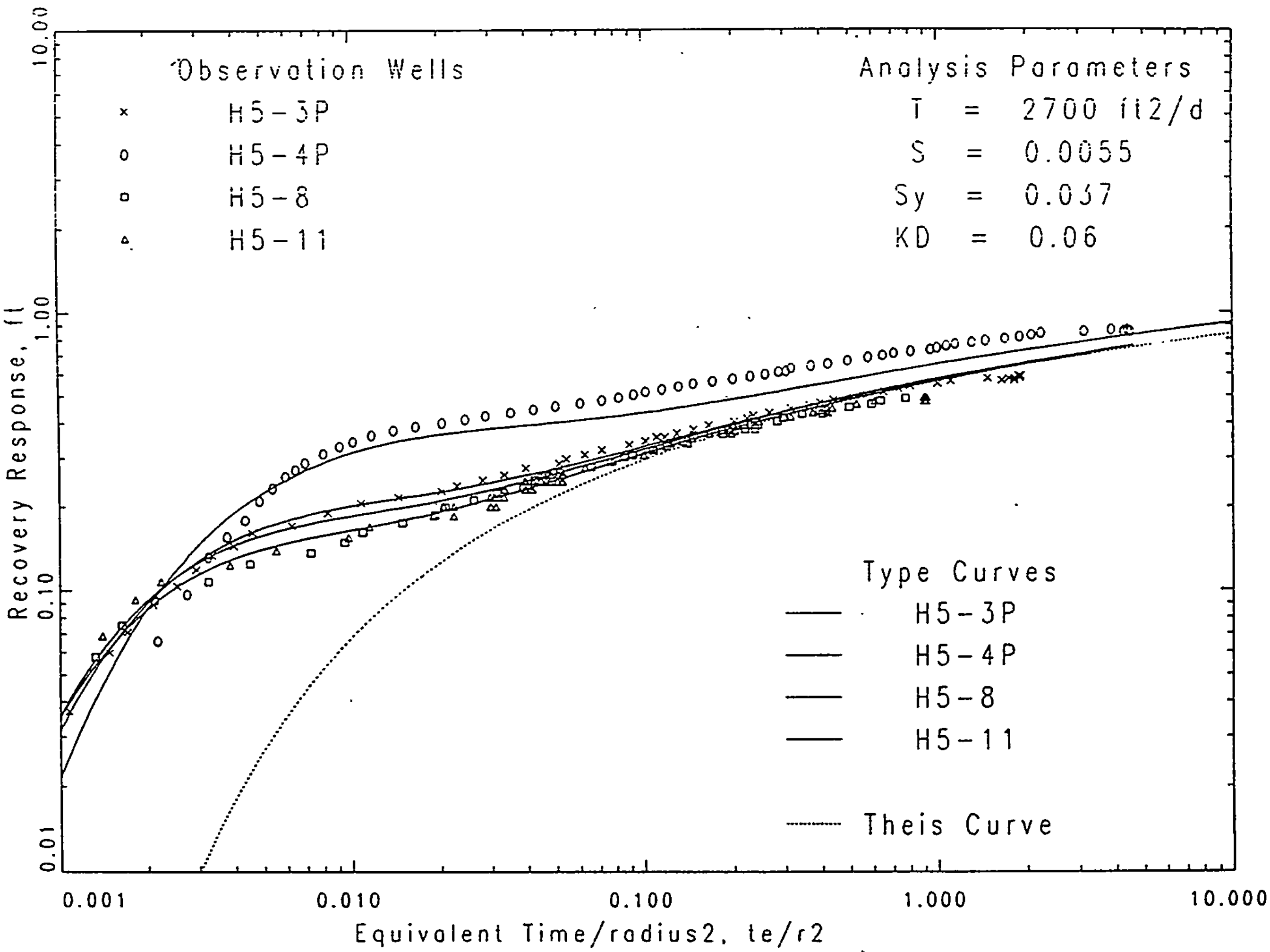


Figure D.20. Composite Analysis of Recovery Response from Monitoring Wells H5-3P, H5-4P, H5-8, and H5-11

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